Review

Euromediterranean Biomedical Journal
for young doctors
(formerly: Capsula Eburnea)

NIPPLE-AREOLA COMPLEX RECONSTRUCTIVE TECHNIQUES APPLIED TO BREAST RECONSTRUCTION: A SYSTEMATIC REVIEW

Susanna Polotto

SUMMARY

Nipple-areola complex (NAC) reconstruction is an essential component of each breast reconstruction technique as it plays a major role in achieving optimal aesthetic results. Its goal is to obtain an appropriately located, sized, shaped, colored and textured NAC when compared to the controlateral one or to ideal landmarks. Several surgical techniques have been developed to obviate the neo-nipple's loss of projection and contracture, mostly due to an inadequate NAC vascularization. Local flaps are the best choice when provided with a well-vascularized and sufficiently thick soft tissue, while grafts are better when there is a lack of local tissue and a donor zone is required to provide an adequate volume to the NAC. An autologous cartilage graft can also be used in similar situations to provide a long-lasting projected nipple. Tattooing is often used both to improve a newly created NAC and as an alternate two-dimensional reconstructive technique.

Introduction

The nipple-areola complex (NAC) reconstruction is an integral part of each breast reconstruction as its objective is to restore patients' body image after a total or partial mastectomy. While NAC can be performed during both immediate and secondary breast reconstruction, this article is focused on secondary NAC reconstruction techniques. The creation of a symmetric breast mound prior to NAC reconstruction should be mandatory since the NAC is basically the final aspect of breast reconstruction. Additional conditions requiring NAC reconstruction include: congenital or developmental pathologies (athelia, amastia), post-traumatic or burn deformities, and breast surgery complications.

The ideal NAC reconstruction requires permanent projection and symmetry of position, size, shape, texture and pigmentation of the neo-nipple compared to the contralateral one. In unilateral reconstructions, the contralateral NAC serves as a model whereas in bilateral reconstructions the NAC location is planned according to anatomical landmarks. The best way to determine NAC position is to measure the transverse midsternal line-to-nipple distance and the sternal notch-to-nipple one, so that the appropriate-sized areola can be sketched around the intersection site of these two lines. Another method involves using fixed anatomical points, such as the clavicle, the body midline, the mid-axillary line and the under-breast track to establish NAC position.

The main nipple reconstruction problem is creating a long-lasting projection, because of the influence of surrounding and underlying tissues' retraction forces and tissue contraction. Several nipple reconstruction techniques have been developed to overcome this issue, which will be examined subsequently.

Address of the authors

Plastic and Reconstructive Surgery Department, IRCSS San Martino University Hospital—IST—National Institute of Cancer Research (IST), University of Genoa, Italy

***Send correspondence to**: Dr. Susanna Polotto, polotto.susanna@gmail.com*

***Received**: February 21th, 2012 — **Revised**: March 13th, 2012 — **Accepted**: March 20th, 2012*

The reconstructed nipple loss of projection could be as much as 50-70% over two years, but should always be anticipated: in fact, an overcorrection of 25-50% of the desired result is advisable in local flaps NAC reconstruction [1]. This complication is observed more frequently on breasts reconstructed using implants rather than flaps, since implants exert an additional pressure force on the skin surface. Other causes of this complication can be: high external pressure, poor flap design, thin epidermal and dermal tissues and lack of subcutaneous fat tissue.

Generally, NAC reconstruction can be safely performed on an out-patient regimen under local anesthesia. It should, however, be postponed until the reconstructed breast mound shape is stable -- that is 3-4 months following breast reconstruction -- although in selected patients, a primary NAC reconstruction can be performed contemporaneously with breast reconstruction so that the neo-nipple is positioned definitively.

Areola reconstruction techniques

The areola reconstruction can be completed by implementing one of five main techniques: areola-sharing grafting techniques, skin grafting techniques, NAC banking, dermabrasion, and areolar tattoo.

