Propeller TAP Flap Breast Reconstruction – a Simplified Surgical Technique

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The latissimus dorsi (LD) myocutaneous flap is a valid option for breast reconstruction although there are some drawbacks to its use due to donor site seroma formation and potential affection of the shoulder and arm function\textsuperscript{1,2}. The muscle sparing LD flap and thoracodorsal artery perforator (TAP) flap have been proposed as alternatives associated with less donor site morbidity, but has not gained general acceptance yet\textsuperscript{1,3}.

We introduced the TAPIA (Thoracodorsal artery perforator flap, implant and acellular dermal matrix) concept, shortly after the introduction of acellular dermal matrix (ADM) in Europe in 2011; a combined use of a propeller TAP flap, an ADM and an implant for delayed breast reconstruction\textsuperscript{4,5}. The use of preoperative color Doppler ultrasound (CDU) for perforator localization has enabled us to modify the design of our flap over time\textsuperscript{6}. The standard TAP flap design and perforator dissection, often considered a challenging procedure has evolved into a simpler extended oblique propeller TAP flap with minimal dissection\textsuperscript{7,8}. The ease of dissection and versatility of the extended TAP flap has made it a workhorse flap in our practice on several indications\textsuperscript{7}. The aim of this paper is to summarize and share our experience using the simple propeller TAP flap design for delayed breast reconstruction over the past 7 years with a focus on surgical technique.

Material and methods

The study was approved by the The health research ethics committee of the Region of Southern Denmark (S-20120207). We performed 123 propeller TAP flap delayed breast reconstructions in 94 patients aged 51 years, range 26-71, between August 2011 and September 2017. In the majority of procedures, the TAP flap was combined with an implant. The median BMI was 24, range 19-32.
There were 15 smokers, 46 had received adjuvant radiation therapy and the comorbidities entailed diabetes (n=2) and hypertension (n=23), Table 1.

We examined all the TAP flaps in this series prior to surgery by CDU to identify and locate the position of the perforators, Figure 1/Video. The location was marked using a permanent marker. The majority of flaps were designed using an oblique downwards design, reaching proximally from two centimetres anteriorly to the perforators to 4 cm from the lumbar column distally, Figure 2/Video. The width of the flap should be uniform throughout the length of the flap except at the ends. The design enables a 100 to 130 degree rotation of the flap as a propeller for safe inset at the recipient site along the inframammary crease, Figure 3/Video. The breast footprint was marked at the recipient site, which entailed the inferior, lateral and medial borders. In unilateral cases, the drawing was adapted to the size and shape of the contralateral breast, which was either left as it was or reduced to achieve symmetry. Surgery commenced in the lateral position. The flap was raised in the subfascial plane starting at the tip of the flap medially, Figure 4/Video.

The incision was bevelled obliquely outwards to increase the size of the flap within the safest boundaries of the perforasome. The dissection can be carried out fast until the perforators are approached. Dissection around the perforators was aided by tenotomy scissors, Figure 5/Video. We used to approach the recipient site through the mastectomy scar, but have changed this to an approach through the inframammary fold and lateral part of the breast footprint. The skin flaps in the recipient site was raised and the inferomedial insertion of the pectoralis major muscle was released in the majority of cases, however in a few cases the skin flaps in the recipient site was of such good quality and thickness, that the implant could be placed prepectorally. The flap was propelled to the recipient site, figure 3/Video. The back-donor site was sutured in three layers, a
deep running absorbable 0 in the fascia of Scarpa, running absorbable 2.0 suture in the deep dermis and an intradermal absorbable 3.0 suture. The patient was then turned to the supine position and the breast was reconstructed in a dual plane using an implant and a mesh; ADM was used in the majority of cases as this was a part of the original description of the TAPIA method. Since then we have used other types of mesh, biologic and synthetic, degradable and non-degradable and it all seems to work, Figure 6/Video. The desired implant was placed in the muscle/mesh pocket, Figure 7/Video. The ADM was sutured in place by absorbable 2.0 or 3.0 sutures, and the flap was inset in three layers using a 3.0 absorbable sutures finalizing the reconstruction, Figure 8/Video. Two drains were placed, one in the axilla and one along the inframammary crease. Oral antibiotics were administered until removal of the drains. The patients were examined in the outpatient clinic after two weeks, and generally after three, six, and twelve months, depending on patient needs.

