Experimental ONCOLOGY

BREAST RECONSTRUCTION

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Mastectomy has been used for the treatment of breast cancer for many years, but the importance of the positive psychosocial benefits of breast reconstruction in breast cancer treatment has been recognized in the past years. Now, more women seek breast reconstruction and surgeons perform more reconstructions. A breast can be reconstructed by two methods: prosthetic implants and autologous tissue. The reconstruction can be performed immediately at the time of mastectomy or on a delayed basis. Factors associated with implant reconstruction include timing, patient selection, method of reconstruction, and filler material. The prosthetic implant reconstruction can be performed in one or two stages. The principal methods of breast reconstruction using autologous tissue include flaps from lower abdominal tissue, the latissimus dorsi musculocutaneous flap, other flaps, and the autologous fat grafting. In this article the main reconstruction methods either with implants or autologous tissue are reviewed and their advantages and disadvantages are discussed.
Key Words: breast reconstruction, prosthetic implants, autologous reconstruction, radiotherapy.

INTRODUCTION

Breast reconstruction has become an integrated part of breast cancer treatment due to long-term psychosexual health and its importance for breast cancer survivors. Both autogenous tissue-based and implant-based reconstruction provides satisfactory reconstructive options although each has their own advantages and disadvantages. A brief overview of the current options in breast reconstruction is presented in this article.

BREAST RECONSTRUCTION WITH PROSTHETIC IMPLANTS

Usage of prosthetic implants for breast reconstruction became the agenda in the early periods of the 1960s. Cronin and Gerow developed silicone prosthesis in 1961 and used it clinically for augmentation mammoplasty in 1962 [1]. Shortly after, these implants began to be used for the reconstruction of mastectomized breasts [2]. Breast reconstructions using prosthetic implants were applied in single stage at first. Development of tissue expanders by Radovan created new possibilities in immediate or delayed reconstruction and during the 1980s, the popularity of single-stage reconstruction by implants was overridden by two-stage reconstructions [3].

Major developments have occurred in implant technology and surgical techniques in the course of years, leading to more successful and natural results obtained by implant reconstruction [4]. Today, although breast reconstruction withy autologous tissues is considered golden standard, 82.7% of breast reconstructions in the United States of America are carried out by implant-

based techniques as demanding microsurgical techniques are not required, operations and hospitalizations last shorter, and costs are lower [5].

SILICONE IMPLANTS

Since the beginning of their use in 1962, 240 different types of implants have been manufactured by at least 10 different manufacturers. Until now, it is estimated that 8000 different implants differing in terms of size, form, valve mechanisms and their contents have been manufactured [6]. Commercially used silicone breast implants can be basically classified depending on their contents, surface structures and shapes.

Silicone-gel filled implants and saline filled implants

Implants are divided into two types according to the materials they contain. Whatever content they have, the outer shell is the same and consists of silicone elastomer. Implants containing saline are divided into two different types such as those with no valve mechanism, that are inflated by the manufacturer and those containing a valve mechanism and can be inflated during surgery [7].

The concern that breast implants might cause cancer and certain autoimmune diseases have been addressed in many studies since the 1980s. The American Food and Drug Administration (FDA) decided to pull silicone implants off the market for 45 days, in 1992, until required information was collected. After 45 days the FDA put some restrictions on the usage of these devices. With the decision taken by the FDA, silicone-gel filled implants have been allowed only in breast reconstruction in the United States; however, these restrictions weren't applied in Europe.

Today, it is proven that there isn't any connection between autoimmune diseases, connective tissue diseases and any systemic diseases such as cancer and silicone-gel filled implants. Also, important improvements have been made in production standards, quality and design of implants within 15 years in which

they have been pulled off the market: silicone elastomer sheath resulting in less leakage, and more cohesive silicone-gels have been produced. In other words, the quality and reliability of implants have increased. Considering these facts, the FDA on April of 2006 approved usage of silicone-gel implants on patients over the age of 22 for cosmetic purposes [8, 9].

The most important disadvantage of saline-filled implants is that they have more solid consistency than silicone-gel implants and can be more palpable. Silicone-gel implants have softer consistency and when these implants are used, more natural-like results are obtained. Even if it is proven that there isn't any connection between silicone-gel implants and systemic diseases, concern regarding leakage of silicone-gel potentially exists. New generation silicone implants currently being used contain cohesive gel with more intensive consistency than the previous generations. When cut or torn, the shape of the implant does not change and silicone-gel does not leak out [10].

Smooth implants and textured implants

The smooth implants were the first produced implants. In order to prevent capsular contracture caused by the usage of these implants textured implants or, in other words, implants with rough surfaces have been developed [11].

Round implants and anatomic-shaped implants

The horizontal and vertical lengths of round implants are identical. The term anatomic-shaped or tear drop-shaped implant is used to identify the implants that have vertical lengths different from their horizontal lengths. When used, it is possible to gain a more natural breast appearance. The disadvantage specific to anatomic implants is that the implant can rotate. Therefore, when the implant pocket is prepared, the preparation of a large pocket should be avoided as it may facilitate rotation [12].