Areola-sharing grafting techniques

Areola-sharing grafting procedures do not affect the contralateral areola significantly, as it constitutes the donor area, although breastfeeding may be impaired due to scar formation and partial lactiferous ducts loss. The main surgical techniques used to take the skin graft from the contralateral healthy areola are: the spiral technique, the S-sharing technique and the Asplund technique. The basic surgical technique involves a pre-operative circular drawing made on the healthy nipple dividing it into two concentric parts. Then, the external part is taken as a full-thickness skin graft and the contralateral area of the future areola site is deepithelializated. Finally, the graft is sutured onto the receiving area using both internal and external sutures, creating the new, smaller areola shape, and the donor site is sutured as well. The nipple is generally reconstructed during the same surgery. The two smaller resulting NACs make this technique optimal for patients with large areolas.

Skin grafting techniques

While many donor areas have been described for areola reconstruction over the years, split-thickness grafts from labia majora or inguino-perineal skin have been considered the best choice based on their hyperpigmentation. However, these graft typologies are rather inadequate for areola reconstruction due to differences in pigmentation and skin structure, and hair presence in the donor area. Based on these factors, the contralateral areola represents the best grafting source.

NAC banking

This technique consists of sampling the NAC as a full thickness skin graft and transferring it to a groin, buttock or abdomen receiving area during the mastectomy surgery. After breast reconstruction, the "banked" NAC is harvested and transferred to the areolar site [2]. This method was abandoned after the histological evidence of breast cancer cells in NACs of patients whose primary breast cancer was significantly distant from the NAC itself, and after consistent evidence of cancer cells spreading to lymph nodes located near the banked NAC. A modification of this technique, consisting of NAC retainment in a refrigerator until pathologist examinations have excluded tumoral infiltration, seems to eliminate the tumor spreading risk; then the original procedure can proceed. Today this technique has largely been abandoned, however, as twice-transferred grafts mostly lost pigmentation and nipple projection, failing to meet aesthetic expectations.

Dermabrasion

This technique could be used for Black patients as partial-thickness skin removal in this patient typology usually results in hyperpigmentation of the healed skin [3].

Areolar tattoo

Intradermal tattooing only provides an optical illusion of a textured surface, but has gained popularity from patients and surgeons for both improving the existing reconstruction techniques as well as being a complete two-dimensional NAC reconstruction technique in and of itself. Since the NAC is often created with local flaps or skin grafts, there is usually no color difference defining the areolar area. By using different color shades, the tattooed NAC can produce a visually projected three-dimensional nipple effect.

The current standard of practice involves surgical nipple reconstruction followed by NAC tattoo with a time interval of at least 6-12 weeks post-reconstruction to allow the neo-nipple to stabilize and to contract. New evidence suggests that NAC tattooing performed at the same time as reconstruction might offer the best aesthetic results: the surgeon should tattoo the nipple flap before NAC reconstruction and then the areolar zone [4]. Another method involves performing both nipple and areola tattoos immediately before the reconstruction [5]. The areolar tattoo should be performed as the first NAC reconstruction step with the nipple being reconstructed under local anesthesia two weeks later to allow the tattoo pigment to stabilize in the deep reticular dermis. This procedure has two benefits: (1) it is simpler to execute because the reconstructed nipple would be difficult to tattoo since the nipple foundation does not have a firm supporting internal structure; (2) the ink distribution throughout the skin would be homogeneous as there would not be any scars from nipple reconstruction [6].

Another technique associated with skin grafts involves primarily tattooing the donor zone and then, at the time of grafting, tatooing the receiving site. When flaps are used, it is indicated to tattoo the flap area both before and after suturing in order to correct possible distortions [7]. The main advantage of areolar tattoo is its simplicity, which requires no hospitalization, no general anesthesia and does not provoke any donor site morbidity. The downside is the need for secondary touch-ups due to the biological tendency of intradermal tattoos to fade with time and the need to wait several months for the color to stabilize. Unlike natural ones, both newly created and artificial nipples maintain their projection unaffected by external temperature or patient sensibility, which often leads patients to choose tattoo instead of surgical NAC reconstruction or adhesive NAC prosthesis. Intradermal tattooing is also advantageous for patients who want to have some form of NAC definition but do not want to undergo another surgical operation.

