Review Article

A clinical practice review on process efficiency in autologous breast reconstruction

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Abstract: Autologous breast reconstruction is considered the gold standard technique for breast reconstruction following mastectomy. Thanks to recent refinements the main focus of surgery has shifted from flaps survival and donor site morbidity to optimal aesthetic outcomes and patients' satisfaction. However, prolonged operative time remains a limiting aspect for many patients and surgeons who aim in improving access to care and outcomes. Process mapping is a quality improvement strategy consisting of the creation of a visual representation of a process to recognize errors, minimize waste and optimize outcomes. It has been effectively applied in abdominal based autologous breast reconstruction in nine papers. The process segments and analysis varied between published papers, but all authors focused on intraoperative process mapping and reported reduced operative times. Additional preoperative and postoperative factors have been studied and are commonly applied to further optimize efficiency (such as preoperative CTA, co-surgery model, flap perfusion evaluation, postoperative monitoring, and ERAS protocol). Although shorter operative times are related to decrease surgical morbidity and faster recovery time, and safety, the aesthetic outcome should remain the main focus in autologous breast reconstruction. In fact, the true ultimate aim should be the achievement of high patient satisfaction.

Keywords: Process mapping; efficiency; autologous breast reconstruction; quality improvement

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Introduction

Background

Breast reconstruction with autologous tissue is considered the gold standard method to restore breast shape after cancer because of the higher patient satisfaction and superior long-term outcomes (1-4). Constant improvements in surgical technique and better understanding of anatomy has allowed an increase in the complement of patient options. In fact, surgeons can tailor the reconstruction based on each individual's needs and donor site availability with a complication rate comparable to prosthetic breast reconstruction (5,6). Ancillary diagnostic procedures such as computed tomographic angiography (CTA) images and indocyanine green angiography has shown to reduce significantly donor-site complications and fat necrosis improving perforator selection and flap inset (7-9). In addition, enhanced recovery pathways have considerably improved the post-operative course reducing the length of stay, opioid requirement, and costs (10,11). For these

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reasons, in recent years, the focus of breast reconstructive microsurgeons has progressively shifted from flap success to aesthetics and efficiency (12).

Rationale and knowledge gap the need for increased efficiency

Prolonged operative time remains one of the main limits of autologous breast reconstruction procedures, which is made of multiple complex and potentially time-consuming steps. In a typical bilateral breast reconstruction, there can be four surgical sites. Globally, the procedure requires flap harvest, recipient site preparation, microsurgical anastomoses and flap inset, which can take from 8 to 12 hours to be completed in many surgical practices. Thus, surgeons' and patients' choice can be influenced towards prosthetic breast reconstruction, even in patients in which prostheses are typically contraindicated (13,14).

Prolonged operative time is associated with increased surgical and medical complications in many surgical fields (15). Specific to autologous breast reconstruction there is a significant raise in surgical (including flap failure rates), medical, wound complications and length of stay with increasing operative time (16-18). Additionally, with an increasing number of patients undergoing mastectomy and requiring autologous breast reconstruction there is an increasing need to be able to accommodate these patients. The safety and feasibility of performing multiple free flaps within the hours of a single working day has been previously demonstrated (19). Even if surgeon experience is considered a significant factor influencing the duration of the surgery together with other technical aspects (20) and extra-operative factors (21), a systematic approach to surgery with process mapping can significantly reduce operative time.

Process mapping is a technique initially used in industries to expedite production based on the partition of a complex process into multiple steps in order to analyze and optimize each step. It consists of a graphic diagram showing the sequence of activities and tasks performed by each individual involved in the overall process. Once the individual elements are visually represented any waste of time or errors becomes readily apparent. This analysis helps with optimization of every step resulting in improved productivity.

A multidisciplinary discussion should be utilized to create a map for the process. This should involve a clear definition of each step and the boundaries of the process to be analyzed. Specific symbols and colors should be used to identify the step and the involved team member. Once completed the map should be tested and approved (22,23). The application of this strategy in the healthcare systems is part of the quality improvement strategy recommended by The World Health Organization to increase efficiency and safety in medicine. In surgery it can be applied to the entire perioperative period, even though many authors mainly focus on intraoperative steps for the impact of operative room utilization and operative costs. Process mapping of the intraoperative period results in increased efficiency in different fields of surgery (24).

Objective: process efficiency in microsurgical breast reconstruction

General improvements and increased efficiency in autologous breast reconstruction is the aim of many plastic surgeons that desire to make these procedures more practical by minimizing time waste. The aim of the paper was to review the existing literature dealing with process efficiency evaluating its impact in improving autologous breast reconstruction.