SELECTION OF PATIENT

The most important factors in decision making for breast reconstruction with implants are whether the reconstruction is unilateral or bilateral, the body type of the patient and accompanying diseases. Obtaining symmetry is one of the most important targets of breast reconstruction. The best results in reconstruction by implants are achieved in patients with 500 g breast volume or lower. The most suitable candidates for breast reconstruction by prosthetic implants are patients with low or normal body weight, patients needing bilateral reconstruction, and patients whose contralateral breasts are not ptotic or slightly ptotic, who have low or normal weight. As volume and ptosis of the patient's contralateral breast increases, obtaining symmetry becomes more difficult and in order to obtain symmetry, methods such as reduction mammoplasty, mastopexy should be applied to the contralateral breast [13].

In patients with multiple health problems, reconstruction operation with implants can be preferred due to shortness of the duration of the operation, but the fact that it will be a multi-stage operation and revisions will be required, causing the patient to receive anesthesia

multiple times should not be ignored. Obesity will make reconstruction difficult and it is an independent risk factor like smoking, hypertension and being over 65 years in terms of perioperative complications [14, 15].

Even if breast reconstruction by implants can be carried out in many patients, it has two absolute contraindications. Soft tissue or skin deficiency to cover the surface of the implant constitutes the first absolute contraindication. This situation may emerge due to aggressive mastectomy or in relation to radiotherapy. Active infection in the operation field is the other absolute contraindication. Irradiation of the chest wall, decision on radiotherapy after mastectomy and systemic diseases such as scleroderma, obesity and active smoking are relative contraindications [14–16].

TIMING

Breast reconstruction by prosthetic implants can be applied as immediate reconstruction with mastectomy and also after mastectomy (delayed reconstruction). Each of these methods has their own advantages and disadvantages. The most important advantage of immediate reconstruction is that the patient can get out of the hospital after the operation without losing their sense of integrity. In other words, a psychological benefit is provided to the patient by this method. Further advantages are related to the surgical technique, which are proper planning of incision patterns in cooperation with the surgeon to carry out mastectomy and preservation of the maximum possible amount of healthy muscle and skin tissue. Increased risk of infection, hemorrhage, possibility of hematoma causing higher rate of skin flap necrosis and not knowing the necessity of radiotherapy preoperatively are the most important disadvantages of the immediate reconstruction methods [14–19]. Recent studies demonstrated no difference in immediate reconstruction surgeries in terms of loco regional recurrence of breast cancer, in comparison with delayed reconstruction surgeries [16, 20]. If reconstruction surgery is performed electively after weeks or months, this approach is called a delayed reconstruction, and the most important advantages of this technique are its simplicity and reliability. Less dissection is performed, and concerns over skin flap viability have been eliminated. Another important advantage of this method is that a corresponding reconstruction method can be chosen since it is known if the patient will receive radiotherapy. The most important disadvantage of this technique is that the patient will stay mastectomized for a long time period until the completion of reconstruction and it may have negative psychological effects [17, 21, 22].

RECONSTRUCTION METHODS

There are mainly two methods applied in breast reconstructions with prosthetic implants. The first one is the single stage reconstruction where permanent implant or permanent expander/implant is placed; the second one is the two-stage reconstruction where permanent implant is inserted following tissue expansion. Apart from these two methods, there are also combined

implant/autologous tissue reconstruction methods available, in which prosthetic implants are used in reconstruction carried out with autologous tissues.

Single stage reconstruction

In a single stage reconstruction with a permanent implant, the place of the resected breast tissue is filled with an implant of appropriate volume. In the first cases breast reconstructions using implants, the single stage technical method was used. However, the clinical studies showed better results with two-stage methods, therefore single stage method with permanent implant left its place to the two-stage methods. Yet, still exist some clinical situations suitable for one stage permanent implant placement. Reconstruction of small breasts using skin-sparing mastectomy can be done with this method. The most suitable reconstructions for this method are reconstructions to be performed on patients who have less ptotic, round shaped breasts, with healthy mastectomy flaps and resected tissue less then 300 g [15, 19, 23].

In single stage reconstruction where a permanent expander/implant is placed, double lumen expandable gel/saline filled implants are used. Becker found this method in 1984 [24]. The implant is partially inflated during the surgical operation, and breast expansion is maintained via a port during the postoperative period until symmetry is achieved. During the operation, the port is placed in subcutaneous tissue, away from the breast implant, and removed after the desired look is achieved. Indications for this method are same as the patients reconstructed with single stage permanent breast implants but vary in respect to obtain symmetry by providing the surgeon with more control and by enabling symmetry in slight ptotic breast cases by deflation following overexpansion. Its most important disadvantage is the necessity of removing the port after the desired expansion [25].

It is difficult to obtain symmetry in single stage reconstruction, also the rate of complications such as infection, skin necrosis and implant exposure also are higher in comparison with two stage methods. When the final breast form reconstructed with single stage methods is compared with two-stage method, it is typically smaller and less ptotic [16].