Surgical nipple reconstruction techniques

Chronologically, nipple reconstruction can take place either in a single surgical procedure or in a two-step surgical procedure where the nipple reconstruction is performed before the areolar one. The surgeon will choose from either one of the aforementioned procedures based upon his experience.

The main nipple reconstructive techniques include:

"Free" nipple reconstruction technique

In patients with ptotic breasts, an immediate skin-sparing breast reconstruction always requires a skin envelope reduction, which allows for immediate nipple reconstruction. Local skin flaps are raised up before proceeding with total mastectomy or wide local excision; then, the surgeon proceeds with reconstructing the nipple, using a triangular flap of excess skin which is situated at the apex of the skin-reduction, drawing vertical limbs, after the flaps' suture. The flap drawing is similar to the "modified C-V flap" one, with two lateral V-shaped wings comprised within the edges of the preserved skin triangle. The nipple is then created from the exceeding skin bulge formed by the suture of the mastectomy flaps at the apex of the surgical wounds. Finally, a skin crescent, located at the superior edge of the triangle skin flap, is deepithelialized and sutured in order to construct the neo-nipple projection. Therefore, the final structure consists of two excess skin flaps: a lateral one and a medial one; the lateral flap forms the cylindrical nipple structure and the medial one the nipple cap. The main characteristic of this technique is the use of only "discarded" tissue for nipple reconstruction [8].

Composite-free nipple graft techniques

This technique is used in women with a consistently projected contralateral nipple. It is the technique of choice, when possible, due to its simplicity and its optimal aesthetic results. The sampling from the healthy nipple can be made using several different techniques, such as: nipple hemisection and top or wedge-shaped nipple sampling. After the sampling, the graft is sutured onto the previously deepithelialized recipient zone with a non-resorbable, simple interrupted suture along its edges. Subsequently, the areolar zone is tattooed.

Skin graft techniques

The main problem with this technique is that all tissues used for nipple reconstruction lack the healthy nipple structural elements of smooth muscle and lactiferous ducts, which are responsible for the

natural nipple firmness and projection. The most common donor zones are the second or third toe, the hallux pulp, or the ear auricle; this last graft donor zone is situated on the posterior ear face in order to be invisible and it is coupled with a local full-thickness graft which covers the donor zone.

The surgeon can also use a combined technique in which a full-thickness skin graft rebuilds the areola and a subcutaneous pedicled island flap is used to reconstruct the nipple. The first step of this procedure involves drawing the future NAC, followed by a circular incision. Next, an incision, which reaches the subcutaneous fat layer, is performed to create an island flap; and finally, the nipple is elevated. A little pocket is created in the base of the flap to improve nipple projection, and a circular full-thickness skin graft is taken from the abdomen and put around the island flap in the previously deepithelized future areolar site.

The advantages of this technique include its simplicity, good nipple projection, preservation of the contralateral NAC, and its adaptability to all breast reconstruction techniques. The main disadvantage is that this technique requires a skilled surgeon [9]. A similar technique, the "button-hole technique," is optimal for patients with small nipples. This method involves drawing the perimeters of the future areola and nipple, and then drawing a third circle, with a diameter twice as long as the nipple, between them. Next, the area situated between the two most external circles is deepithelized and the neo-nipple circumference, which corresponds to the middle circle, is full-thickness incised and thus separated from the areolar zone. The areola is created with a full-thickness graft harvested from the groin crease and sutured to the previously deepithelized receiving zone. Finally, a small circular graft is excised from the graft centre and the nipple is pulled through the newly created opening like a button through a buttonhole [10].