Methods

Literature in NCBI database (PubMed) was reviewed using combinations of key words (efficiency, autologous breast reconstruction, process mapping, DIEP flap, operative time). All English papers were included.

Results

In the literature nine papers dealt with efficiency in autologous breast reconstruction. Two papers retrospectively evaluated the impact of different steps in autologous breast reconstruction without a proper process mapping approach (25,26). Process mapping was specifically utilized in seven papers dealing with unilateral or bilateral deep inferior epigastric perforator (DIEP) flap breast reconstruction. A retrospective review of data was performed in three papers, while four papers were based on prospectively acquired data. Two studies specifically compared the impact of process mapping between a mapped cohort/group and a non-mapped one (*Table 1*). Only one paper focused on optimizing efficiency in a non-DIEP flap breast reconstruction through a retrospective analysis of bilateral muscle-sparing TRAM flaps.

Lee *et al.* used a multidisciplinary team discussion based

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Table 1 Summary of all the study dealing with efficiency in microsurgical breast reconstruction available in the literature

Authors	Flap type and number of flaps	Country	Duration	Study design	Intervention stated	Number of process segments	Steps	Comparison of training level	Co-surgery attending model	Outcome considered
Elliott *et al.* 2007 (26)	111 muscle sparing free TRAM flaps: 91 unilateral, 10 bilateral	United States	3 years	Retrospective review	Standardization of operative sequence	No process mapping	N/A	N/A	N/A Complication	Operative time
Lee *et al.* 2008 (27)	225 DIEP flaps: 50 unilateral and 50 bilateral before pathway, 25 unilateral and 25 bilateral after pathway	United States	4 years	Prospectively acquired database	Intraoperative pathway based on "relational coordination" teamwork. Comparison between mapped and non-mapped group	9 steps: - Mastectomy - Perforator dissection - Flap harvest - Recipient vessel harvest - Division of vessels - Flap transfer - Microsurgery - Flap inset - Closure	N/A	N/A	N/A	Operative time Complications Operating room and hospital costs Administration of prophylactic antibiotics and heparin Operating room staff satisfaction surveys
Canizares *et al.* 2015 (25)	104 DIEP flaps: 32 unilateral, 36 bilateral	United States	6 months	Retrospective review	Standardization of operative sequence	- No process mapping	N/A	N/A	N/A	Operative time
Marsh *et al.* 2016 (28)	163 immediate, delayed, unilateral or bilateral DIEP flaps	United Kingdom	12 months	Retrospective review	Process mapping	- Mastectomy - Prep recipient vessels - Anastomosis - Hemostasis - Flap inset - Wound closure - Simultaneous flap elevation, harvest and abdominal closure - Simultaneous flap shaping	N/A	N/A	N/A	Operative time Complications

Table 1 (*continued*)

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Table 1 (*continued*)

Authors	Flap type and number of flaps	Country	Duration	Study design	Intervention stated	Number of process segments	Steps	Comparison of training level	Co-surgery attending model	Outcome considered
Sharma *et al.* 2019 (29)	20 unilateral DIEP flaps: process mapped 6 delayed and 4 immediate, control 3 delayed and 7 immediate	United Kingdom	N/A	Prospective cohort study comparing two groups	Process mapping Comparison between mapped and control group	- Preparation and draping - Initial flap raise - Perforator dissection - Vessel preparation and Flap inset - Abdominal closure - Microsurgery - Breast/Flap closure - Final transfer	100	N/A	N/A	Operative time
Haddock and Teotia 2020 (30)	147 unilateral DIEP flaps	United States	9 months	Prospective process analysis	Process mapping	- Flap harvest - Microsurgery	8	Yes	Yes 3/4-person team	Operative time Complications
Haddock and Teotia 2021 (12)	50 consecutive bilateral DIEP flaps	United States	8 months	Prospective process analysis	Process mapping	- Recipient site preparation - Flap harvest - Microsurgery - Breast inset - Abdominal closure	23	Yes	Yes 3/4-person team	Operative time Complications
Easton *et al.* 2022 (32)	32 bilateral autologous breast reconstruction with DIEP, TRAM, flaps	United States	5 years	Retrospective cohort study	4DX business Model (the 4 Disciplines of Execution)	- Preoperative and intraoperative interventions - Timing of presurgical steps - Timing of intraoperative steps (chest dissection, perforator dissection, anastomosis - Procedure duration	N/A	No	Yes	Operative time Length of stay Complications
Haddock *et al.* 2023 (31)	375 bilateral DIEP flaps	United States	- 9 months for flap harvest and microsurgery - 8 months for entire operation	Prospective process analysis	Process mapping	- Recipient site preparation - Flap harvest - Microsurgery -Breast inset -Abdominal closure	8 23	Yes	Yes 3/4-person team	Operative time Complications

N/A, not available; DIEP, deep inferior epigastric perforator; TRAM, transverse rectus abdominal muscle.