Two-stage reconstruction

The most commonly practiced form of breast reconstruction with implants is the two-stage reconstruction [21]. In this method, a temporary device called as tissue expander is placed in a submuscular pocket during the first operation if immediate breast reconstruction is performed and at the first stage if delayed reconstruction is performed. But at the second stage the tissue expander is removed, and breast reconstruction is completed with a permanent implant. Following Radovan's first presentation of tissue expanders for breast reconstruction in 1982, the two-stage method replaced the single stage method [3]. Expanders have a port either integrated on the device or positioned in a remote area by means of a tube in order to allow infiltration of saline for expansion. The tissue expanders used for breast reconstructions are anatomically shaped in general and thus the lower pole can be expanded more. First infiltration for expansion is carried out generally after incisions are healed. Predictors of how much volume is to be infiltrated at a time are skin tolerance and the patient's resistance to the feeling of tension. Expansion time may vary between 3 to 7 months [16]. Approximately a 30% overexpansion is needed to obtain an acceptable breast ptosis. After completion of expansion, the tissue expander is removed, and an appropriate sized permanent implant is placed. Two-stage reconstruction is a more reliable method and has several advantages over the single stage method. While the tissue quality covering the implant is improved at the first stage, it becomes possible to re-adjust the position of the permanent implant, manipulate the inframammary fold and thus give better shape to the breast. The period between the first stage and second stage also gives time for the patient and the surgeon in dealing with factors such as chemotherapy and radiotherapy [19, 21].

Radiotherapy and prosthetic breast reconstruction

The number of the patients requiring radiotherapy to their chest wall after mastectomy is increasing [26]. The first controversial issue is whether the immediate reconstruction method shall be applied to the patients who are known to receive radiotherapy after mastectomy; and the other controversial issue is what breast reconstruction option will be preferred for patients who have already received radiotherapy. Radiotherapy, whether before or after the breast reconstruction has been shown to have adverse effects on implants and the results of breast reconstruction and increases the rate of complications. These complications include infection, implant rupture, and implant exposure, wound dehiscence and contractures. These wound related complications may lead to the patient's dissatisfaction with results [22, 26, 27].

The current approach is to avoid prosthetic reconstruction in patients who received or will receive radiotherapy, and to prefer reconstructions with autologous tissue. But some patients may not prefer reconstructions with autologous tissue or may not be suitable for this approach; the surgeon may decide on breast reconstruction with implants considering the high complication risk in these cases [26].

Another problem is the necessity of subsequent radiotherapy in some patients who underwent implant based breast reconstruction. Management of these patients is rather difficult, high complication rates are seen and a large number of surgical interventions may be required [28].

ADVANTAGES AND DISADVANTAGES OF BREAST RECONSTRUCTION WITH PROSTHETIC IMPLANTS

In summary, simplicity of operations compared to breast reconstruction with autologous tissue, the usage of tissue in same structure and skin color with contralateral breast for the reconstruction procedure and no donor sites are the most important advantages

of the breast reconstruction with implants. Short duration of surgery and recovery process and lower costs of operations are its additional advantages. But although the operation and recovery period is short, the period of expansion may be quite long and troubled. Additional interventions need to be performed frequently in order to ensure symmetry, and the symmetry cannot usually be obtained as well as in reconstructions with autologous tissues [14–17, 21]. Adverse effects of the radiotherapy are also much greater on breast reconstruction with implants [22, 26–28].

AUTOLOGOUS BREAST RECONSTRUCTION

Although implant-based reconstruction is the most popular method of breast reconstruction [29], autologous tissue reconstruction is generally regarded as the gold standard in breast reconstruction [26]. Autologous reconstruction has the benefit of replacing like with like. Autologous tissue can be transferred either on a pedicle, remaining attached to its own blood supply, or as a free flap, which requires microvascular anastomosis of the donor tissue vessel to the recipient site vessel.

Despite requiring lengthier procedures and longer recovery, autologous tissue-based reconstruction recreates soft, naturally ptotic breast shape that is ideal for matching an unaffected contralateral breast [30]. Also this kind of reconstruction provides good vascularity, which can be critical in patients exposed to radiotherapy [31].

The most favored donor site and method of choice in autologous breast reconstruction is utilization of the lower abdominal tissue [32]. The back, flank, buttocks, and thighs also can be used as alternative donor sites when necessary [33, 34].

Lately, autologous fat grafting for breast reconstruction has become another important option [35, 36]. Successful results using structural fat grafting for the breast reconstruction have been published, however indication and safety in clinical practice is still controversial [37–39].

(Pedicled) transvers rectus abdominis myocutaneous flap

The pedicled transvers rectus abdominis myocutaneous (TRAM) flap by Hartrampf et al. in 1982 remains most common procedure of autologous breast reconstruction [40, 41]. This myocutaneous flap has two dominant pedicles: the superior and inferior epigastrics, and is classified as a type III flap according to the Mathes — Nahai classification [42]. Although the pedicled TRAM flap survives on the choke vessels by means of the superior epigastrics, free TRAM and muscle-sparing free TRAM are all based on the inferior epigastrics.