Local flap techniques

The use of local flaps in nipple reconstruction techniques is the method of choice, especially for significantly protuberant nipples; it can also be applied with skin grafts to recreate the areola. This method can be divided into two techniques: (1) centrally based flaps, which are now outdated, and (2) subdermal pedicled flaps, which are still in use. These techniques aim at obtaining a three-dimensional structure (the neo-nipple) from a two-dimensional one (the flaps).

The main complications of these techniques are tissue retraction, contraction of the flaps, and neo-nipple projection loss. The structural contractile elements of the surrounding and underlying tissues exert centrifugal forces on local flaps, which tend to retract them to their original position. These retraction forces significantly differ between the two flap-categories described above. Centrally based flaps are subject to the greatest retraction forces, which act on the entire flap foundation; subdermal pedicle flaps, on the other hand, experience significantly reduced forces because the bigger flap part is undermined and thus protected from retraction.

Another complication is flap contraction, which occurs to variable degrees in all local flaps and leads to a loss of flap volume and projection. Flaps involving a complicated drawing are subject to more significant scarring and contracture. Blood supply is also of paramount importance in flap shrinkage; it is better in subdermal pedicled flaps, which are nourished through a rich subdermal blood plexus. Central core flaps, on the other hand, receive blood supply from the subcutaneous tissue, which gives them less consistent nourishment. Breast irradiation also significantly compromises blood supply, damaging the flap quality.

Therefore, in order to achieve a stable flap size, the surgeon should achieve a wide flap pedicle, a simple flap design, an optimal flap undermining from retractile surrounding tissues, a good blood supply by widening the subdermal pedicled flap bases utilizing the double-pedicled flaps technique, and minimal retraction forces.

1. Centrally based flaps:

These kinds of flaps are lifted from the geometrical centre of the newly created areola. They are divided into four categories:

- *Split-thickness skin flap techniques:* These pioneer techniques utilize three triangular split-thickness skin flaps, taken from the future NAC area, whose borders are sutured together, forming a nipple-like umbilicated structure. To further increase flap volume, the 'mushroom-flap technique'

was developed, which employs the entire peripheral part of the flap without excising skin wedges [11]. These techniques are no longer in use today.

- *Central-core techniques:* These techniques include subcutaneous tissue within the central flap core to increase the neo-nipple bulk and projection. The 'double-bubble technique' consists of lifting a central core of skin and fat tissue after a circular incision, which reaches the subcutaneous tissue [12]. A suspension device should be utilized to keep the central core flap in position, after the circular incision creates the nipple, until spontaneous exposed subcutaneous tissue re-epithelization occurs. Alternatively, split-thickness or full-thickness skin grafts can be used to circumferentially cover a central fat core [13, 14, 15]. The 'buried dermal hammock technique' involves two denuded dermal flaps that pass through a subcutaneous core tunnel to create the neo-nipple. The flaps are then secured to each other and the entire areola and core areas are covered with a full-thickness skin graft [16]. All these techniques are no longer in use because of the resulting gradual loss of nipple projection.

- *Extended central-core techniques:* These techniques are an innovation of the central -core ones. They involve an extension of the split-thickness skin flap from the future areola site, which is left attached to the central-core flap and then wrapped around the newly created fat core [14]. Despite these attempts to increase flap bulk, simplify flap design, decrease retraction and prevent contracture, long term results of all central-core techniques appear to be scarcely encouraging; for this reason, they are not in use today.

- *Dermal flap techniques:* These techniques are based on denuded inverted flaps and combine bi-lobed or tri-lobed dermal-fat flaps with rolled auricular cartilage grafts positioned in the centre of the dermal base and wrapped with the elevated flaps. A skin graft is then applied to cover the raw surfaces [17].

