



Reconstruction of the nipple-areola complex: an update

**Jian Farhadi*, Giedra K. Maksvytyte, Dirk J. Schaefer, Gerhard Pierer,
Oliver Scheufler**

*Department of Plastic, Reconstructive and Aesthetic Surgery, University Hospital Basel, Spitalstrasse 21,
CH-4031 Basel, Switzerland*

Received 12 January 2005; accepted 25 August 2005

KEYWORDS

Nipple;
Areola;
Breast reconstruction;
Tattoo;
NAC;
Local flap

Summary Along with continuing progress in reconstructive surgery of the breast numerous techniques of nipple-areola reconstruction have been developed. With time and experience some methods have been discredited to historical significance only while others have evolved to widely accepted concepts used by surgeons all over the world, which in turn contributed new ideas and modifications. In addition to those favourite techniques others are reserved as second-line alternatives in specific situations. The principle criterion for a pleasing nipple-areola complex is symmetry regarding several parameters: colour, texture, size, and projection. The purpose of this manuscript is to review and discuss the concepts and techniques of nipple-areola reconstruction that have evolved over the past decades. Furthermore, those principles and techniques are pointed out that fulfil best the criteria of an ideal nipple-areola complex with emphasis on different techniques of breast reconstruction and individual conditions of the patient.

© 2005 The British Association of Plastic Surgeons. Published by Elsevier Ltd. All rights reserved.

Reconstruction of the nipple-areola complex (NAC) is indicated to complete breast reconstruction and to restore the patient's body image. Following mastectomy for breast cancer, NAC reconstruction is mostly the final aspect of breast reconstruction because prior creation of a symmetric breast mound is mandatory. Other conditions requiring NAC reconstruction include congenital or

developmental pathology (athelia, amastia), post-traumatic or burn deformities, and complications from breast surgery such as reduction mammoplasty. The development of NAC reconstruction parallels the history of breast reconstruction. Continuous progress in the treatment of breast cancer, technical advances in reconstructive techniques and increasing public awareness of the possibilities of breast reconstruction have stimulated the development of new concepts in NAC reconstruction, and numerous techniques were created over the years. While some methods have

* Corresponding author. Tel.: +41 61 265 2525; fax: +41 61 265 7301.

E-mail address: jfarhadi@uhbs.ch (J. Farhadi).

been discredited to historical significance only, some other techniques have evolved to widely accepted concepts. It is the purpose of this publication to review and discuss various concepts and techniques described in the literature, and to point out those, that in our opinion fulfil the objectives of NAC reconstruction most closely.

General principles of NAC reconstruction planning

Ideal reconstruction of the NAC requires symmetry in position, size, shape, texture, and pigmentation and permanent projection. Generally, NAC reconstruction can be safely performed on an outpatient basis under local anaesthesia. In order to achieve successful NAC reconstruction, general guidelines must be adhered to independent of the chosen technique:

- (1) NAC reconstruction is postponed till the final and stable setting of the reconstructed breast mound, optimally 3-4 months following breast reconstruction,¹⁻⁴ although some authors have proposed primary NAC reconstruction at the time of breast reconstruction.

- (2) In unilateral reconstruction, the contralateral NAC serves as a template. However, the position has to be adapted to residual breast asymmetries.
- (3) In bilateral reconstruction, the NAC location is planned according to relative anatomical landmarks and aesthetic preferences of the patient.
- (4) Loss of projection of the reconstructed nipple should always be anticipated due to contraction, and overcorrection of 25-50% of the desired result is advisory in NAC reconstruction with local flaps.

Areola reconstruction

Reconstruction of the areola has been achieved by grafting, replantation, dermabrasion and tattoo.

Grafting

Sharing techniques

In spite of the advantages of like tissues in nipple/NAC-sharing techniques, they are associated with significant donor site morbidity. Although Gruber² asserted, that nipple sharing procedures

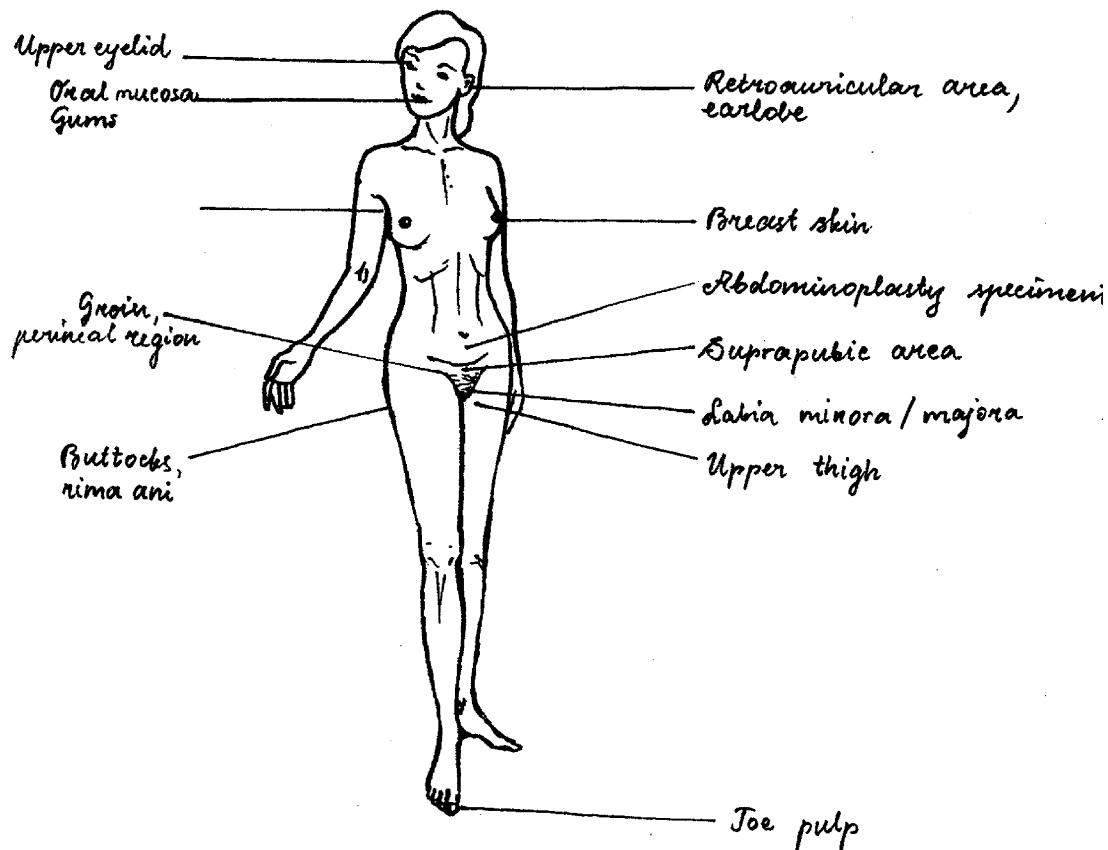


Figure 1 Donor sites for NAC grafting.

do not significantly affect sensation of the donor nipple, the potential harm to a significant erogenous structure cannot be denied.⁵ Also, due to scarring and partial loss of the lactiferous ducts, breast feeding may be impaired in the future. Further, patients frequently decline to have surgery on the normal breast and NAC. Therefore, many surgeons became reluctant to sacrifice a healthy NAC for the sake of reconstructing the diseased one, and rather employ new alternative methods. Nowadays nipple/NAC-sharing is only used in selected cases, i.e. a hypertrophic contralateral nipple or thin skin coverage in an alloplastic breast reconstruction, where local flaps may not be safe.

Grafts from other sites

Over decades, a multitude of donor areas have been described for NAC reconstruction (Fig. 1).

A full-thickness graft from the labia minora, introduced by Adams⁶ in 1949 represents the first attempt of areola reconstruction. Split-thickness grafts from the labia majora were used later.^{7,8} Inherent disadvantages of both techniques were an unpopular and ambivalent donor site, and frequently inappropriate colour match of the labial skin compared to the counterpart areola.⁹ Even in patients with dark complexion, split-thickness skin grafts from other sites rendered superior results to labial grafts.⁷ The inguino-perineal skin has been proposed for darker-complexion.^{2,8,9} Although the scar was inconspicuous and easily hidden by clothes, these donor sites were sometimes inconvenient to the patient. Skin from the upper inner thigh became a popular donor site, as it is more pigmented than breast skin and less pigmented than labial skin, and is more acceptable to most patients.

