Review Article

Donor site morbidity associated with thoracodorsal artery flap breast reconstruction: a narrative review

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Objective: The aim of this paper is to give an overview of the available evidence on shoulder-related morbidity associated with the thoracodorsal artery (TDA) flaps when used for breast reconstruction.

Background: The pedicled TDA flaps are well described for breast reconstruction with the myocutaneous latissimus dorsi (LD) flap being the standard procedure. This flap is well described and considered a safe and reliable reconstructive method. However, use of the flap may be associated with a risk of donor site morbidity—most importantly shoulder dysfunction. Muscle sparring alternatives, including the muscle sparring LD (MS-LD) flap and the thoracodorsal artery perforator (TDAP) flap, has been introduced based on the hypothesis that these would reduce post-operative sequelae.

Methods: We conducted a review presenting the available literature on donor site morbidity after TDA flap harvest with focus on shoulder dysfunction. We found 12 papers dealing with shoulder dysfunction after breast reconstruction with the TDA flaps. Level of evidence (LOE) are highest for LD flaps and lower for the muscle sparring versions.

Conclusions: The available evidence on shoulder morbidity after breast reconstruction with the TDA flaps is scarce and has a low LOE. Furthermore, outcome measures and follow-up time are not uniform and most of the publish studies either lack a control group or simply do not compare the relevant outcomes between groups. However, there is a clear trend showing low functional impairment after reconstruction with the muscle sparring flap types.

Keywords: Breast reconstruction; latissimus dorsi flap (LD flap); thoracodorsal artery perforator flap (TDAP flap)

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Introduction

Modern breast cancer treatment is multifaceted. The main focus is curing cancer, but as the treatment modalities has developed and improved an increased scrutiny on the associated morbidity has emerged concurrently over the last decades. As a natural result the surgical procedures used for tumor removal also carry an important aesthetic aspect as well as an increased focus on the possible negative effects associated with treatment.

The continuous refinement of the abdominal flaps used for breast reconstruction has led to a shift in the surgical approach and is a good example of the evolving focus on

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decreasing procedure-related morbidity—from the classical transverse rectus abdominis myocutaneous (TRAM) flap introduced by Hartrampf and colleagues in 1982, to the deep inferior epigastric perforator (DIEP) flap which today is considered a gold standard in autologous breast reconstruction (1-8). Since the introduction of the abdominal free flaps, several alternatives have been developed and introduced (9-11). This has provided a wide armamentarium of options available for autologous breast reconstruction.

However, not all patients are suited for microsurgical reconstruction. Women who have received adjuvant radiation therapy (RT) towards the chest and axilla, and who for some reason are deemed non-eligible for free flap breast reconstruction present a special challenge. RT generally contradicts the use of implant-based reconstruction unless autologous well-vascularized and non-radiated tissue is added to decrease the risk of subsequent capsular contracture and necrosis (12). In these cases, the thoracodorsal artery (TDA) flaps from the back are the workhorse flaps with the latissimus dorsi (LD) flap being the traditional choice (13).

This flap was introduced by Tansini in 1906, but remained dormant until 1977, where it was re-introduced for breast reconstruction by Schneider and colleagues (14,15). The LD flap has since been widely used for breast reconstruction and often combined with an underlying implant to gain sufficient volume (15,16). However, just like advances in the surgical techniques have facilitated a shift to the muscle-sparing versions of the abdominal flaps, alternatives to the conventional myocutaneous flap from the back have also emerged. These flaps may be classified as the TDA flaps and range from the classical LD flap over several muscle sparring versions (MS-LD) to the thoracodorsal artery perforator (TDAP) flap (15,17-23).

The different indications for using the various TDA flaps have recently been described in the literature (24). The TDAP flap represents the most muscle sparring version of TDA flaps, but like the DIEP flap harvest it is more technically demanding to dissect and harvest. The aim of this paper is to give an overview of the available evidence on shoulder-related morbidity associated with the TDA flaps when used for breast reconstruction. We present the following article in accordance with the Narrative Review reporting checklist (available at https://abs.amegroups.com/article/view/10.21037/abs-21-31/rc).

Methods

We performed a review of the existing literature based on a search in the PubMed, Scopus and Web of Science databases. The search included papers published before December 2020 and was based on either of the keywords LD or TDAP combined with the following keywords: flap, breast reconstruction, morbidity.

The results from the search were screened based on title of the paper and if deemed relevant the abstract was read for final inclusion in the review. To be included papers had to be in either English or in a Scandinavian language.