2. Subdermal-pedicle flaps

These techniques are characterized by: their utilization of a flap base located outside the geometrical centre of the future areola site; and elevated full-thickness skin flaps, which receive blood supply from the subdermal plexus, thus providing them with an optimal nourishment compared to the centrally-based ones. During flap dissection, the whole flap is completely separated from its subcutaneous bed, so that the surgeon can incorporate a high amount of subcutaneous tissue and minimize the centrifugal retraction forces, thus increasing bulk and projection of the neo-nipple. Of course, all subdermal-pedicle flap techniques have the donor-site closure issue, which can be resolved by choosing a limited flap size, in order to allow primary closure, or by grafting of the donor site. Subdermal-pedicle flaps can be divided into single-pedicle and double-pedicle:

- *Single-pedicle subdermal flaps:* The first subdermal-pedicle flap technique was described in 1984 and consisted of an inferiorly pedicled 'U-shaped skin flap' taken from the deepithelialized future areola site which is raised up and then sutured onto itself in order to create a nipple shape. Two separate full-thickness skin grafts were taken from the inner thigh and used to minimize graft contracture [18]. In the same year, a similar technique was described using an inferiorly based 'Omega-shaped dermis-fat flap' and three separate full-thickness skin grafts taken from the infragluteal fold or the contralateral areola [19]. The 'Deepithelialized U-flap technique' added a split-thickness skin flap extension to the previously described technique. The extension is wrapped around the U-flap and elevated to cover the subcutaneous fat side [14].

The 'Skate-flap technique' consists of sampling a graft from the inguino-genital-crural zone to form the areola, coupled with a flap used to form the nipple. It includes a vertical cutaneous-fat flap with two bilateral wing-like split-thickness skin extensions; the flap is elevated with a consistent amount of subcutaneous fat tissue to provide adequate volume and blood supply to the neo-nipple. The flap wings are wrapped around the fat core to create a nipple with about 50% of overcorrection, in order to avoid the natural loss of projection. The V-shaped defect resulting from the flap dissection can be difficult to close initially without excessive tension, can cause flap and scar complications, and often requires a small skin graft to close it [20]. This technique has been modified into the 'Star-flap technique', which includes a vertical cutaneous flap with two bilateral full-thickness and 90 degree-oriented arms, wrapped around the central

one to cover its subcutaneous surface [21]. This technique allows for the direct closure of the donor zone defect, but its main drawback is an inadequate nipple projection that frequently results in large and short neo-nipples. Some modifications to this technique have incorporated additional fat tissue in the lateral arms to avoid the loss of projection [22, 23]. The union of the 'Dermal platform' and 'Star-flap' techniques has also been used to prevent the loss of projection of the neo-nipple. After marking three triangular, equal-sized and star-shaped flaps, as in the standard technique, an arch is drawn from the midpoint of the edges of the lateral flaps transecting the vertical flap across its midpoint. This creates three smaller zones to be deepithelized. A full-thickness incision is then made around the flaps, including the deepithelized tip of the vertical one and, finally, the flaps are raised up. After the closure of the vertical flap donor site, the two lateral deepithelized tips are sutured together to create a semi-circular dermal platform in order to provide an additional layer of support for the neo-nipple. In the end, the two lateral arms are wrapped around, as in the standard technique, and the vertical one serves as a cap, with the deepithelized tip tucked inside the nipple structure [24].

Other variations to the 'Star-flap technique' sharing the same design -- a vertical flap with a cap and two lateral arms -- are the 'Cylindrical-flap' [25], the 'Top-hat flap' [26], the 'C-V flap' [27] and the 'Arrow flap' [28]. The 'C-V flap technique' involves two laterally extended V-wings and one central C-cap that forms the neo-nipple tip. The flap width should be between 15 and 25 mm so as not to damage its vascularization that flows by the common bases. The vertical flap length should be the same as the neo-nipple height. The V-wings are elevated and the donor sites are primarily closed; then, the C-flap is elevated. Finally, the V-wings are wrapped around the C-flap, which is placed on top of them as a cap. The advantages of this technique include its simplicity, reliability, and desirable aesthetic outcome; especially, the presence of a shorter scar confined to the future areolar site.