For reconstruction of fairly pigmented areolae, transplants from the retroauricular area, upper eyelid and oral mucous membranes have been described. In 1977 Brent¹⁰ proposed the use of retroauricular skin as a full-thickness graft, as it provides a natural pinkish colour most suitable for patients of fair-complexion, such as true blondes and red-haired.

For bilateral reconstruction, Gruber¹¹ proposed a circular split- or full-thickness graft, which was removed from the breast and immediately returned to the donor site. By virtue of having grafted the skin, hyperpigmentation can be anticipated. The author used UV light exposition in order to enhance pigmentation.

In males, undergoing NAC reconstruction scrotal skin has been an excellent choice.⁴

Despite various attempts to predict and control pigmentation of skin grafts used for areola reconstruction, clinical experience proofs that this can hardly be achieved. Hyperpigmentation after

grafting has frequently been observed, often followed by fading with time,¹² requiring colour correction by tattoo. Donor site morbidity remains an issue with all skin grafts. Therefore, initial tattooing of the areola has made skin grafting dispensable in most cases.

In order to enhance permanent pigmentation, Gruber^{2,11} applied ultraviolet light to areolas reconstructed with split-thickness skin grafts. The patient was asked to use a standard UV light 5 min daily from the second to tenth week after surgery. UV light irradiation was employed as an adjunct by others to enhance pigmentation of areola skin grafts. However, it did not gain wider popularity because permanent pigmentation was not achieved.

NAC saving (banking)

'Nipple saving', also known as 'Nipple banking', was first introduced in 1971 by Millard et al.¹³ Originally, at the time of mastectomy the complete NAC was removed as a full thickness skin-graft and transferred to the groin, buttocks or abdomen. After breast reconstruction, the 'banked' NAC was harvested again and transferred to the areola site. Doubts about the safety of this method were raised after the report of several cases, where cancer cells had spread to the inguinal lymph nodes following NAC banking in the groin.¹⁴⁻¹⁶ Subsequently, several studies revealed a significant frequency of NAC involvement in both, invasive and noninvasive breast cancer.¹⁷⁻²² In 1980 Lemperle and Spitalny²³ proposed a modification of the technique. They removed and retained the NAC in a conventional refrigerator until examination of the specimen had been accomplished by the pathologist. Only when tumour infiltration was excluded, the NAC was banked in the groin until breast reconstruction was completed. However, such twice-transferred grafts frequently lost pigmentation and nipple projection and failed to meet aesthetic expectations.¹²

In spite of significant disadvantages, the principle of 'reconstruction-in-kind' was not totally abandoned. In 2003 Nakagawa et al.²⁴ reported cryopreservation of the NAC, which was grafted 3 months after breast reconstruction. However, results were inconsistent, and the mechanisms of cell injury during cryopreservation require further investigation.

Dermabrasion

In 1981 Cohen²⁵ published a case report of areola reconstruction by dermabrasion in a black patient, based on the clinical phenomenon that partial-thickness skin removal in black patients usually

results in hyperpigmentation of the healed skin. He dermabraded the outlined area of areola to a level of the mid-dermis and three months later inserted a piece of soft silicone to create a nipple projection. A regular deep pigmentation of the new areola was observed after 6 months, but no long-term results were reported.

Tattoo

Although decorative tattooing is known for thousands of years, it has been introduced to medical use only recently. In 1974 Bunchman et al.²⁶ described intradermal tattooing as an adjunct to NAC reconstruction in the burn patient. However, when used in the absence of a projecting nipple, results were not satisfactory. Tattooing provides merely an optical illusion of a textured surface.²⁷ However, as an adjunct to other techniques of nipples reconstruction, the tattoo gained a wide popularity.

In the past, emulsions of a dense white base with added pigments were used. The base powder, initially barium sulphate, was later replaced by titanium dioxide. Various shades of skin-tone pigments became available, offering a more natural colour match. Initially used pigments from soluble inorganic salts of metals were replaced with stable synthetic organic compounds improving pigment fixation in tissues.²⁸ Masser et al.²⁷ introduced the pigment-gel-suspension technique in 1989, achieving more natural results by avoiding a painted appearance. The fine pigment particles are dispersed over the surfaces of dextranomer gels, resulting in a hydrophilic gel-suspension. Such pigments, when introduced into the dermis, resemble the distribution of natural skin pigments, such as melanin in melanocytes and haemoglobin in skin capillaries.

Tattoo can be used either as a supplementary, 'final-touch' technique to achieve the best colour match, and correct discrepancies in shape, size or location of the reconstructed NAC, or as an independent technique for areola reconstruction. The skin can be tattooed before or after nipple reconstruction, depending on the surgeon's preference. When applied after nipple reconstruction, a time interval of at least 6-12 weeks should be allowed for the nipple to stabilise and contract.²⁸ Some authors proposed tattooing prior to elevation of the nipple in order to obtain a more natural and uniform colour distribution.²⁹⁻³² Nipple reconstruction (usually by a local flap) has been reported immediately after tattooing or after a time interval. However, immediate flap dissection may overstress the tolerance of flap vascularity due to the additional trauma. Advantageous of the tattoo is

the simplicity of the procedure, requiring neither hospitalisation nor general anaesthesia, which makes it relatively inexpensive. Also, there is no donor site morbidity. Tattooing can be performed in the office under local anaesthesia. The risk of complications such as allergic and photosensitive reactions or local infections are low.^{30,33} Vadodaria³⁴ hardly found any amount of fibrosis or foreign body reaction in histological specimens of tattooed skin. However, the extent of this effect depends on the chemical origin of the pigments. Literature reports high skin sensitivity reactions to mercury, cadmium, aluminium, and cobalt pigments, but very low incidence of skin reactions to titanium dioxide pigments.²⁸ Most important, intradermal tattoos tend to fade with time^{28,31} frequently requiring secondary touch-ups. Fading is a normal biological process. Histological studies^{34,35} have revealed pigment deposition in the epidermis and at various levels of the dermis in tattoos.³⁶ Normally, the epidermis peels away after a few days and only dermal pigments remain. Those in the deep dermis are absorbed by lymphatic.³⁴ These processes are responsible for early fading of the tattoo. By days 7-10 the site of the tattoo has healed and remaining pigments reside in the dermis, accumulating in the perivascular spaces in macrophages and in the extracellular matrix within collagen bundles. At this stage, the tattoo is still dark and distinct. Over the months, pigment particles undergo phagocytosis by macrophages, resulting in slow fading of colours and hazy margins. After several months and more, pigment particles eventually reside in the upper dermis and only within the cell membranes of fibroblasts. At this time, no pigment is found in macrophages, melanocytes, or the intercellular space. These findings demonstrate that the final colour of a tattoo stabilises after several months and is determined by the remnants of pigment embedded in fibroblasts.^{28,34}

The technique of tattooing requires training and experience in order to get optimal results. The depth of pigment introduction into the skin is of paramount importance, because pigments placed too superficially will be lost with desquamation of the epidermis and those introduced too deeply will be taken up by lymphatic, both leading to fading of the tattoo. Within few minutes after initiation of the procedure the skin becomes erythematous due to ecchymosis. Application of antibiotic ointments to the tattooed skin is usually advised for a few days. Spear²⁸ even proposed systemic perioperative antibiotics for about 48 h to prevent infection. Superficial skin infections respond well to local and systemic antibiotic therapy. The patient must be instructed not to peel off the scabs as this would

remove pigment.²⁹ Apart from minor swelling little discomfort is expected after the first day. After a week swelling and ecchymosis usually subsides allowing a first evaluation of the colour match. Secondary touch-ups may be necessary in case of fading after several months. In rare cases initial over correction of the tattoo may persist.

Nipple reconstruction

Grafting

All tissues which have been used for nipple reconstruction lack the structural elements of a normal nipple, namely smooth muscle and lactiferous ducts, which are primarily responsible for the natural firmness and projection of the nipple.