Due to a rather large and heterogenic amount of papers concerning the donor site morbidity after LD flap harvest we choses to include only reviews and meta-analysis that had already discussed the excising evidence. The number of studies describing donor site morbidity after harvest of the remaining TDA flaps was rather scarce and we chose to include all studies that described a population who had been reconstructed by any of the muscle sparring flap versions and included and included an objective assessment of donor site morbidity.

Donor site morbidity

Due to a consistent anatomy and blood supply the LD flap is considered easy to harvest and a safe choice with regard to the risk of necrosis and flap loss (13,25). Harvest does, however, come with some downsides. Raising the flap ultimately leads to release and removal of one of the largest muscles in the body. By this, function of the muscle is compromised and a large donor site defect deep to the skin is formed. These are the key points that contribute to the possible donor site morbidity and the newer versions of the TDA flaps have been developed to diminish these two factors.

Contour and animation deformities

Contour deformity on the back after removal of the muscle along with a visible donor site scar is considered undesirable by some (26,27). In addition, animation deformity of the reconstructed breast due to activation of the LD muscle relative to the pectoralis major muscle may pose both a functional and an aesthetic problem (28). One solution to this problem is transection of the thoracodorsal nerve which does, however, lead to muscle atrophy resulting in volume loss over time. However, there is no consensus about transecting the nerve or not (28-30). When applying the muscle sparing versions of the flap the cavity deep to the skin is reduced considerably alleviating the problem of

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volume loss and thereby contour deformity. At the same time, the problems of animation deformity are remedied since muscle transfer is minimal.

Seroma formation

The donor site defect deep to the skin often leads to seroma formation, which can be very uncomfortable to the patient, require prolonged drainage or aspiration, and cause wound dehiscence with healing problems (31,32). Different solutions to this problem have been presented over time with quilting sutures being the most effective way of reducing prolonged seroma (33). Though a nuisance to the patient this problem is always self-limiting and will subside with time.

Shoulder dysfunction

The missing function of the LD muscle is probably what may cause the most problems (34). Although it is believed that activation of agonistic muscles over time will compensate for the lack of LD function, several studies do, however, suggest that harvest of the flap can lead to some degree of impaired shoulder function, chronic pain and discomfort. The extent and severity of any shoulder-related donor site morbidity is, however, debated and the published evidence is both scarce and ambiguous.

The conventional LD flap

Numerous papers of varying quality and with different outcome measures have investigated the possible shoulder-related donor site morbidity associated with harvest of the classical pedicled LD flap; three papers offering the highest LOE exists (35-37).

The latest of these was published by Steffenssen and colleagues in 2019 (35). This paper contains a systematic review and meta-analysis that includes 26 articles published up until May 2017. The majority of these articles deal with the conventional and the extended LD flap. Four of the articles investigated the outcome of reconstruction with the MS-LD. The review included 1,045 patients with level of evidence (LOE) ranging from II–V. The meta-analysis was based on eight articles alone-LOE II–III.

Overall, the authors found many of the published studies to be with small study populations and with great variation in terms of population, follow-up time and included parameters. The conclusion was, however, that there is a clear tendency that LD flap reconstructions can affect shoulder function, but that these limitations seem to be minimal. They found the existing literature on long-term shoulder function impairment to be insufficient to draw any conclusions and advocated further studies with higher levels of evidence and longer follow-up.

The two remaining reviews were published prior to that of Steffenssen *et al.* and include many of the same papers (36,37). Conclusions from these reviews were also that some impairment of the shoulder function can be observed after breast reconstruction with the LD flap. Furthermore, the review by Lee and colleagues found that the extended LD flap (E-LD) showed a relatively high functional morbidity whereas the MS-LD and the TDAP flap introduced minimal impairment (37).

The TDAP flap

Available evidence on donor site morbidity after harvest of the TDAP flap is very limited.

The authors of this paper published the results of a randomized clinical trial (RCT) studying the differences in shoulder dysfunction following a unilateral, delayed breast reconstruction by either the classical LD flap or the TDAP flap (38). The RCT included 40 women—18 in the LD group and 22 women in the TDAP group. The Constant Shoulder Score (CSS) that assesses pain, activity in daily life (ADL), range of motion (ROM) and strength on a combined scale ranging from 0–100 assessed by both patient-reported pain (PRP) and shoulder function.