Results

We performed the described procedure 123 times; in 65 unilateral and 29 bilateral cases. The extended oblique propeller TAP flap was based on one perforator in 51 cases, two perforators in 54 and three perforators in 18 cases. Silicone implants were used in 86 reconstructions, an expander in 28 cases, a Becker implant in 6, and no implant in three cases. The median implant volume was 300 cc (100-650), Table 2. The median time for surgery was 3 hours and 25 minutes (1 hour 15 minutes to 9 hours) in unilateral cases and 4 hours and 10 minutes (three hours to 5,5 hours) in bilalateral cases. The median time with drains was 8 days (2 to 16 days). The median number of days until discharge was 7 days (2 to 16 days). The registered number of
reconstructions with major complications was 16 (13%); 11 of these were partial necrosis of the flap, the majority due to tip/rim necrosis, three because of venous congestion and two suffered a hematoma. The number of direct to implant breast reconstructions was 92/123 (75%). A two-stage approach using an expander prior to implant was used in 28/123 (23%) reconstructions, of which 12 were placed primarily and 16 secondarily during revision surgery. Three (2%) patients did not receive an implant. The intended reconstruction was successfully achieved in 120/123 (98%) cases.

Late corrections and secondary follow-up surgical procedures were performed in 77/123 (63%) of patients for correction of shape or volume. The volume adjustments and symmetrical procedures were; fat grafting in 41/123 (33%) of the reconstructions and silicone implant exchange in 14/123 (12%). In 24/123 (20%) of reconstructions a remaining lateral fullness was reduced by combined liposuction and surgical revision. An adjustment of the medial part of the reconstruction was required in 6/123 (5%) reconstructions. The donor site scar at the back was corrected in 2/123 (2%), Table 2. The median patient follow-up was 1 year and 8 months, (two months to 4 years).

Discussion

Since 2011 the propeller TAP flap has increasingly been replacing the classic LD flap in our practice for delayed breast reconstruction where muscle is not required\(^4\text{-}^8\). This is largely due to the surgical modifications described in this article. The vast majority (98%) of the flaps in this series resulted in a successful reconstruction and most were performed as a direct to implant reconstruction (75%), Table 2, Figure 9/Video. We consistently use CDU for perforator identification, which gives the needed information about perforator location as well as course and
branching pattern of the feeding vessels through the muscle to the subcutaneous tissue\textsuperscript{4,6,9}. This enables a more comfortable flap design and speeds up the surgical procedure as the dissection is relatively easy to perform once the perforators have been identified and marked out. The TAP flap was originally described as the latissimus flap without muscle by Angrigiani\textsuperscript{10} and later defined as a perforator flap by Hamdi et al\textsuperscript{11}. In our hands the propeller TAP flap has evolved into a simple surgical technique, which requires minimal pedicle dissection and minimal rotation, which eases the inset of the flap all of which is facilitated by the oblique downwards and extended flap design\textsuperscript{4,6-8}. The observed consistency of the perforator location at the anterior border of the LD muscle and mobility of the muscle has enabled us to rotate the flap sufficiently and quite easily with minimal perforator dissection\textsuperscript{8}. In a majority of patients, the dominant perforators can be found along the course of the descending branch of the thoracodorsal vessels. When one or two well-sized perforators in close proximity are identified at the anterior edge of the LD muscle, then it is safe to use the propeller TAP flap, Video. In some patients CDU reveals several smaller perforators instead of a one or two large perforators. In some of these cases the larger perforators are to be found adjacent to the typical finding at the anterior edge of the LD muscle. They may originate from an intercostal artery, the horizontal branch of the thoracodorsal artery or even the subscapular artery. These perforators are more challenging to use for propeller flap reconstruction unless the perforator is dissected through some of the muscle or when needed all the way to the feeding vessel. We have included a lateral intercostal perforator and a concomitant intercostal nerve in some cases and these patients often experience sensation in the lateral part of the flap. We have found that the oblique design of the flap in combination with dissection of the scar tissue at the anterior border of the LD muscle is sufficient to mobilize and rotate the flap to the recipient site\textsuperscript{8}. In a few cases a small back-cut into the anterior edge of the LD muscle is necessary to enable
rotation of the flap. This, however, does not seem to affect the overall function of the LD muscle. In our experience the rotation from the donor site to the recipient site has been greatly simplified by changing the flap design from horizontal to an oblique downward design, reducing the arc of rotation from 180 degrees to 120 degrees or less. The oblique downward flap design resulted in a longer flap; up to 30 centimetres, although the most distal part of the flap can sometimes be unreliable regarding venous return. We also changed the shape of the flap design as it has evolved into an extended version of the flap as we aim to extend the adipofacial portion of the flap subcutaneously 2-3 cm beyond the markings of the skin island. This combined change in geometric design and limited perforator dissection facilitates a faster operation, a larger flap, and to our observation, a safer flap as more perforators can be included in the pedicle. In the early part of our experience using the TAP flap for breast reconstruction, the proximal part of the flap overlying the perforators was deepithelialized and the flap tunnelled through the axilla to its anterior position. We have recently changed this into a design, where we merge the incisions/scars of the recipient and donor site to rotate the TAP flap without deepithelialization as this facilitates a natural closure of the posterolateral donor site, Figure 10.