TRAM flap consists of predominantly infraumbilical skin and subcutaneous fat that is attached to its superior epigastric vascular pedicle within the rectus abdominis. The flap is tunneled subcutaneously to the mastectomy defect, and the donor site is closed in a cosmetic abdominoplasty fashion (tummy tuck) [43]. The amount of the tissue that can be transferred is generally smaller and fat necrosis rates can be higher in comparison to the other abdominal flaps such as free TRAM flap, because the blood supply is derived from the less dominant superior epigastric system for the pedicled TRAM flap [44–46]. In certain high-risk individuals, such as obese, smokers, and irradiated patients, who leads to higher rate of flap complications, may be required delay procedure to decrease these risks.

The pedicled TRAM flap sacrifices the rectus abdominis muscle and its overlying fascia, so this requires usage of the mesh in reconstructing the abdominal wall and can lead to functional deficits postoperatively [46]. This has led to the popularization of the other abdominal flaps such as the free TRAM flap, and deep inferior epigastric artery perforator (DIEP) flap.

One of the important advantages of the pedicled TRAM flap is that it doesn't require microvascular capabilities and, thus, tends to require shorter operative times [46].

Free transvers rectus abdominis myocutaneous flap

The main advantages of the free TRAM over the pedicled TRAM are less disturbance of the rectus abdominis muscle, more aesthetic inset of the transferred tissue, and a more robust blood supply [47]. The free TRAM flap represents a spectrum ranging from harvest of the full width of the rectus muscle down to thin cuff of muscle surrounding the vessels. In the muscle-sparing 0 free TRAM flap, the lower rectus muscle is transected. The muscle-sparing 1 free TRAM flap leaves either a medial or lateral component behind, whereas the muscle-sparing 2 free TRAM flap leaves both medial and lateral fibers intact. Although the microvascular procedure is more technically demanding, sparing more muscle and fascia minimizes risks of abdominal morbidity [48, 49].

DIEP flap

The DIEP flap is a true perforator flap that leaves the rectus abdominis muscle intact. The DIEP flap has variable vascular anatomy and requires microvascular dissection; this makes the operation even more technically demanding and can further lengthen operative time. Excellent aesthetic results combined with lower abdominal wall morbidity with the DIEP flap have been reported [50–52]. Significant functional differences between the DIEP and muscle-sparing TRAM have not been clearly demonstrated [48, 49]. However, DIEP flap surgery has been associated with more complications, such as fat necrosis or complete flap loss [53, 54].

The modification of the DIEP flap is superficial inferior epigastric flap that is based on superficial vessels (SIEA). This flap shares same lower skin island with DIEP to create a breast mound. Preservation of the anterior abdominal wall fascia is the major benefit of this flap. The SIEA vessels can be quite small and present different anatomic challenges for insetting at the recipient area [55, 56].

Latissimus dorsi myocutaneous (LDM) flap

Despite the fact that the latissimus dorsi muscle is the largest muscle in the body, it is quite thin (less than

1 cm thick) and no significant donor functional deficit results from the removal of the muscle. This flap is not used for primary breast reconstruction because of the lack of appropriate volume. It usually serves as a salvage flap in cases of previous flap failure or exposed implant/expander [57]. Also LDM flap is useful for combination with implant-based reconstruction. LDM flap can especially be utilized in patients who have inadequate soft tissue coverage due to prior radiotherapy or nonviable mastectomy skin flaps [58–60]. The most recognized complication of LDM flap harvest is donor-site seroma formation. The LDM flap creates a donor site scar on the back [61].

Other flap choices

In patients who are not candidates for abdominal flaps due to insufficient abdominal donor tissue, alternate flaps can be used. These are the superior gluteal artery perforator (SGAP) flap, inferior gluteal artery perforator flap, transvers upper gracilis flap, lateral thigh flap, and the Rubens flap [62–65]. Gluteal flaps often lead to firmer, less pliable breast mound as a result of the innate quality of the skin and subcutaneous tissue. Transvers upper gracilis flap of the inner thigh is often limited in volume [66, 67]. However, a detailed discussion of these is beyond the scope of this article.

COMPLICATIONS

Most of the complications of the flaps from an abdominal donor site are wound-related. These are simple infections, seromas, hematomas, and skin flap necrosis and delayed wound healing of the donor or recipient site. Wound-related complication rates vary from 30 to 50% in the largest series [68–70]. Ischemic complications are fat necrosis or flap loss in free flap reconstruction. A recent meta-analysis showed that ischemic complications are higher in DIEP flaps when compared with free TRAM flaps [71]. Total flap loss, occurring 1 to 4%, is a rare entity [69, 72]. Ischemic complications of pedicled TRAM flaps can be reduced by the delay procedure that can be performed 2 to 3 weeks before surgery [73, 74].