A variation of the 'C-V flap' consists of a shorter C-flap, which allows for a crescent of dermis to be deepithelizated to serve as a stable base for the neo-nipple, and lateral V-flap tips, which are also deepithelialized and included in the raised C-flap. The distal portions of the flaps are turned into the core of the construct. These modifications allow more vascularized tissue to be incorporated into the flap giving it major bulk and a stable base for the neo-nipple, thus decreasing risk of flattening. Furthermore, the use of a wider pedicle base reduces the risk of flap necrosis, thanks to its higher blood supply. The shortening of the C-flap causes the neo-nipple to triradiate at its tip, giving a more natural final appearance [29].

Yet another 'C-V flap' variation involves modifying the flap design: a V- and M-pattern is used at the end of each flap allowing them to fit perfectly together when sutured. The scar situated on the inferior border of the neo-nipple is lengthened into a V, so that is possible to reduce the contracture. Finally, after previous deepithelization, the C-flap is raised leaving a dermal base for the neo-nipple in order to prevent its retraction and loss of projection [30].

The 'Swiss-Roll flap technique' is another modification to the 'C-V flap,' specifically designed for breasts with little subcutaneous fat due to the patient's overall lack of adiposity or as a result of the prior use of tissue expanders. By not utilizing fat tissue, complications directly related to fat use, such as fat necrosis and nipple projection loss due to fat resorption, are avoided [31]. The major differences between these two techniques are that, with respect to the "C-V flap technique," the "Swiss roll flap technique" raises the lateral V-flaps with extended rectangular wings and only dermal flaps are raised up, lacking subcutaneous fat tissue. The horizontal length of one V-flap should be equal to the circumference of the C-flap, and the length of the other V-flap should provide adequate volume for the neo-nipple. The triangular flap ends are excised and, subsequently, one of the V-wings is deepithelized and 'rolled' before being wrapped with the other one. It is of paramount importance to leave the vertical edge of the second wing free so the dermal plexus is uninterrupted. The C-flap is used as a cap, and then the donor site is closed directly as in the original technique.

Diversely, the 'Arrow-flap' technique consists of a flap formed by an upper C-component with a triangular deepithelized

area above it, and an arrow-shaped lower component with a deepithelized "tail," and a height of 150% of the final nipple projection. The donor site is then directly closed and the dermal triangular flap is folded under the top, covered by the arrow-shaped wings, and sutured together. Modifications to the 'Arrow flap technique' regard donor site closure. After the flap is raised up and molded into a cylindrical shape, the nipple flap edges are sutured together. Finally, the arrow-shaped flap defect is sutured by parallel approximation and the neo-nipple is moved onto the deepithelializated donor site defect of its top and sutured in place [32].

Another group of bi-lobed cutaneous-fat flaps composed of only two arms is defined by the 'Fish-tail flap technique,' which employs two inferiorly pedicled flaps whose shape is similar to a fish tail [33], and by the 'Double U-shaped flap technique' [34]. The 'Cigar-Roll technique' is a new modification to the 'C-V flap'. After raising the flaps, one half of one flap is deepithelized and inset into the neo-nipple. The opposing flap is then sutured over the other one, in order to create the nipple [35].

- *Double-pedicle subdermal flaps:* This flap typology is centered on the mastectomy scar, thus avoiding the lack of blood supply that often results from single-pedicle flaps. The direction of both flaps is parallel to the scar, and their orientation is opposite each other, so that the scar does not cross their bases. This technique adds total bulk to the neo-nipple and increases the chance of flap survival due to its improved blood supply. However, the suturing of the two flaps creates a certain tension on the flaps themselves, leading to a greater amount of retraction forces from the surrounding tissues than the single-pedicle ones.