Most frequently, separate grafts were used for reconstruction of the areola and nipple prominence. Initially, full-thickness grafts from the labia minora were employed for nipple reconstruction,⁶ but were abandoned due to hyperpigmentation of the graft and donor site morbidity. Oral mucous membranes and gums as well as rima ani at the coccygeal level²³ never gained wider popularity. In 1977 Brent¹⁰ proposed to use the earlobe as a composite graft for nipple reconstruction. It provided better projection compared to grafts from other sites but lacked pigmentation and was restricted to fair-skinned patients or required tattooing. The same applies to pulp composite grafts from the second or third toe. Further, both procedures are associated with significant donor site morbidity.

Local flaps

Local flaps for nipple reconstruction can be divided into two groups: (1) centrally based flaps and (2) subdermal pedicle flaps (Fig. 2).

Of primary concern in nipple reconstruction is the

creation of a long-lasting projection. This is influenced essentially by two factors:

1. retraction forces of surrounding and underlying tissues,
2. tissue contraction (=shrinking) of the flap.

The structural contractile elements of the surrounding and underlying tissues exert centrifugal forces on the local flap, tending to retract it to its original position. The power of retraction forces significantly differ between centrally based and subdermal pedicle flaps. Centrally based flaps are subjected to the greatest retraction forces, which act on the entire base of the flap. In subdermal pedicle flaps these forces are significantly reduced, because the major part of the flap is freed from the underlying tissue and thus protected from retraction. Contraction, however, occurs to a variable degree in all local flaps, resulting in loss of flap volume and projection. Contracture of superficial scars adds to this effect. Flaps with complicated design are subjected to more scarring and contracture. In addition, blood supply is an important determinant of flap shrinkage. Subdermal pedicle flaps are nourished through the rich subdermal plexus and thus have better blood supply compared to central core flaps, which depend on blood supply via the subcutaneous tissue. Scarring or irradiation can significantly compromise blood supply and, therefore, the final result of all flaps. Essential prerequisites to achieve a stable flap size are a wide pedicle, simple flap design, and separation from retractile surrounding tissues.

Local flap techniques have evolved significantly over the past years. Evolution was directed towards improving blood supply, minimizing retraction forces by simplification of flap design and by rejection of centrally based flap techniques. Enhanced vascularisation was achieved by widening of the subdermal pedicle base and development of double-pediced flaps.

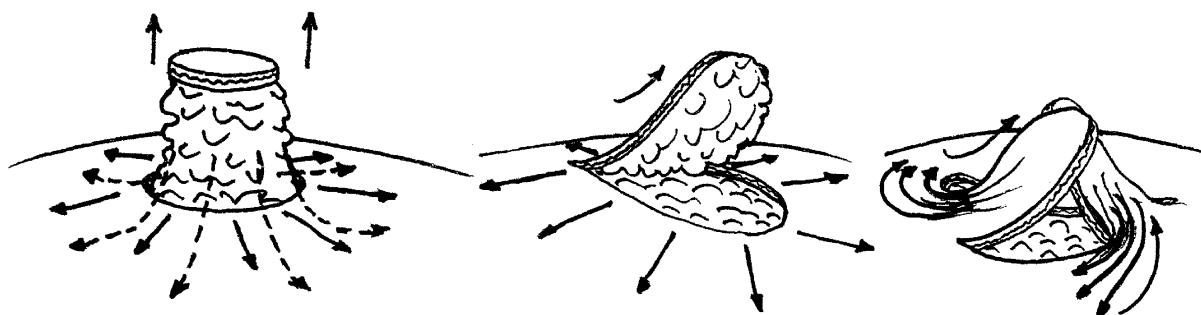


Figure 2 Centrally based local flaps, Subdermal pedicle local flaps: single pedicle, double pedicle.

Centrally based flaps

Centrally based flaps are elevated from the geometrical centre of the future areola.

Split thickness skin flaps. The first local flap technique for nipple reconstruction was published by Berson³⁷ in 1946, using three triangular split-thickness skin flaps of the future areola. The margins of these flaps were sutured together, forming a nipple-like umbilicated projection (Fig. 3). The donor site reepithelialised spontaneously to form the areola. This technique pioneered further modifications of the peripheral split-thickness skin flaps. In 1972 Snyder et al.³⁸ reported a similar technique of V-Y advancement flaps (Fig. 4). Barton³⁹ introduced a modified peripheral flap design in 1982, using a blunted Maltese-cross pattern, which was closed spherically and, therefore, preserved maximum dermal bulk (Fig. 5). To further increase flap volume, Asplund⁴⁰ proposed his 'Mushroom flap' technique in 1983, employing the whole peripheral part of the flap, without excision of skin wedges. None of these techniques stood the test of time.

Dermal flaps. Recently, Tanabe et al.⁴¹ proposed a technique based on the principle of denuded inverted flaps. They combined bilobed or trilobed dermal-fat flaps with rolled auricular cartilage positioned in the centre of the dermal base and wrapped by the elevated dermal-fat flaps. A skin graft was applied to the raw surfaces (Fig. 6).

Central core techniques. Previous attempts to increase bulk and projection of the nipple were based on the inclusion of subcutaneous tissue within the central core of the flap. This concept was first

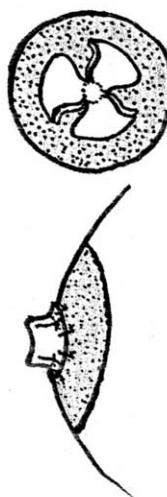


Figure 3 Centrally based 'three flap', Berson 1946.

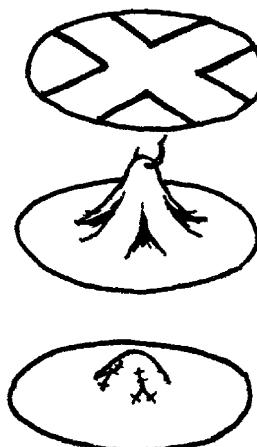


Figure 4 V-Y advancement flaps, Snyder 1972.

incorporated into the 'double bubble' technique by Bunchman²⁶ in 1974. A central core of skin and fat was elevated after a deep circular incision into the subcutaneous tissue. Dubin⁴² employed a suspension device to keep the central core flap in position until spontaneous epithelisation of the exposed subcutaneous margins had occurred (Fig. 7). However, contracture during secondary healing resulted in significant loss of nipple projection. Olivari⁴³ covered the central fat core with a circular strip of split thickness skin graft. Serafin and Georgiade⁴⁴ and later Vecchione⁴⁵ used full-thickness skin grafts to cover the central core circumferentially. However, all central core flaps suffered extensive loss of projection with time. 1987 Mukherjee⁴⁶ proposed the 'buried dermal hammock' technique, combining the principles of double dermal flaps by⁴⁷ with the central core technique (Fig. 8). Two denuded dermal flaps were passed through a tunnel of the subcutaneous core and secured with each other. The areola and subcutaneous core were covered with full

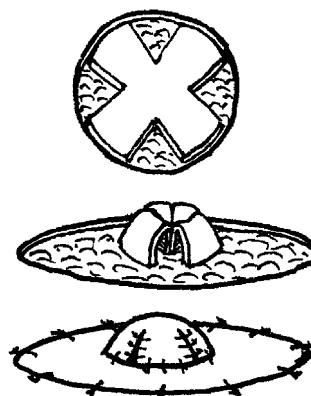


Figure 5 Centrally based 'four flap', Barton 1982.

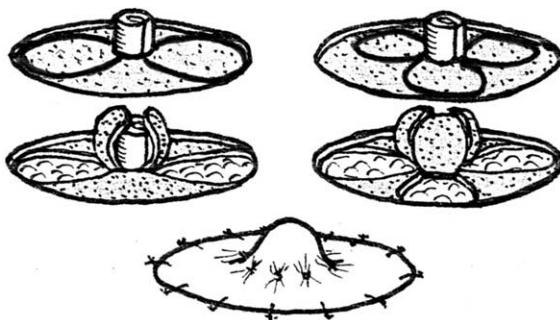


Figure 6 Inverted dermal flap with central cartilage graft, Tanabe 1997.

thickness skin grafts. However, blood supply of the flap and permanence of projection are questionable.