The proportion of women reporting pain at baseline showed no difference between groups but was significantly higher for LD patients at twelve months after the reconstruction. When applying a logistic regressions model to adjust for pain at baseline, the study showed a significantly decreased risk of experiencing pain at twelve months after the breast reconstruction when reconstructed with the TDAP flap (OR =0.05, 95% CI: 0.005–0.51, P=0.011).

A significant positive impact on the shoulder function measured with CSS score was found both at 6 months (5.6 points, 95% CI: 0.1–11.0 points, P=0.047) and at 12 months (6.2 points, 95% CI: 0.5–12.0 points, P=0.033).

Sub-score analysis showed that the TDAP flap seems to have a significant positive effect on pain and ADL after one year, while there is no significant impact on ROM and strength. The same effect is found at six months after the surgery. At three months, only ADL showed a significant

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difference.

A retrospective cohort study including 49 women reconstructed by either the LD or TDAP flaps were published by the same group in 2018 (39). Again the CSS was used for assessment of shoulder function. Comparing LD-reconstructed to TDAP-reconstructed women, a significant reduction in overall shoulder function on the reconstructed side was found, with a mean difference in CSS score of 10.9 points (95% CI: 2.6–19.2 points, P=0.01). There was no difference on the non-reconstructed side. Mean follow-up for these study women was 33.7 months for the LD group and 26.6 for the TDAP group.

Comparison of the reconstructed and non-reconstructed side within each group also showed a highly significant difference for LD patients with a mean of 15.5 points (95% CI: 8.3–22.7 points, P=0.0001). In comparison, the same analysis for the TDAP patients showed a non-significant difference of 4.7 points (95% CI: −2.7 to 12.1 points, P=0.208).

Sub-score analysis was performed for the reconstructed side only. It showed that both pain and range of motion differed significantly between the two groups: Pain score by 3.2 points (95% CI: 1.2–5.2 points, P=0.003) and ROM score by 5.5 points (95% CI: 1.3–9.7 points, P=0.011). Both showed an advantage to the TDAP flap. ADL and strength did not differ significantly (39).

A study conducted by Hamdi and colleagues was published in 2008 as a retrospective cohort study (40). It included 22 patients who had partial breast reconstruction with a pedicled TDAP flap over a two-year period. The mean follow-up time from the reconstructive surgery was 19.4 months, and patients were assessed clinically evaluating LD muscle strength, shoulder mobility and thickness of the LD muscle. Comparison between the operated and non-operated sides was performed.

Results showed no detectable difference in muscle strength or muscle thickness when comparing the two sides. ROM was however, affected. Forward abduction was reduced in both active (range: 120–180° *vs.* 180–180°, P=0.041) and passive (range: 130–150° *vs.* 190–190°, P=0.017) motion, whereas abduction was only affected in passive motion (range: 110–145° *vs.* 180–180°, P=0.018). The remaining motions did not differ significantly and their conclusion was that donor site morbidity after TDAP flap harvest is low and acceptable.

Additionally, Lee and colleagues published a paper in 2016 also presenting a retrospective cohort analysis (41). The study included 293 patients who, over a 12-year period, had a free TDAP flap harvested for various reconstructive purposes. Shoulder function impairment was evaluated using the Quick-DASH tool that ranges from 1–100. This score is based on the patients' subjective evaluation of different disabilities of the shoulder, hand and arm with a high score indicating a high disability; a score below 10 is considered low disability. The study by Lee included 293 cases, 41 flaps (14%) were raised including a segment of LD muscle and could thus be classified as free MS-LD flaps.

Shoulder function impairment was only investigated in patients operated within the last five years of the study period. Out of the 137 possible candidates, 110 responded—the follow-up time was 37 months. Results showed that the mean disability score using Quick-DASH was 2.68 (0–18.2). In 90% of the patients, the disability score was below 10, translating to a low functional impairment of the shoulder.

One further study investigating shoulder function after harvest of the TDAP flap was published in 2018 by Elgohary and colleagues (42). This prospective study used the CSS to evaluate shoulder function before and one year after surgical treatment of hidradenitis suppurativa with resection and following closure with a pedicled TDAP flap. Though well conducted, the results cannot be used for comparison as the disease itself directly affects shoulder function and TDAP flap transfer in part is performed to gain better function. Results of the study does however show high scores for both the total CSS and sub-scores at one year after the surgery dependent on the pre-reconstructive stage of the disease.