The donor-site morbidity is mostly related with abdominal wall weakness. Non-muscle-sparing TRAM flaps appear to cause the largest decline in function [75]. Some studies have concluded that SIEA flap reconstruction has significantly less donor site morbidity and more patient satisfaction [76]. According to the literature, abdominal weakness due to DIEP flap reconstruction is between the TRAM reconstruction and SIEA reconstruction [71]. Overall, cosmetic results appear to be similar between all groups.

AUTOLOGOUS FAT GRAFTING

The transfer of autologous fat for breast reconstruction has gained popularity [76, 77]. Czerny was the first one, who used a large lipoma from the dorsal flank for breast reconstruction, in 1895 [79, 80].

Techniques of structural fat grafting have been standardized by Coleman and Khouri. This technique has become the method used in breast reconstruction [77, 78]. The concept of structural fat grafting is that, the fat must be inserted in small amounts using multiple tunnels, in many layers and directions, so that the largest possible number of adipocytes will be in contact with host tissue to receive adequate nutrition for their survival [77].

Although a number of studies on autologous fat grafting for breast reconstruction have been published with good results, fat grafting raises doubts with respect to indication and safety in clinical practice [37, 38, 81].

The procedure is mainly used for partial breast reconstruction and/or correction of breast deformities followed by total breast reconstruction with other techniques. Also autologous fat grafting is used for therapy for post radiotherapy radiodermatitis [82, 83].

The major concern about structural fat grafting for breast reconstruction was the potential risk of breast cancer. However, this theory was refuted in a recent study [83]. In a review, the rate of breast cancer recurrence was similar between those who had fat grafting to the breast and those who did not receive fat grafting [84–89].

THE EFFECT OF RADIOTHERAPY IN AUTOLOGOUS RECONSTRUCTION

Although radiotherapy has been shown to decrease the incidence of locoregional recurrence and has a survival advantage in patients with node-positive disease, radiotherapy after mastectomy or breast reconstruction, regardless of the reconstruction method, increases the incidence of postoperative complications [90, 91].

Implant-based reconstructions have higher rates of delayed healing, capsular contracture, implant malposition or extrusion, and infection, for those who receive radiation before/after undergoing reconstructive surgery [92, 93]. Thus autologous tissue-based reconstruction is indicated for these patients.

Although complications like fat necrosis, parenchymal fibrosis, skin retraction and scarring have been reported in those who underwent autologous reconstruction, autologous tissue-based reconstruction seems to have a more favorable outcome in terms of morbidity compared to implant-based reconstruction [94].

REFERENCES

1. **Cronin TD, Gerow FJ.** Augmentation mammaplasty: A new "natural feel" prostheses. Excerpta Medica International Congress Series 1963; **66**: 41–6.

2. **Cronin TD.** Subcutaneous mastectomy and gel implants. AORN J 1969; **10**: 81–5.

3. **Radovan C.** Breast reconstruction after mastectomy using the temporary expander. Plast Reconstr Surg 1982; **69**: 195–208.

4. **Spear SL, Spittler CJ.** Breast reconstruction with implants and expanders. Plast Reconstr Surg 2001; **107**: 177–87.

5. **Gurunluoglu R, Gurunluoglu A, Williams SA, et al.** Current trends in breast reconstruction: survey of American Society of Plastic Surgeons 2010. Ann Plast Surg 2013; **70**: 103–10.

6. **Rohrich RJ.** Advances in breast augmentation. Plast Reconstr Surg 2006; **118**: 1S-2.

7. **Cunningham BL, Lokeh A, Gutowski KA.** Saline-filled breast implant safety and efficacy: a multicenter retrospective review. Plast Reconstr Surg 2000; **105**: 2143–9.

8. **Tanne JH.** FDA approves silicone breast implants 14 years after their withdrawal. BMJ 2006; **333**: 1139.

9. Silicone-gel-filled breast implants approved. FDA Consum 2007; **41**: 8–9.

10. **Rohrich RJ, Reece EM.** Breast augmentation today: saline *versus* silicone-what are the facts? Plast Reconstr Surg 2008; **121**: 669–72.

11. **Embrey M, Adams EE, Cunningham B, *et al.*** A review of the literature on the etiology of capsular contracture and a pilot study to determine the outcome of capsular contracture interventions. Aesthetic Plast Surg 1999; **23**: 197–206.

12. **Hobar PC, Gutowski K.** Experience with anatomic breast implants. Clin Plast Surg 2001; **28**: 553–8.

13. **McCarthy CM, Pusic AL.** Tissue expander/implant reconstruction. In: Guyuron B, Persing JA, Kinney B, et al., eds. Plastic Surgery: Indications and Practice. London: Saunders; 2008.

14. **McCarthy CM, Mehrara BJ, Riedel E, *et al.*** Predicting complications following expander/implant breast reconstruction: an outcomes analysis based on preoperative clinical risk. Plast Reconstr Surg 2008; **121**: 1886–92.