Extended central core techniques. Serafin and Georgiade⁴⁴ described yet another variation of the central core technique. An extension of split-thickness skin from the area of the future areola was left attached to the central core flap and then wrapped around its fat core (Fig. 9). This variation was the first of a series of modifications, which combined the concepts of a central core with a peripheral skin flap extension. In 1983 Little et al.⁴⁸ introduced the 'quadripod flap', which was used by many surgeons for some time. Four opposing split-thickness skin flaps are dissected on the central fat core in the shape of a cross formée* [*The cross formée is a modification of a Greek cross. Its limbs are narrow at the centre and gradually expand towards the periphery. This pattern was often misnamed the Maltese cross, a further modification of the cross formée with indented limbs (Little, 1984)]. Then the central fat core was dissected in the usual fashion and covered by the four flaps. The areola was simulated by grafting of the dermal bed. Although this technique gave impressive early results, long-term results were less satisfactory. In an effort to overcome loss of projection, Little invaginated the dermal triangles between the limbs of the cross formée in the 'modified quadripod flap' (Fig. 10). Silversmith⁴⁹ suggested a simplification of the 'quadripod flap' technique by converting the

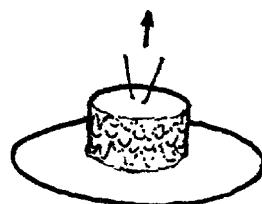


Figure 7 Central core technique, Dubin 1980.

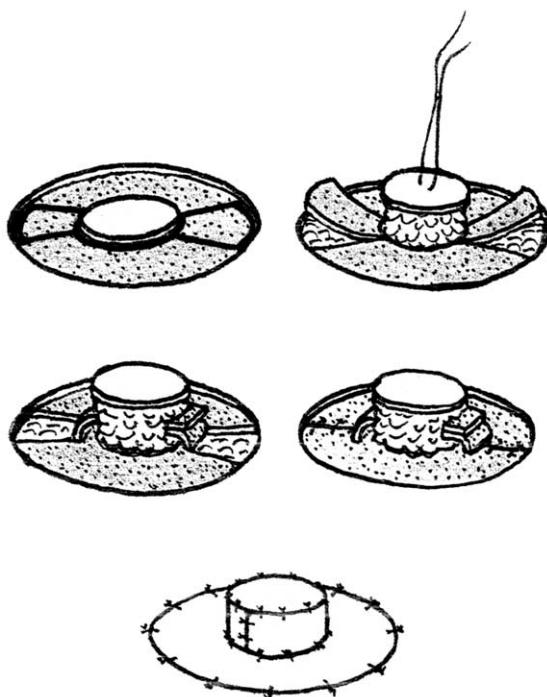


Figure 8 'Buried dermal hammock' flap, Mukherjee 1987.

complicated cross formée to a semicircular flap design (Fig. 11).

Cohen et al.⁵⁰ incorporated two concepts in the 'pinwheel flap', published in 1986: (1) a straight-line scar contracts more than a broken-line scar; (2) a new nipple will not retract if there is an underlying epithelial barrier. The flap was designed as a pinwheel, containing four arms of a Z-like shape. A full-thickness skin graft for the areola was placed over the flap and the flap was pulled out through a small stab incision within the graft. The four arms were then sutured together creating a hernia like prominence supported the skin graft (Fig. 12).

Further modifications of the central core technique include variations in flap design, as the 'H-flap' (Fig. 13) by Hallock,⁵¹ the 'double-opposing pennant

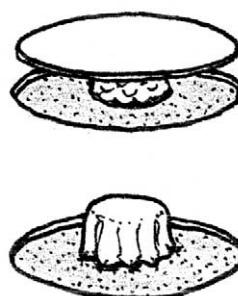


Figure 9 Extended central core technique, Serafin and Georgiade.

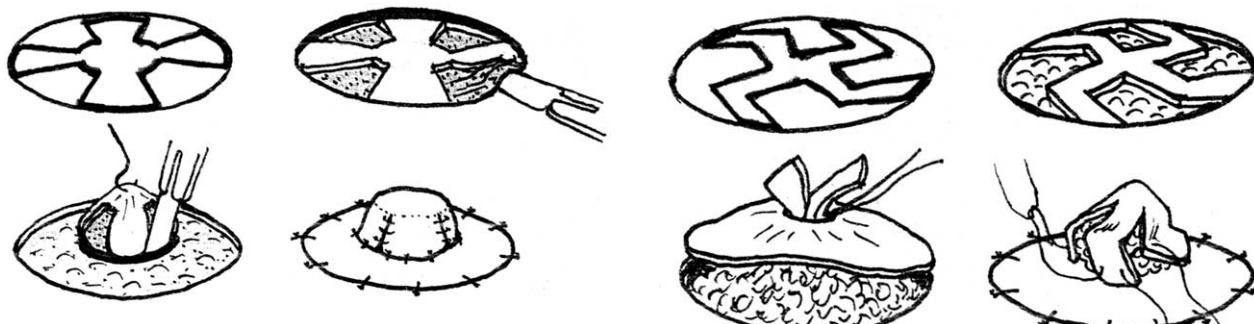


Figure 10 Modified 'quadripod flap', Little 1983.

'flap' technique by Hugo,⁵² and the 'propeller flap' by Teimourian and Duda.⁵³

Despite these attempts to increase flap bulk, simplify flap design, counteract retraction, and prevent contracture, long term results of all central core techniques remained disappointing.

Subdermal-pedicle flaps

Subdermal-pedicle flaps are based outside the geometrical centre of the areola. They are raised as full-thickness skin flaps, which receive their main blood supply from the subdermal plexus. During flap dissection the whole flap is completely elevated from its subcutaneous bed up to its base, thereby incorporating a maximum of subcutaneous tissue and minimising centrifugal retraction forces in order to increase bulk and projection of the nipple. All subdermal-pedicle flap techniques share the problem of donor-site closure. This can be achieved by a limited flap size allowing primary closure or by grafting of the donor site. Subdermal-pedicle flaps can be classified as single-pedicle and double-pedicle flaps.

Single subdermal pedicle flaps. The first subdermal-pedicle flap was described by Bosch and Ramirez¹ in 1984. Within the deepithelialised future areola an inferiorly pedicled U-shaped skin flap was raised and projected forward with the subcutaneous fat side



Figure 12 'Pinwheel flap', Cohen 1986.

pointing upward and the epidermal surface pointing downward (Fig. 14). In order to minimise graft contracture, two separate full-thickness skin grafts from the inner thigh were used to cover the deepithelialised areola surface and the raw flap surface. Problems with colour match of the grafted upper flap side and the original skin of the lower flap side sometimes required corrective measures, as additional skin grafts or tattoo. In the same year Hartrampf and Culbertson³ reported a similar technique with an inferiorly based omega-shaped dermis-fat flap, employing three separate full-thickness skin grafts from the infragluteal fold or contralateral areola to cover both sides of the flap and the deepithelialised areola. In 1985 Georgiade et al.⁵⁴ reported another U-shaped nipple flap, but added a split-thickness skin extension in the size of the future areola to the vertical skin flap, which was wrapped around the elevated flap to cover the subcutaneous fat side (Fig. 15). Flap size was planned twice the length and width considered to

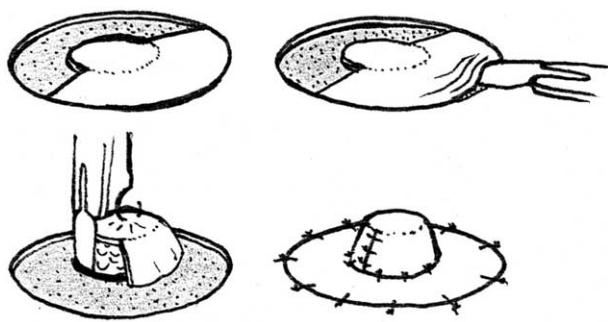


Figure 11 Simplified 'quadripod flap', Silversmith 1983.