The MS-LD flaps

Schwabegger and colleagues were the first to describe the muscle-sparing version of the LD flap in 2003 (17). Their paper presents the first eight cases in seven patients and includes a simple test of muscle strength and function compared to the non-operated side. The authors report normal conditions at two months after surgery.

Saint-Cyr and colleagues published the first retrospective series of twenty cases investigating twenty women who had a breast reconstruction with a transverse MS-LD based on the descending branch of the TDA (19). Patients underwent assessment of the functional and aesthetic outcome, including the DASH questionnaire. The mean follow-up time was 6.3 months (1.4–15.4 months). In unilateral cases (n=12), the operated and non-operated sides were compared. Neither ROM nor strength showed any significant difference between the two sides. The DASH

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score showed low disability with a mean score of 7.2 for function/symptoms, 2.9 for sports/music and 4.0 for work.

In 2010, Brackley and colleagues published their prospective series of women reconstructed with a MS-LD type II combined with an implant and a fascial envelope (43). The study included 22 cases in 18 patients. DASH was used to evaluate shoulder function, however, the mean follow-up time is not specified in the paper. Though still acceptably low, the disability scores were somewhat higher than in the series presented by Saint-Cyr with a mean score of 6.4 for function/symptoms, 15.7 for sports/music and 7.8 for work.

The main drawbacks of both studies are that the LOE is low and, furthermore, there is no control group or other group to compare these findings against.

The first study including more patient groups was published by Bonomi and colleagues in 2011 (21). This retrospective study included 82 women who had LD flap-based breast reconstruction over a period of three years. Women were classified into three groups based on reconstruction with either a classic LD flap with implant (n=35), MS-LD type II with implant (n=18) or E-LD for complete autologous reconstruction of the breast (n=29). Two questionnaires were completed by the patients between four and seven months after the operation—one evaluating functional outcome and satisfaction and the DASH questionnaire. Furthermore, a functional assessment of ROM and strength was performed at six months by a physiotherapist. Oddly, the authors did not investigate differences in these outcomes between the three groups. They indicated overall low shoulder function affection with a mean disability score of 7.8 function/symptoms, 19.0 for sports/music and 11.3 for work. 88% of patients reported no change in their ability to perform hobbies/sports and 93% perceived no permanent functional impairment. Objective evaluation showed a difference of less than 10° in ROM between the operated and non-operated side in 11 patients.

The only comparative study dealing with shoulder-related donor site morbidity after MS-LD reconstruction was published in 2013 by Kim and colleagues (22). They presented a retrospective cohort study based on review of medical records, including a total of 73 women who had immediate or delayed unilateral breast reconstruction with a pedicled LD flap. 37 cases were E-LD and 36 cases were MS-LD type II, either alone (n=14), in combination with an implant (n=18) or in combination with fat grafting (n=4). Shoulder ROM had been evaluated at four weeks and six months after the surgery. Limitations of movement, defined as not being able to lift their shoulder above 90°, was found in 9/36 MS-LD patients and 28/37 E-LD patients. At six months after rehabilitation, the same was true for 0/37 MS-LD patients and 3/36 E-LD patients. The multivariate analysis that followed showed how two factors significantly increased the risk of shoulder-movement limitations, these were: E-LD flap reconstruction (OR =7.5, 95% CI: 2.2–25.0, P=0.0011; and higher age OR =0.91, 95% CI: 0.81–0.99, P=0.0488). The paper does not, however, indicate whether analysis was performed on data at four weeks or six months.

Conclusions

In summary, the available evidence on shoulder morbidity following breast reconstruction with the TDA flaps is scarce and has a low LOE. Furthermore, outcome measures and follow-up time are not uniform and most of the publish studies either lack a control group or simply do not compare the relevant outcomes between groups. The heterogeneity of the patient population and the fact that the different flap types are often used in different patient categories further complicated the matter even further. However, there is a clear trend showing low functional impairment after reconstruction with the muscle sparring flap types.

The TDA flaps could be viewed as a spectrum ranging from the extended version of the full LD at one end and the purely perforator-based propeller TDAP flap at the other end. The invasiveness of the procedure relating to flap harvest decreases through the armamentarium of different designs, as less muscle is included in the pedicle. The theoretical extent of damage to muscle function is already minimal by the MS-LD type II. One could thus expect that the donor site morbidities after MS-LD flap harvest and TDAP flap harvest are similar. The available evidence points in that direction, but further prospective studies preferably comparing LD, MS-LD and TDAP flaps is needed to draw final conclusions in this respect.

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