15. **Pinsolle V, Grinfeder C, Mathoulin-Pelissier S, *et al.*** Complications analysis of 266 immediate breast reconstructions. J Plast Reconstr Aesthet Surg 2006; **59**: 1017–24.

16. **Mesbahi AN, McCarthy CM, Disa JJ.** Breast reconstruction with prosthetic implants. Cancer J 2008; **14**: 230–5.

17. **Kroll SS, Baldwin B.** A comparison of outcomes using three different methods of breast reconstruction. Plast Reconstr Surg 1992; **90**: 455–62.

18. **Cassileth L, Kohanzadeh S, Amersi F.** One-stage immediate breast reconstruction with implants: a new option for immediate reconstruction. Ann Plast Surg 2012; **69**: 134–8.

19. **Roostaeian J, Sanchez I, Vardanian A, *et al.*** Comparison of immediate implant placement versus the staged tissue expander technique in breast reconstruction. Plast Reconstr Surg 2012; **129**: 909e–18.

20. **Murphy RX Jr, Wahhab S, Rovito PF, *et al.*** Impact of immediate reconstruction on the local recurrence of breast cancer after mastectomy. Ann Plast Surg 2003; **50**: 333–8.

21. **Spear SL, Mesbahi AN.** Implant-based reconstruction. Clin Plast Surg 2007; **34**: 63–73.

22. **Hirsch EM, Seth AK, Dumanian GA, *et al.*** Outcomes of tissue expander/implant breast reconstruction in the setting of prereconstruction radiation. Plast Reconstr Surg 2012; **129**: 354–61.

23. **Malata CM, McIntosh SA, Purushotham AD.** Immediate breast reconstruction after mastectomy for cancer. Br J Surg 2000; **87**: 1455–72.

24. **Becker H.** Breast reconstruction using an inflatable breast implant with detachable reservoir. Plast Reconstr Surg 1984; **73**: 678–83.

25. **Camilleri IG, Malata CM, Stavrianos S, *et al.*** A review of 120 Becker permanent tissue expanders in reconstruction of the breast. Br J Plast Surg 1996; **49**: 346–51.

26. **Recht A, Edge SB, Solin LJ, *et al.*** Postmastectomy radiotherapy: clinical practice guidelines of the American Society of Clinical Oncology. J Clin Oncol 2001; **19**: 1539–69.

27. **Lin KY, Blechman AB, Brenin DR.** Implant-based, two-stage breast reconstruction in the setting of radiation injury: an outcome study. Plast Reconstr Surg 2012; **129**: 817–23.

28. **Ascherman JA, Hanasono MM, Newman MI, *et al.*** Implant reconstruction in breast cancer patients treated with radiation therapy. Plast Reconstr Surg 2006; **117**: 359–65.

29. **Spear SL, Onyewu C.** Staged breast reconstruction with saline-filled implants in the irradiated breast: recent trends and therapeutic implications. Plast Reconstr Surg 2000; **105**: 930–42.

30. **Losken A, Carlson G, Bostwick J, *et al.*** Trends in unilateral breast reconstruction and management of the contralateral breast: the Emory experience. Plast Reconstr Surg 2002; **110**: 89–97.

31. **Kronowitz SJ, Robb GL.** Radiation therapy and breast reconstruction: a critical review of the literature. Plast Reconstr Surg 2009; **124**: 395–408.

32. **Sigurdson L, Lalonde DH.** MOC-PSSM CME article: breast reconstruction. Plast Reconstr Surg 2008; **121**: 1–12.

33. **Vega SJ, Bossert RP, Serletti JM.** Improving outcomes in bilateral breast reconstruction using autogenous tissue. Ann Plast Surg 2006; **56**: 487–91.

34. **Tachi M, Yamada A.** Choice of flaps for breast reconstruction. Int J Clin Oncol 2005; **10**: 289–97.

35. **Ueberreiter K, von Finckenstein JG, Cromme F, *et al.*** BEAULITM — a new and easy method for large-volume fat grafts. Handchir Mikrochir Plast Chir 2010; **42**: 379–85.

36. **Murphy C, El-Fadl D, McManus P.** Experience of autologous fat transfer in a single breast unit — first 100 cases. Eur J Surg Oncol 2011; **37**: 14.

37. **Illouz YG, Sterodimas A.** Autologous fat transplantation to the breast: a personal technique with 25 years of experience. Aesth Plast Surg 2009; **33**: 706–15.

38. **Delay E, Garson S, Tousson G, *et al.*** Fat injection to the breast: technique, results, and indications based on 880 procedures over 10 years. Aesthet Surg J 2009; **29**: 360–76.

39. **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; **124**: 272–80.

40. **Hartrampf CR, Scheflan M, Black PW.** Breast reconstruction with a transverse abdominal island flap. Plast Reconstr Surg 1982; **69**: 216–25.

41. **Serletti JM, Fosnot J, Nelson JA, *et al.*** Breast reconstruction after breast cancer. Plast Reconstr Surg 2011; **127**: 124e–35.