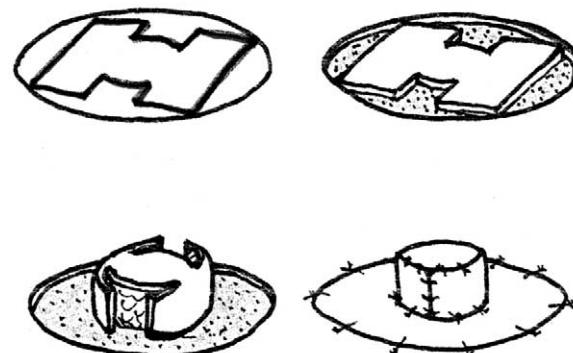


Figure 13 'H-flap', Hallock 1993.

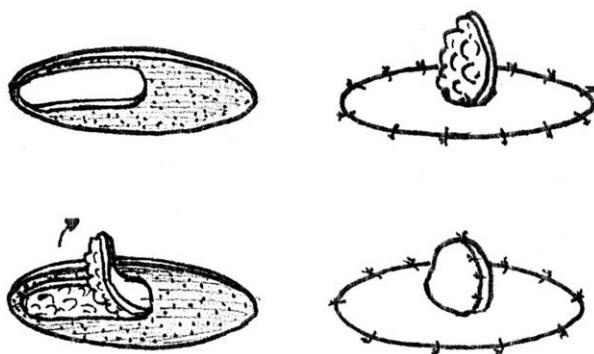


Figure 14 Single dermal pedicle flap, 'U-flap', Bosch and Ramirez 1984.

be satisfactory for the final projection of the nipple. Depending on the location of the mastectomy scar the flap could be based superiorly or inferiorly.

In 1984 Little⁴ invented the 'skate flap' design, which became the most popular technique for nipple reconstruction. It included a vertical cutaneous-fat flap with bilateral wing-like split-thickness skin extensions. The vertical cutaneous-fat flap is elevated with a significant amount of fatty tissue to provide adequate volume to the nipple and to improve blood supply. Both split-thickness wings are then wrapped around the fat core to create a prominent nipple with approximately 50% over correction, because of the expected loss of projection (Fig. 16). Dissection of the vertical cutaneous-fat flap left a deep V-shaped defect, which was difficult to close primarily without excessive tension and loss of flap projection or scar dehiscence and hypertrophy. Therefore, a small skin graft was often needed to close larger defects. A tattoo was employed after several weeks to create the areola. The 'skate flap' became a first choice procedure in reconstruction of large nipples.

The 'star flap', described by Anton and Hartrampf⁵⁵ in 1990, was a modification of the 'skate flap'. It included a vertical cutaneous-fat flap and

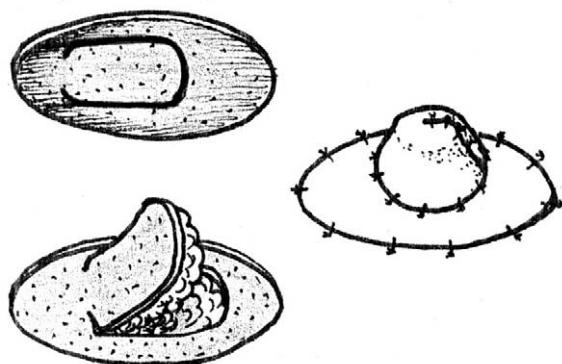


Figure 15 Deepithelialised 'U-flap', Georgiade 1985.

bilateral full-thickness skin arms oriented at 90° angles, which were wrapped around the central flap to cover its subcutaneous surface (Fig. 17). This design allowed direct closure of the donor defect without skin grafting but limited flap dimension. Although the size of the flap was pushed to its limits for primary closure, inadequate projection frequently resulted in cases of large nipples. However, the 'star flap' became a popular alternative to the 'skate flap' in small and moderate size nipples.

Several modifications of the 'star flap' were published by Wong³¹ and Eskenazi²⁹, in 1993, and Yamamoto⁵⁶ in 2001. These flaps can all be assigned to the category of star and wrap flaps.⁵⁵ Wong and Eskenazi incorporated more subcutaneous fat in the lateral arms of the flap for additional nipple bulk. Wong et al. tattooed the whole area of the future areola 2-3 weeks before nipple reconstruction. Eskenazi tattooed the 'star flap' only with subsequent dissection of the flap and followed by tattooing of the corrected area of the areola. The flap base was varied as dictated by the direction of local scars. Further modifications of the 'star flap' are the cylindrical flap of Thomas et al.⁵⁷ in 1996 (Fig. 18), the 'top-hat flap' of Hamori and LaRosa⁵⁸ in 1998, the 'C-V flap' of Bostwick in 1998,⁵⁹ and the 'arrow flap' of Guerra et al.⁶⁰ in 2003 (Fig. 19). All these flaps share a similar design, a vertical flap with a cap and two lateral wings or arms.

The 'fish-tailed flap' of McCraw presented in 1992, and the double U-shaped flap of Kargul and Deutinger⁶¹ published in 2001, represent a group of bilobed cutaneous fat flaps, composed of two arms only (Fig. 20).

Double subdermal pedicle flaps. Double-pedicled flaps are centred on the mastectomy scar, which may cross the base of the nipple flap in single pedicle flaps, thereby compromising its blood supply. Both flaps are directed parallel to the mastectomy scar and oriented in opposing directions, so that flap bases are not crossed by the scar. Using two flaps also adds total bulk to the nipple reconstruction and increases the chance of flap survival. However, opposition and fixation of the two flaps creates a certain amount of tension on the flaps, which subjects the whole structure to a greater amount of retraction forces from the surrounding tissues than with single pedicle flaps.

The first double-pedicled flap, the 'S-flap' was described independently by Cronin et al.⁶² in 1988. The 'S-flap' was composed of two U-shaped opposing dermal-fat flaps of equal size. The flaps were raised after deepithelialisation of the areola, approximated in opposition and loosely sutured together

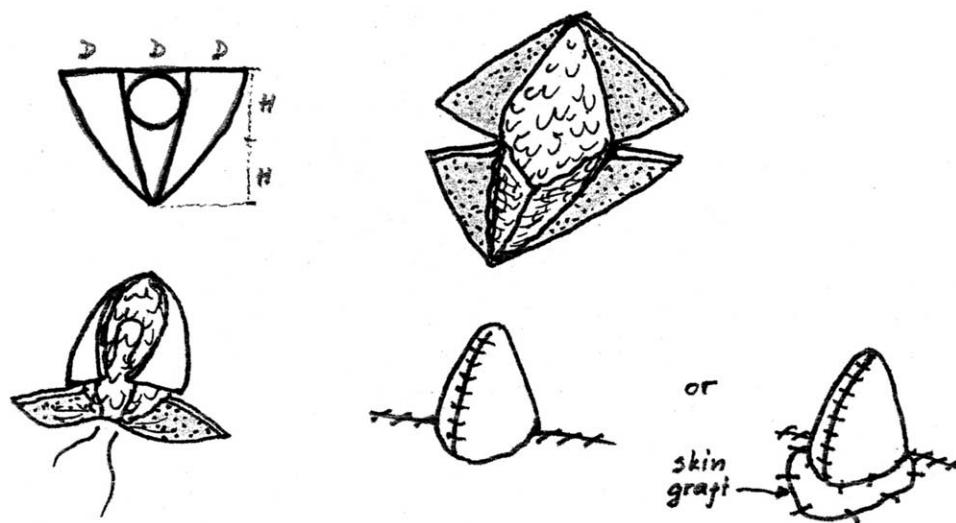


Figure 16 'Skate flap', Little 1987.

(Fig. 21). Nipple and areola were then covered with full-thickness skin grafts. Weiss et al.⁶³ published a modification of the 'S-flap' in 1989 without deepithelialisation of the flap, which was tattooed after surgery.