In the course of time our flap insertion has changed as well. Initially, we inserted the flap where the mastectomy scar was located to replace the missing breast mound. However, we have noticed that the best recipient site for the flap is the lateral and inferior part of the intended breast reconstruction. Placing the proximal part of the flap in the axilla and the central and distal part along the inframammary crease facilitate optimal conditions for breast reconstruction and seemingly the best conditions for flap survival. This not only simplifies the procedure, but also leads to a better shape of the reconstructed breast than when the flap is tunnelled and inserted into the mastectomy scar. In our experience, patients prefer correct shape and volume and care less
about scars. In this multicentre study, the median time for reconstruction was 3 hours and 25 minutes for unilateral cases and 4 hours and 10 minutes for bilateral cases. With increased experience it is possible to perform the procedures in 2 hours and 30 minutes and less than 4 hours, respectively.

Overall, 20% of our patients need a secondary procedure for debulking/correction of lateral excess underneath the axilla. This seems to be more frequent in patients, who have not had axillary node clearance. In patients who had a clearance, the extra fatty tissue provided by the flap seems to be an advantage, because the scar tissue and missing tissue in the axilla is replaced by healthy tissue from the back. Although not systematically recorded, we noticed that several radiated patients reported improvement of their shoulder and arm function, feeling less restricted and less pain than prior to the reconstructive surgery. A couple of patients even claimed that their lymphoedema of the arm had changed for the better. This must largely be due to the release and removal of scar tissue at the mastectomy site and in the axilla.

The delayed breast reconstruction can be performed successfully as a one stage direct to implant procedure in the majority of cases (75%), Table 2. However, in some cases an expander was used to reduce the pressure on the flap and avoid venous congestion. This was more noticeable in cases where the tissue surrounding the axilla and perforators was scarred and less pliable and where the implant was large causing compression on the flap and hindering the venous return over the implant mound from the distal portion of the flap. The typical oblique designed propeller TAP-flap includes three adjacent angiosomes according to Taylors classification$^{12,13}$ and as predicted the blood flow through the distal third angiosome is not always reliable. The tip/rim necrosis is our main concern and it resulted in revision surgery in most of the 11 described cases of necrosis even
though it constituted less than 10% of the flap surface area, Table 2. Arterial inflow to the tip of the flap is always available, whereas the venous return is more unpredictable. In several of these cases a significant sized perforator was noticed within the boundaries of the second angiosome of the flap. This anatomical finding may be the reason for the lacking/insufficient venous return from the third angiosome in those cases and that the designed flap was larger than the functional angiosome in these cases\textsuperscript{13}.

For that reason, we often discard the tip of the flap if it is not needed for the reconstruction.

The following observations may aide the surgeon to decide whether the third angiosome can be used for reconstruction or should be discarded. The capillary filling and hyperemic coloring of the flap can be evaluated during surgery. When there is a potential problem regarding the venous return the flap is usually subdivided in two or three segments representing two or three angiosomes. If the colors of the angiosomes differ, for instance if the second angiosome is slightly venous congested and the third a bit more congested, then we recommend that the most distal third angiosome be excised and that an expander be used for a two stage reconstruction.