The 'S-flap technique' is composed of two opposing U-shaped dermal-fat flaps equal in size, designed within a circle with the central line located on the mastectomy scar. In this way, two opposite flaps are created, raised up after the deepithelialization of the future areolar zone, approximated, placed opposite of one another and, in the end, sutured together. The entire neo-nipple and areolar site is then covered with full-thickness skin grafts [36]. One modification to this technique involves eliminating the deepithelialization of the areolar zone, which is to be tattooed after the nipple reconstruction. Another modification to the 'S-flap technique' is the 'Double-Opposing-Tab (DOT) flap technique', which is performed by adding two lateral split-thickness tab extensions. These tab extensions allow for a better interdigitation of the two main flaps, thus reducing scar contraction [37]. A further modification to the 'DOT flap technique' involves widening of the flap base in order to improve blood supply. This variation is inconvenient because of the resulting oval shape of the nipple and the distortion or flattening of the breast contour caused by the use of more breast skin for the flap. Therefore, the use of double-pedicle flaps should be restricted to larger breasts, smaller nipples or to situations in which the use of single-pedicle flaps is not advised.

Yet another variation of the 'S-flap technique' is the 'H-flap technique'. Finally, the 'Twin-flap technique' combines the main characteristics of the central-core and the subdermal-pedicle flap; it is recommended in the presence of a mastectomy scar crossing the nipple reconstruction area. This flap has a central core of subcutaneous tissue with a skin cap and a rectangular dermal flap, which must be wrapped around the first one. The bases of the central-core flap are opposite to the rectangular flap and its length corresponds to the height of the neo-nipple. After the elevation of both flaps, the rectangular one is wrapped around the central-core one, thus creating a cylindrical nipple. At the end, a full-thickness skin graft reconstructs the areola [38]. Recently, a new technique using a bi-pedicled vertical flap, with horizontally oriented extensions departing from its mid-portions, has been proposed. After the flap design, the incisions are made and the flap is raised up on its superior and inferior pedicles, whose borders are sutured together. The lateral extensions have a V-Y shape which allows the neo-nipple to acquire projection [39]. Additionally, the 'Z-flap technique' has been proposed as an alternative when the 'C-V flap' cannot be performed. This technique uses a double-pedicled, Z-shaped flap, with two lateral wings; the width of each flap and the distance between them corresponds to the diameter of the future nipple. The two wings are lifted up and then sutured directly face to face. Their thick-

ness equals half of the nipple to be reconstructed. It is also possible to cut the tips of the flaps to give the nipple a more natural aspect [7].

Internal nipple prostheses

In 2010, Jankau et al. proposed an addition to the 'C-V flap' technique implementing a silicone rod to support the neo-nipple [40]. The advantage of this technique is the reduced loss of the neo-nipple projection due to its increasingly stable form combined with the superstructure of the 'C-V flap'. The silicone rod used in this study is a part of a Nagor silicone tendon substitute, placed inside the muff formed by means of the 'C-V flap' technique. In a significant percentage of observed patients, there was a necrosis of the nipple, which required the removal of the silicone rod. The authors assumed that the reason for this complication was the excessive pressure on the endoprosthesis due to the breast prosthesis or expander. However, this method has provided positive results in autologous breast mound reconstruction with pedicled TRAM flap, due to the lack of pressure created by the use of autologous soft tissues which do not give rise to necrotic complications.

Autologous and alloplastic material implants

After primary NAC reconstruction, some women are not satisfied with the final outcome because of the loss of projection of the neo-nipple. Recently, the use of an acellular dermal matrix (AlloDerm) associated with a flap reconstruction of the NAC has been proposed to address this issue. It is recommended to use a 1x2 cm thick or extra-thick piece of AlloDerm, measuring approximately 3x6 mm, which should be oriented towards the skin flaps and should be placed between the two opposing skin flaps. The upper tip of the AlloDerm is sutured to the superior dermal edge of the local flap to prevent displacement or migration [41].