The 'double-opposing tab (DOT) flap', described by Kroll and Hamilton⁶⁴ in 1989 added two lateral split-thickness tab extensions to the s-flap design. Following opposition of the two cutaneous fat flaps, the tab extensions allowed interdigitation of the flaps when sutured together to reduce scar contraction. Donor sites were closed by direct approximation and the deepithelialised areola was grafted with full-thickness skin from the medial thigh. Further modifications of the 'DOT flap' abandoned skin grafts, eliminated the back-cuts on the tabs in order to improve blood supply, and widened the base of the flap. Attempts to increase the width of the flap base to 20 mm and more optimised blood supply, and reduced the risk of flap necrosis. However, this created an oval rather than round nipple in need of secondary shaping. Also, investing

more breast skin for the flap may distort the breast contour and even flatten the breast, especially in smaller breasts. Therefore, use of double pedicled flaps should be restricted to larger breasts or smaller nipples, and situations in which single pedicle flaps are not feasible.⁶⁵

The 'twin flap', described by Ramakrishnan et al.⁶⁶ in 1997 combined principles of the central-core and subdermal-pedicle flaps. It was proposed when the mastectomy scar traversed the region of nipple reconstruction. The 'twin flap' incorporated two separate components, a central-core of subcutaneous tissue with a skin cap, and a rectangular dermal wrap-around flap. The central-core flap opposed the base of the dermal wrap-around flap with the length equal to the height of the future nipple. After elevation of both flaps, the dermal flap was wrapped around the central core, creating a cylindrical nipple (Fig. 22). The areola was reconstructed with a full-thickness skin graft from the medial thigh. The authors emphasised the advantage of two flaps complementing each others function.

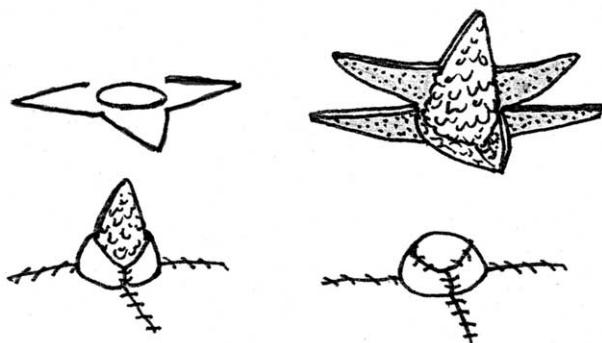


Figure 17 'Star flap', Anton and Hartrampf 1990.

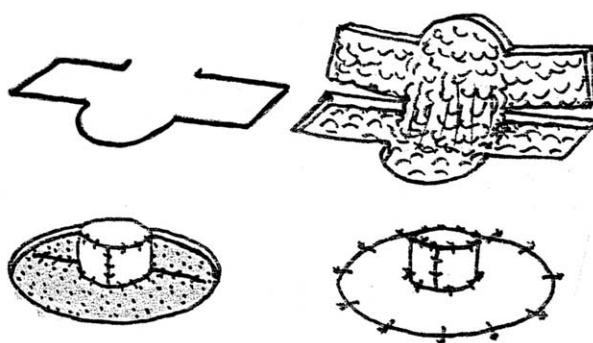


Figure 18 Cylindrical flap, Thomas 1996.

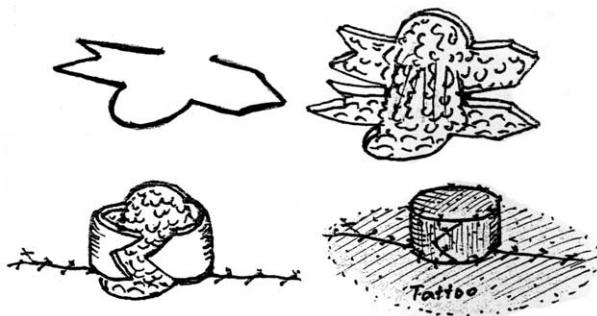


Figure 19 'Arrow flap', Guerra 2003.

The central-core flap provided bulk, and the wrap-around flap formed a dermal cuff that retained projection of the nipple flap.

Internal nipple prostheses

The most challenging aspect of nipple reconstruction is maintenance of a long-lasting nipple projection. Firm autologous substances, including cartilage, scar tissue and dermal grafts, have been employed to achieve this goal. Silicone nipple implants have been suggested as ancillary procedures to increase or maintain projection once the nipple had been reconstructed. Silicone rubber endoprosthesis for nipple reconstruction were proposed by Guida et al.⁶⁷ in 1975. In 1990 Hallock⁶⁸ developed a custom-made nipple endoprosthesis of 8 mm height and width, which was polyurethane-coated and filled with silicone-gel. They were used when the skin of the reconstructed breast was tense and did not provide sufficient soft tissue for nipple reconstruction by local flaps. Nipple implants were also recommended as a second-choice after a failed autologous nipple reconstruction. The implant was inserted either directly under the breast skin or underneath the previously reconstructed nipple. Polyurethane coating was believed to diminish

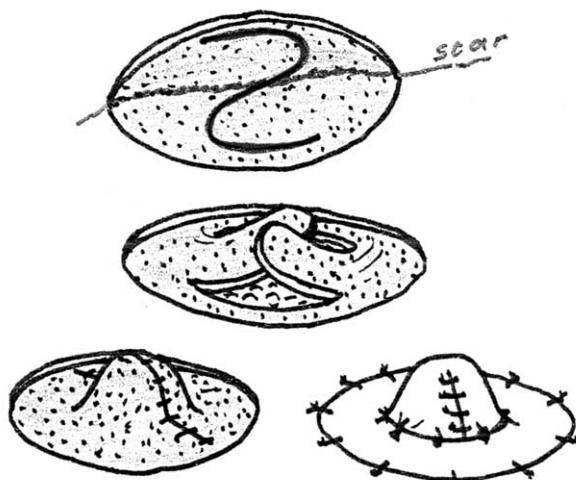


Figure 21 'S-flap', Cronin 1988.

capsular contracture around the implant. Several studies of polyurethane-covered breast implants showed, that polyurethane polymers interfere with the cross-linking of collagen fibers and thereby may prevent spherical capsular contracture. However, possible complications of polyurethane covered breast implants were well documented, including itching, allergic rash, foreign body reaction, increased risk of infection, implant perforation, systemic dissemination of polyurethane, unknown long-term effects, and difficulties in complete extirpation when necessary.⁶⁹⁻⁷⁵ Apart from these complications, cosmetic results were disappointing and prevented wider acceptance of this method.

Autogenous implants

In 1977 Brent and Bostwick¹⁰ proposed to use a laminated disc of auricular cartilage in order to provide support for the newly elevated nipple. The cartilage discs were obtained with a dermal punch,

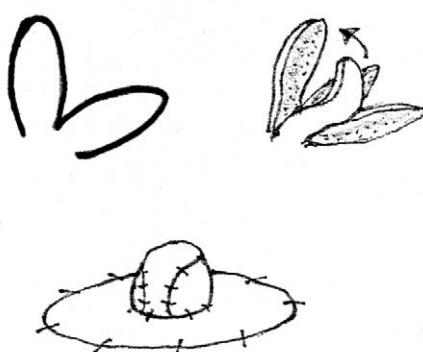


Figure 20 Double U-shaped flap, Kargul and Deutinger 2001.

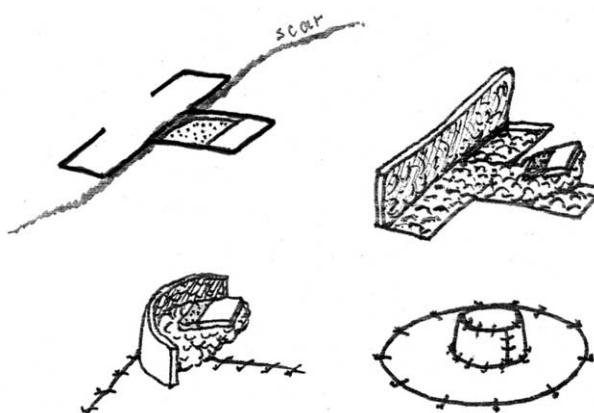


Figure 22 'Twin flap', Ramakrishnan 1997.