42. **Mathes SJ, Nahai F.** Classification of the vascular anatomy of muscles: Experimental and clinical correlation. Plast Reconstr Surg 1981; **67**: 177–87.

43. **Roostaeian J, Crisera C.** Current options in breast reconstruction with or without radiotherapy. Breast Cancer 2011; **23**: 44–50.

44. **Tuominen HP, Asko-Seljavaara S, Svartling NE.** Cutaneous blood flow in the free TRAM flap. Br J Plast Surg 1993; **46**: 665–9.

45. **Tuominen HP, Asko-Seljavaara S, Svartline NE.** Cutaneous blood flow in the TRAM flap. Br J Plast Surg 1992; **45**: 261–9.

46. **Vyas RM, Dickinson BP, Fastekjian JH, *et al.*** Risk factors for abdominal donor-site morbidity in free flap breast reconstruction. Plast Reconstr Surg 2008; **121**: 1519–26.

47. **Schusterman MA, Kroll SS, Weldon ME.** Immediate breast reconstruction: why the free TRAM over the conventional TRAM flap. Plast Reconstr Surg 1992; **90**: 255–61.

48. **Nahabedian MY, Tsangaris T, Momen B.** Breast reconstruction with the DIEP flap or the muscle-sparing (MS-2) free TRAM flap: is there a difference? Plast Reconstr Surg 2005; **115**: 436–44.

49. **Bajaj AK, Chevray PM, Chang DW.** Comparison of donor site complications and functional outcomes in free muscle-sparing TRAM flap and free DIEP flap breast reconstruction. Plast Reconstr Surg 2006; **117**: 737–46.

50. **Blondeel PN.** One hundred free DIEP flap breast reconstructions: a personal experience. Br J Plast Surg 1999; **52**: 104–11.

51. **Hamdi M, Weiler-Mithoff EM, Webster MH.** Deep inferior epigastric perforator flap in breast reconstruction: experience with the first 50 flaps. Plast Reconstr Surg 1999; **103**: 86–95.

52. **Keller A.** The deep inferior epigastric perforator free flap for breast reconstruction. Ann Plast Surg 2001; **46**: 474–9.

53. **Vandeweyer E, Hertens D, Nogaret JM, *et al.*** Immediate breast reconstruction with saline-filled implants: no in-

terference with the oncologic outcome? Plast Reconstr Surg 2001; **107**: 1409–12.

54. **Spear SL, Parikh PM, Reisin E, et al.** Acellular dermis-assisted breast reconstruction. Aesthet Plast Surg 2008; **32**: 418–45.

55. **Stern HS, Nahai F.** The versatile superficial inferior epigastric artery free flap. Br J Plast Surg 1992; **45**: 270–4.

56. **Uraloglu M, Kerem M, Arpac E.** Arterial and venous anatomy of deep inferior epigastric perforator and superficial inferior epigastric artery flaps. Plast Reconstr Surg 2009; **123**: 1883.

57. **Munhoz AM, Aldrighi C, Montag E, et al.** Periareolar skin-sparing mastectomy and latissimusdorsi flap with biodimensional expander implant reconstruction: surgical planning, outcome, and complications. Plast Reconstr Surg 2007; **119**: 1637–49.

58. **Hultman CS, McCraw J.** Breast reconstruction with the autogenous latissimus flap: current indications, technique, and outcomes. Breast Dis 2002; **16**: 65–72.

59. **Delay E, Gounot N, Bouillot A, et al.** Autologous latissimus breast reconstruction: a 3-year clinical experience with 100 patients. Plast Reconstr Surg 1998; **102**: 1461–78.

60. **Spear SL, Boehmler JH, Bogue DP, et al.** Options in reconstructing the irradiated breast. Plast Reconstr Surg 2008; **122**: 379–88.

61. **Disa JJ, McCarthy CM, Mehrara BJ, et al.** Immediate latissimus dorsi/prosthetic breast reconstruction following salvage mastectomy after failed lumpectomy/irradiation. Plast Reconstr Surg 2008; **121**: 159e–64.

62. **Codner MA, Nahai F.** The gluteal free flap breast reconstruction: making it work. Clin Plast Surg 1994; **21**: 289–96.

63. **Shaw WW.** Superior gluteal free flap breast reconstruction. Clin Plast Surg 1998; **25**: 267–74.

64. **Allen RJ, Tucker CJr.** Superior gluteal artery perforator free flap for breast reconstruction. Plast Reconstr Surg 1995; **95**: 1207–12.

65. **Boustred AM, Nahai F.** Inferior gluteal free flap breast reconstruction. Clin Plast Surg 1998; **25**: 275–82.

66. **Arnez ZM, Pogorelec D, Planinsek F, et al.** Breast reconstruction by the free transverse gracilis (TUG) flap. Br J Plast Surg 2004; **57**: 20–6.

67. **Wechselberger G, Schoeller T.** The transverse myocutaneousgracilis free flap: a valuable tissue source in autologous breast reconstruction. Plast Reconstr Surg 2004; **114**: 69–73.