The TAP flap has become our first-choice as an alternative or backup for the DIEP flap for delayed breast reconstruction. Our understanding and knowledge about the vascular anatomy of the perforators and their feeding vessels targeted by CDU has enabled us to to preserve the LD muscle and maintain its function in most our breast reconstructions based on a skin island from the back.. This implies that the indications for the use of an LD musculocutaneous flap for breast reconstruction are becoming fewer and further apart in our practice. The volume provided by the muscle as it atrophies is questionable when the nerve is cut and if the nerve is left intact there is a
large risk of breast animation deformity. Therefore, volume is better provided by fat or an implant rather than a muscle\textsuperscript{14, 15}.

Conclusion

The propeller TAP flap in combination with an implant can safely be used for breast reconstruction. The described refined and simple design enables a surgical procedure, which is fast and easy to perform in patients with well calibrated perforators identified by color Doppler ultrasound. The donor site morbidity is significantly less than from the conventional LD flap harvest and patients seems to recover faster, a finding that awaits to be tested in future studies.

Conflict of Interest: None

Funding: None

References

Legends

Figure 1  Color Doppler ultrasonography is used to identify the location of the thoracodorsal artery perforators.
Figure 2  The TAP flap is drawn in an oblique downwards design. The distal tip ends 4 cm from the lumbar column.
Figure 3  The TAP flap rotated to the intended recipient site along the inframammary crease.
Figure 4  The TAP flap is raised in the subfascial plane.
Figure 5  Tenotomy scissors is used to dissect around the perforators.
Figure 6  The implant is supported by a mesh, in this case a degradable synthetic mesh.
Figure 7  The implant is placed under the pectoralis major muscle and mesh, in this case a biological mesodermal mesh.
Figure 8  The final reconstructive result showing the TAP flap in place laterally and along the inframammary crease.
Figure 9  Pre- and postoperative images of a 70 year old woman reconstructed by bilateral TAP flaps and implants 25 years after mastectomy.

Figure 10  The donation site scars in the back and axilla following bilateral TAP flap reconstructions.
Tabel 1: Demography

<table>
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<tr>
<th>Patients (N)</th>
<th>94</th>
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<tr>
<td>Age (median)</td>
<td>51 years (range: 26-71)</td>
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<tr>
<td>BMI (median)</td>
<td>24 (range: 19-32)</td>
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<tr>
<td><strong>Risk factors</strong></td>
<td></td>
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<tr>
<td>- Smoking</td>
<td>15 (12.1 %)</td>
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<tr>
<td>- Adjuvant Radiation Therapy</td>
<td>46 (37.4 %)</td>
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<tr>
<td>- Diabetes</td>
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<td>- Hypertension</td>
<td>23 (18.7 %)</td>
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Table 2 Results

<table>
<thead>
<tr>
<th>Reconstruction</th>
<th>Unilateral</th>
<th>Bilateral</th>
<th>65</th>
<th>29</th>
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<tbody>
<tr>
<td>Perforators</td>
<td>One</td>
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<td>51 (41 %)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two</td>
<td></td>
<td>54 (44 %)</td>
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<td></td>
<td>Three</td>
<td></td>
<td>18 (15 %)</td>
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<tr>
<td>Implant (type)</td>
<td>Silicone</td>
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<td>86 (70 %)</td>
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<td>Expander</td>
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<td>28 (23 %)</td>
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<tr>
<td></td>
<td>Becker</td>
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<td>6 (5 %)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No implant</td>
<td></td>
<td>3 (3 %)</td>
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</tr>
<tr>
<td>Implant (Size)</td>
<td>300 cc (100 - 650 cc)</td>
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<tr>
<td>Surgery (time)</td>
<td>Unilateral</td>
<td>3 h 25 m (1 h 16 m - 9 h)</td>
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<tr>
<td></td>
<td>Bilateral</td>
<td>4 h 10 m (3 h – 5 h 30 m)</td>
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<td></td>
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<tr>
<td>Surgery (type)</td>
<td>Direct to implant</td>
<td>92 (75 %)</td>
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<td></td>
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<td>Two-stage</td>
<td>28 (23 %)</td>
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<td>Partial necrosis of the flap</td>
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<td>Venous congestion</td>
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<td>Hematoma</td>
<td>2 (2 %)</td>
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<td>Fat grafting</td>
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<td></td>
<td>Correction of donosite scar</td>
<td>6 (5 %)</td>
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