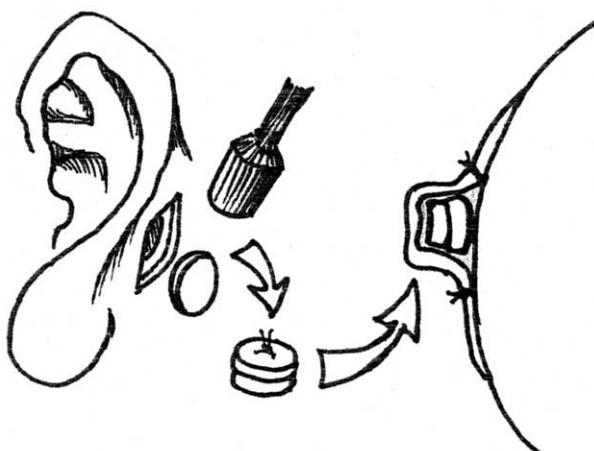


Figure 23 Auricular cartilage for nipple reconstruction, Brent and Bostwick 1977.

sutured together with 5-0 nylon to form a cartilage bolus, and inserted under the skin of the new areola (Fig. 23). The authors also employed this method for correcting inverted nipples. They proposed diced conchal cartilage to imitate Montgomery glands. Reconstruction of these glands was attempted by others, using rib cartilage,⁶⁰ perforated mesh grafts⁷⁶ or tattoo.⁷⁷ Early results of auricular cartilage grafts to augment nipple projection appeared to be promising. However, wider acceptance was precluded by the need of the additional surgery to harvest the conchal cartilage. In 2003 Guerra⁶⁰ proposed to preserve the cartilage segment of the third rib, that was removed during dissection of the internal mammary vessels for microvascular flap transfer in autologous breast reconstruction. The cartilage was preserved in a subcutaneous pocket at the 6 o'clock position of the new breast. At the time of nipple reconstruction the cartilage was harvested, carved to the desired shape and covered by local flaps of the new nipple. Smaller pieces of cartilage could be implanted in the epidermal-dermal junction of the future areola to imitate Montgomery glands. This rigid structure maintained good projection of the reconstructed nipple over time. However, exposure of cartilage may occur in the early postoperative period due to impaired vascularity and healing of the skin flaps or from too tight closure of the skin flaps over a large graft. Use of the cartilage grafts in breast reconstructions with thick and stiff skin flaps, i.e. the S-GAP flap, did not produce satisfying results and is, therefore, discouraged.

NAC reconstruction techniques have evolved significantly over the past decades along with advances in reconstructive breast surgery. Some methods are no longer used and are of historical

significance only. These include some NAC/nipple sharing techniques, NAC banking, composite grafts from distant sites, reconstruction with labial tissues, centrally based flap techniques, and nipple reconstruction with tattoo alone.

While reconstruction of areola usually does not pose difficulties, creation of a natural 3-dimensional nipple with lasting projection remains a challenge. The variable consistency of this anatomical structure in relaxed or erect condition is yet unattainable. Multiple procedures have been described, but none has been universally favoured. Currently, subdermal single and double-pedicled flap techniques for nipple reconstruction combined with skin grafting and tattoo for areola reconstruction are the first-choice. In order to avoid donor site morbidity, some authors refuse skin grafting and use only tattoo for the simulation of the areola.

Today's techniques are able to provide a satisfactory imitation of the NAC with good symmetry and long-lasting results. Different techniques are available, to suit the individual situation, and have to be selected according to local tissue requirements and the preferences of the patient and surgeon. Future developments in NAC reconstruction could be directed towards reconstruction of a more dynamic and functional nipple-like structure by tissue engineering techniques.⁷⁸

References

1. Bosch G, Ramirez M. Reconstruction of the nipple: a new technique. *Plast Reconstr Surg* 1984;73:977-81.
2. Gruber RP. Nipple-areola reconstruction: a review of techniques. *Clin Plast Surg* 1979;6:71-83.
3. Hartrampf Jr CR, Culbertson JH. A dermal-fat flap for nipple reconstruction. *Plast Reconstr Surg* 1984;73:982-6.
4. Little III JW. Nipple-areola reconstruction. *Clin Plast Surg* 1984;11:351-64.
5. Maliniac JW. Critical analysis of mammectomy and free transplantation of nipple in mammoplasty. *Am J Surg* 1944; 65:364.
6. Adams WM. Labial transplant for correction of loss of the nipple. *Plast Reconstr Surg* 1949;4:295.
7. Cronin TD, Upton J, McDonough JM. Reconstruction of the breast after mastectomy. *Plast Reconstr Surg* 1977;59:1-14.
8. Schwartz AW. Reconstruction of the nipple and areola. *Br J Plast Surg* 1976;29:230-3.
9. Broadbent TR, Woolf RM, Metz PS. Restoring the mammary areola by a skin graft from the upper inner thigh. *Br J Plast Surg* 1977;30:220-2.
10. Brent B, Bostwick J. Nipple-areola reconstruction with auricular tissues. *Plast Reconstr Surg* 1977;60:353-61.
11. Gruber RP. Method to produce better areolae and nipples on reconstructed breasts. *Plast Reconstr Surg* 1977;60:505-13.
12. Little III JW. Cryopreserved autologous nipple-areola complex transfer to the reconstructed breast. *Plast Reconstr Surg* 2003;111:148.