68. **Sullivan SR, Fletcher DR, Isom CD, et al.** True incidence of all complications following immediate and delayed breast reconstruction. Plast Reconstr Surg 2008; **122**: 19–28.

69. **Mehrara BJ, Santoro TD, Arcilla E, et al.** Complications after microvascular breast reconstruction: Experience with 1195 flaps. Plast Reconstr Surg 2006; **118**: 1100–9.

70. **Selber JC, Kurichi JE, Vega SJ, et al.** Risk factors and complications in free TRAM flap breast reconstruction. Ann Plast Surg 2006; **56**: 492–7.

71. **Man LX, Selber JC, Serletti JM.** Abdominal wall following free TRAM or DIEP flap reconstruction: A meta-analysis and critical review. Plast Reconstr Surg 2009; **124**: 752–64.

72. **Andrades P, Fix RJ, Danilla S, et al.** Ischemic complications in pedicle, free, and muscle sparing transverse rectus abdominis myocutaneous flaps for breast reconstruction. Ann Plast Surg 2008; **60**: 562–7.

73. **Kanchwala SK, Bucky LP.** Optimizing pedicled transverse rectus abdominis muscle flap breast reconstruction. Cancer J 2008; **14**: 236–40.

74. **Codner MA, Bostwick J III, Nahai F, et al.** TRAM flap vascular delay for high-risk breast reconstruction. Plast Reconstr Surg 1995; **96**: 1615–22.

75. **Atisha D, Alderman AK.** A systematic review of abdominal wall function following abdominal flaps for postmastectomy breast reconstruction. Ann Plast Surg 2009; **63**: 222–30.

76. **Wu LC, Bajaj A, Chang DW, et al.** Comparison of donor-site morbidity of SIEA, DIEP, and muscle-sparing TRAM flaps for breast reconstruction. Plast Reconstr Surg 2008; **122**: 702–9.

77. **Coleman SR.** Long-term survival of fat transplants: controlled demonstrations. Aesth Plast Surg 1995; **19**: 421–5.

78. **Coleman SR.** Structural fat grafting. Quality Medical Publishing: St Louis, 2004.

79. **Hinderer UT, del Rio J.** Erich Lexer's mammoplasty. Aesth Plast Surg 1992; **16**: 101–7.

80. **Coleman SR, Saboeiro AP.** Fat grafting to the breast revisited: safety and efficacy. Plast Reconstr Surg 2007; **119**: 775–85.

81. **Pear SL, Wilson HB, Lockwood MD.** Fat injection to correct contour deformities in the reconstructed breast. Plast Reconstr Surg 2005; **116**: 1300–5.

82. **Panettiere P, Marchetti L, Accorsi D.** The serial free fat transfer in irradiated prosthetic breast reconstructions. Aesth Plast Surg 2009; **33**: 695–700.

83. **Panettiere P, Accorsi D, Marchetti L, et al.** Large-breast reconstruction using fat graft only after prosthetic reconstruction failure. Aesth Plast Surg 2011; **35**: 703–8.

84. **Lohsiriwat V, Curigliano G, Rietjens M, et al.** Autologous fat transplantation in patients with breast cancer: "silencing" or "fueling" cancer recurrence? Breast 2011; **20**: 351–7.

85. **Slavin SA, Love SM, Goldwyn RM.** Recurrent breast cancer following immediate reconstruction with myocutaneous flaps. Plast Reconstr Surg 1994; **93**: 1191–204.

86. **Kroll SS, Schusterman MA, Tadjalli HE, et al.** Risk of recurrence after treatment of early breast cancer with skin-sparing mastectomy. Ann Surg Oncol 1997; **4**: 193–7.

87. **Veronesi U, Cascinelli N, Mariani L, et al.** Twenty-year follow-up of a randomized study comparing breast-conserving surgery with radical mastectomy for early breast cancer. N Engl J Med 2002; **347**: 1227–32.

88. **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.

89. **Petit JY, Gentilini O, Rotmensz N, et al.** Oncological results of immediate breast reconstruction: long term follow-up of a large series at a single institution. Breast Cancer Res Treat 2008; **112**: 545–9.

90. **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**: 2087–106.

91. **Benson JR, Jatoi I, Keisch M, et al.** Early breast cancer. Lancet 2009; **373**: 1463–79.

92. **Vandeweyer E, Deraemaecker R.** Radiation therapy after immediate breast reconstruction with implants. Plast Reconstr Surg 2000; **106**: 56–8.

93. **Forman DL, Chiu J, Restifo RJ, et al.** Breast reconstruction in previously irradiated patients using tissue expanders and implants: a potentially unfavorable result. Ann Plast Surg 1998; **40**: 360–3.

94. **Albino FP, Koltz PF, Ling MN, et al.** Irradiated autologous breast reconstructions: effects of patient factors and treatment variables. Plast Reconstr Surg 2010; **126**: 12–6.