A nipple reconstruction technique has also been proposed making use of a cartilage graft, harvested during the breast reconstruction and banked beneath a local skin flap, created with the 'Modified top hat technique'. This method is particularly effective in Asian patients, who have wider nipples with a prominent, but small areola area. The use of a composite soft and firm tissue technique mostly prevents the loss of projection typical of soft tissue reconstruction thanks to its supporting action. The third costal cartilage is removed during the initial dissection and a 1 cm long cartilage segment, including the perichondrium, is stored in saline solution and then banked between the flap and the mammary pocket. When nipple reconstruction is planned, the cartilage is retrieved from the pocket and the previously designed flap is incised as usual. The cartilage is placed underneath the central flap core and sutured there [42]. Unlike the use of prosthetic material or composite graft tissue, the use of autologous tissue results in the absence of post-operative complications such as infections or skin necrosis. The nipple height remains stable over time and the relatively low loss of projection is attributed to the cartilage resorption, which can be easily avoided by maintaining the perichondrium, which guarantees better revascularization to the cartilage itself. An innovative technique proposed for harvesting the cartilage grafts details the harvesting site as the rib or the ear and uses a punch biopsy tool to harvest multiple discs of cartilage with various diameters (3-6 mm) from the conchal fossa of one or both ears. They are sutured together like hamburgers, providing a central core around which a standard local-flap technique, generally the 'Star flap,' is performed [43].

AlloDerm is an acellular human-derived cadaveric dermis which has been used as a central core under a 'Modified star-flap'; the results of this clinical study, however, weren't encouraging as there was no difference between the therapy-group and the control-group in improving of projection of the neo-nipple [44].

Complications

Local complications following NAC reconstruction are not common, however, partial or total nipple necrosis (<2% of all reconstructions) is the most severe of them. The probability increases if the breast has been irradiated or if the patient is a smoker, because of the tissue sufferance. The most common complication is the NAC depigmentation (i.e. a progressive color fading), which can easily be resolved by tattooing the nipple. Another complication is the malposition of the NAC or its lateral dislocation due to bad flap design or tissue retraction, which sometimes requires the

excision of the newly created NAC and a new reconstruction. Other complications include common surgical ones such as: wound infections, scar dehiscence or the need for surgical revision.
Bodin et al. reported a study in which they compared many different NAC reconstruction techniques, noting 6% of patients suffered complications (4% infections and 1% necrosis) [45]. Other clinical studies have reported the absence of any immediate complications [46], while Spear et al. reported 5% of complications (3% infections) in areolar tattooing technique patients [47]. Jabor et al. reported 11% of minor complications (partial necrosis and infections) in full-thickness grafts from the inner part of the thigh associated with many nipple reconstructive techniques [48].

Conclusion

NAC reconstruction is the last step of the breast reconstructive process and its aim is to provide a satisfying aesthetic result. Several techniques have been developed to obviate the main reconstruction side effects of loss of projection, contracture and necrosis. It is essential that an adequate blood supply be provided to the NAC. Local flaps are the best choice when local tissue has a good vascularization, a sufficient thickness, and it has not been irradiated. Double-pedicle subdermal flaps are particularly effective at adding bulk to the nipple and increasing the chance of flap survival since they augment the blood supply. Grafts of different thickness, mostly taken from the contralateral NAC, are used when there is a paucity of local soft tissue or the vascularization has been compromised by irradiation or by breast reconstruction. Internal silicone nipple prosthesis, autologous cartilage and alloplastic material implants are all reconstructive alternatives which can provide a permanent nipple projection, even if their use should be accurately planned due to their higher incidence of side effects. Areolar tattooing can be performed both preoperatively and post-operatively to obtain an optimal NAC pigmentation; it is also a reconstructive, two-dimensional technique which creates a three-dimensional realistic NAC illusion and should be performed in patients who do not want to undergo any other surgery.

In conclusion, an accurate pre-operative planning must be performed for each patient, as there are many different surgical choices for the plastic surgeon to choose from and each reconstructed breast has different characteristics to be considered. The breast reconstruction is completed with the formation of a newly created NAC, symmetrical in place, size, shape, color and texture.

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