13. Millard Jr DR, Devine Jr J, Warren WD. Breast reconstruction: a plea for saving the uninvolvled nipple. *Am J Surg* 1971;122:763-4.
14. Allison AB, Howorth Jr MG. Carcinoma in a nipple preserved by heterotopic auto-implantation. *N Engl J Med* 1978;298:1132.
15. Bouvier B. Problems in breast reconstruction. *Med J Aust* 1977;1:937.
16. Rose Jr JH. Carcinoma in a transplanted nipple. *Arch Surg* 1980;115:1131-2.
17. Andersen JA, Pallesen RM. Spread to the nipple and areola in carcinoma of the breast. *Ann Surg* 1979;189:367-72.
18. Andersen JA, Gram JB, Pallesen RM. Involvement of the nipple and areola in breast cancer. Value of clinical findings. *Scand J Plast Reconstr Surg* 1981;15:39-42.
19. Fisher ER, et al. The pathology of invasive breast cancer. A syllabus derived from findings of the National Surgical Adjuvant Breast Project (protocol no. 4). *Cancer* 1975;36:1-85.
20. McCarty Jr KS, Kesterson GH, Barton TK, Seigler HF, Georgiade NG. Selection of patients for heterotopic implantation of the areola and nipple. *Surg Gynecol Obstet* 1980;150:545-7.
21. Quinn RH, Barlow JF. Involvement of the nipple and areola by carcinoma of the breast. *Arch Surg* 1981;116:1139-40.
22. Lagios MD, Gates EA, Westdahl PR, Richards V, Alpert BS. A guide to the frequency of nipple involvement in breast cancer. A study of 149 consecutive mastectomies using a serial subgross and correlated radiographic technique. *Am J Surg* 1979;138:135-42.
23. Lemperle G, Spitalny H. Reconstruction of the nipple and areola after radical mastectomy. *Acta Chir Belg* 1980;79:155-7.
24. Nakagawa T, Yano K, Hosokawa K. Cryopreserved autologous nipple-areola complex transfer to the reconstructed breast. *Plast Reconstr Surg* 2003;111:141-7.
25. Cohen IK. Reconstruction of the nipple-areola by dermabrasion in a black patient. *Plast Reconstr Surg* 1981;67:238-9.
26. Bunchman HH, Larson DL, Huang TT, Lewis SR. Nipple and areola reconstruction in the burned breast. The 'double bubble' technique. *Plast Reconstr Surg* 1974;54:531-6.
27. Masser MR, Di Meo L, Hobby JA. Tattooing in reconstruction of the nipple and areola: a new method. *Plast Reconstr Surg* 1989;84:677-81.
28. Spear SL, Arias J. Long-term experience with nipple-areola tattooing. *Ann Plast Surg* 1995;35:232-6.
29. Eskenazi L. A one-stage nipple reconstruction with the 'modified star' flap and immediate tattoo: a review of 100 cases. *Plast Reconstr Surg* 1993;92:671-80.
30. Rees TD. Reconstruction of the breast areola by intradermal tattooing and transfer. Case report. *Plast Reconstr Surg* 1975;55:620-1.
31. Wong RK, Banducci DR, Feldman S, Kahler SH, Manders EK. Pre-reconstruction tattooing eliminates the need for skin grafting in nipple areolar reconstruction. *Plast Reconstr Surg* 1993;92:547-9.
32. Becker H. The use of intradermal tattoo to enhance the final result of nipple-areola reconstruction. *Plast Reconstr Surg* 1986;77:673-6.
33. Becker H. Nipple-areola reconstruction using intradermal tattoo. *Plast Reconstr Surg* 1988;81:450-3.
34. Vadodaria SJ, Vadodaria BS. Tattooing for the management of white patches. *Ann Plast Surg* 1989;23:81-3.
35. Lea PJ, Pawlowski A. Human tattoo. Electron microscopic assessment of epidermis, epidermal-dermal junction, and dermis. *Int J Dermatol* 1987;26:453-8.
36. Jaspars JJ, Posma AN, van Immerseel AA, Gittenberger-de Groot AC. The cutaneous innervation of the female breast and nipple-areola complex: implications for surgery. *Br J Plast Surg* 1997;50:249-59.
37. Berson MI. Construction of pseudoareola. *Surgery* 1946;20:808.
38. Snyder C, Pickens JE, Slater TB. Surgery of the areola-nipple complex. In: Master FW, Lewis JR Jr (eds). *Symposium on aesthetic surgery of the face, eyelid and breast*. St Louis: Mosby Co; 1972. p. 192.
39. Barton Jr FE. Latissimus dermal-epidermal nipple reconstruction. *Plast Reconstr Surg* 1982;70:234-7.
40. Asplund O. Nipple and areola reconstruction. A study in 79 mastectomized women. *Scand J Plast Reconstr Surg* 1983;17:233-40.
41. Tanabe HY, Tai Y, Kiyokawa K, Yamauchi T. Nipple-areola reconstruction with a dermal-fat flap and rolled auricular cartilage. *Plast Reconstr Surg* 1997;100:431-8.
42. Dubin DB. A new simplified method for nipple reconstruction. Presented at the Annual Meeting of the American Society of Plastic and Reconstructive Surgeons, New Orleans; 1980.
43. Olivari N. International symposium of breast reconstruction. Rotterdam; 1979. The technique of Olivari is reported in: Eder H and Lejour M. Reconstruction of the nipple-areola complex after radical mastectomy. *Acta chir belg* 1980; 79: 147-53.
44. Serafin D, Georgiade N. Nipple-areola reconstruction after mastectomy. *Ann Plast Surg* 1982;8:29-34.
45. Vecchione TR. Reconstruction and/or salvage of nipple projection. *Plast Reconstr Surg* 1986;78:679-83.
46. Mukherjee RP, Gottlieb V, Hacker L. Nipple-areolar reconstruction with buried dermal hammock technique. *Ann Plast Surg* 1987;19:421-3.
47. Muruci A, Dantas JJ, Noguerira LR. Reconstruction of the nipple-areola complex. *Plast Reconstr Surg* 1978;61:558-60.
48. Little III JW, Munasifi T, McCulloch DT. One-stage reconstruction of a projecting nipple: the quadrapod flap. *Plast Reconstr Surg* 1983;71:126-33.
49. Silversmith PE. Nipple reconstruction by quadrapod flaps. *Plast Reconstr Surg* 1983;72:422.
50. Cohen IK, Ward JA, Chandrasekhar B. The pinwheel flap nipple and barrier areola graft reconstruction. *Plast Reconstr Surg* 1986;77:995-9.
51. Hallock GG, Altobelli JA. Cylindrical nipple reconstruction using an H flap. *Ann Plast Surg* 1993;30:23-6.
52. Hugo NE, Sultan MR, Hardy SP. Nipple-areola reconstruction with intradermal tattoo and double-opposing pennant flaps. *Ann Plast Surg* 1993;30:510-3.
53. Teimourian B, Duda G. The propeller flap: a one-stage procedure for nipple-areola reconstruction. *Aesthetic Plast Surg* 1994;18:81-4.
54. Georgiade GS, Riefkohl R, Georgiade NG. To share or not to share. *Ann Plast Surg* 1985;14:180-6.
55. Anton MA. ELBCHR. Nipple reconstruction with local flaps: star and wrap flaps. *Perspect Plast Surg* 1991;5:67.
56. Yamamoto Y, et al. Two innovations of the star-flap technique for nipple reconstruction. *Br J Plast Surg* 2001;54:723-6.
57. Thomas SV, Gellis MB, Pool R. Nipple reconstruction with a new local tissue flap. *Plast Reconstr Surg* 1996;97:1053-6.
58. Hamori CA, LaRossa D. The top hat flap: for one stage reconstruction of a prominent nipple. *Aesthetic Plast Surg* 1998;22:142-4.
59. Losken A, Mackay GJ, Bostwick III J. Nipple reconstruction using the C-V flap technique: a long-term evaluation. *Plast Reconstr Surg* 2001;108:361-9.
60. Guerra AB, Khoobehi K, Metzinger SE, Allen RJ. New technique for nipple areola reconstruction: arrow flap and rib cartilage graft for long-lasting nipple projection. *Ann Plast Surg* 2003;50:31-7.

61. Kargul G, Deutinger M. Reconstruction of the breast areola complex. Comparison of different techniques. *Handchir Mikrochir Plast Chir* 2001;33:133-7.
62. Cronin ED, Humphreys DH, Ruiz-Razura A. Nipple reconstruction: the S flap. *Plast Reconstr Surg* 1988;81:783-7.
63. Weiss J, Herman O, Rosenberg L, Shafir R. The S nipple-areola reconstruction. *Plast Reconstr Surg* 1989;83:904-6.
64. Kroll SS, Hamilton S. Nipple reconstruction with the double-opposing-tab flap. *Plast Reconstr Surg* 1989;84:520-5.
65. Kroll SS, et al. Comparison of nipple projection with the modified double-opposing tab and star flaps. *Plast Reconstr Surg* 1997;99:1602-5.
66. Ramakrishnan VV, Mohan D, Villafane O, Krishna A. Twin flap technique for nipple reconstruction. *Ann Plast Surg* 1997;39:241-4.
67. Guida CA, Picchi A, Inzirillo S. Areola and nipple reconstruction. *Plast Reconstr Surg* 1975;56:454-5.
68. Hallock GG. Polyurethane nipple prosthesis. *Ann Plast Surg* 1990;24:80-5.
69. Berrino P, Galli A, Rainero ML, Santi PL. Long-lasting complications with the use of polyurethane-covered breast implants. *Br J Plast Surg* 1986;39:549-53.
70. Brand KG. Polyurethane-coated silicone implants and the question of capsular contracture. *Plast Reconstr Surg* 1984;73:498.
71. Capozzi A, Pennisi VR. Clinical experience with polyurethane-covered gel-filled mammary prostheses. *Plast Reconstr Surg* 1981;68:512-20.
72. Eyssen JE, von Werssowetz AJ, Middleton GD. Reconstruction of the breast using polyurethane-coated prostheses. *Plast Reconstr Surg* 1984;73:415-21.
73. Ward CM. The uses of external nipple-areola prostheses following reconstruction of a breast mound after mastectomy. *Br J Plast Surg* 1985;38:51-4.
74. Slade CL, Peterson HD. Disappearance of the polyurethane cover of the Ashley Natural Y prosthesis. *Plast Reconstr Surg* 1982;70:379-83.
75. Smahel J. Tissue reactions to breast implants coated with polyurethane. *Plast Reconstr Surg* 1978;61:80-5.
76. Robles JM, Zimman OA, Lee JC. Reconstructing a finely nodular areola. *Br J Plast Surg* 1979;32:238-40.
77. Becker H, Prysi MF. A new technique for reconstructing Montgomery's tubercles. *Plast Reconstr Surg* 1990;86:147-8.
78. Cao YL, Lach E, Kim TH, Rodriguez A, Arevalo CA, Vacanti CA. Tissue-engineered nipple reconstruction. *Plast Reconstr Surg* 1998;102:2293-8.