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on "relational coordination" teamwork, similar in design to a Harvard Business School model to identify each step (27). Marsh *et al.* used a personal approach to process mapping, without stating the method used to select different steps (28). Sharma *et al.* based the process mapping on the observation of senior author's experience (29). Haddock and Teotia mapped exclusively the surgical procedure and based the selection of different steps on their experience discussing the map with the team before surgery (30).

Even if the number, type, and order of steps differ among papers, the main categories were in common. All authors analyzed the steps involving flap harvest and microsurgery. Lee *et al.* and Marsh *et al.* included the mastectomy in the process mapping in the immediate breast reconstruction group (27,28). All surgeons suggested to perform different steps in sequence and in parallel with simultaneous execution of multiple steps concurrently (i.e., mastectomy and flap elevation, anastomosis, and abdominal closure etc.).

The primary outcome measured in all papers was operative time. Elliott *et al.* reported an average operative time of 185 minutes (3 hours and 5 minutes) for unilateral free TRAM flap breast reconstruction (26). Lee *et al.* compared outcomes before and after implementation of the mapping protocol. They reported a significant reduction of operative time both in unilateral (from 8.2 to 6.9 hours) and bilateral reconstruction (from 12.8 to 10.6 hours). Additional outcomes considered were the rate of complication, which remained the same, the cost of the surgery, which decreased. The intraoperative administration of antibiotic and heparin became more consistent in the mapped group. The satisfaction survey showed increased staff satisfaction (27). Canizares *et al.* reported an average operative time of 201 minutes (3 hours and 21 minutes) for unilateral cases and 346 minutes (5 hours and 46 minutes) for bilateral cases (25). Marsh *et al.* reported a mean operative time including unilateral and bilateral cases of 248 minutes (4 hours and 8 minutes) (28).

Sharma *et al.* compared a process-mapped group with a non-mapped group of unilateral DIEP flaps showing a significant reduction of operative time, 163.1 minutes (2 hours and 43 minutes) *vs.* 219.2 minutes (3 hours and 39 minutes) respectively. Differences in techniques used, pedicle length and used of barbed sutures with comparable complication rate were reported (29). In 2020, Haddock and Teotia reported an average total procedure time for bilateral autologous breast reconstruction with DIEP flaps of 340.3 minutes (5 hours and 40 minutes) with 73.1 minutes improvement compared to historical data (30). In this series the authors mapped only a portion of the operation. The same authors, in 2021, reported a mean operative time from skin to skin of 238 min (3 hours and 58 minutes) for bilateral cases. The number of complications remained comparable to non-mapped surgery (12). In a most recent paper a decrease in risk of morbidity was associated to the process mapping group (31). The impact of different level of expertise on each step was considered for training purposes in each study. Easton *et al.* evaluated the impact of the application of a business model called the Four Disciplines of Execution in increasing efficiency in autologous breast reconstruction. They retrospectively compared a pre (15 cases of bilateral breast reconstruction) and a post (17 cases of bilateral breast reconstruction) intervention cohort aiming in performing the surgery in less than nine hours. Even if comparing cohorts with different types of autologous breast reconstruction, they were able to show a significant reduction of operative time and length of stay without an increase of complications (32).

In all included studies the surgeons were aware of the process mapping and the increased awareness of tracking operative time. While the Hawthorne effect very likely plays a roll (33), one study evaluated the sustained impact of process analysis. Haddock and Teotia evaluated the sustained impact of their two process analysis studies before, between and after the study periods (31). The findings were significant in that the benefits were sustained in both operative efficiency and decreased morbidity following the process analysis time periods (see *Figure 1*).

Discussion

Autologous breast reconstruction is an ideal field for process mapping: each procedure can be long, made of multiple complex surgical steps requiring coordination and a precise sequence. In addition, the number of patients requiring, or electing, autologous breast reconstruction continues to increase. In current times the DIEP flap is the most common autologous option, and for these reasons, several authors have focused on improving efficiency of the procedure. A comprehensive study of the impact of process mapping on alternative flaps has yet to be performed.

The process mapping produced a reduction in operative time in all studies analyzed, even if the steps and categories considered were different among different facilities. This confirms the role of process mapping as a valuable tool to optimize efficiency in autologous breast reconstruction (24). A validated template shared by the international community

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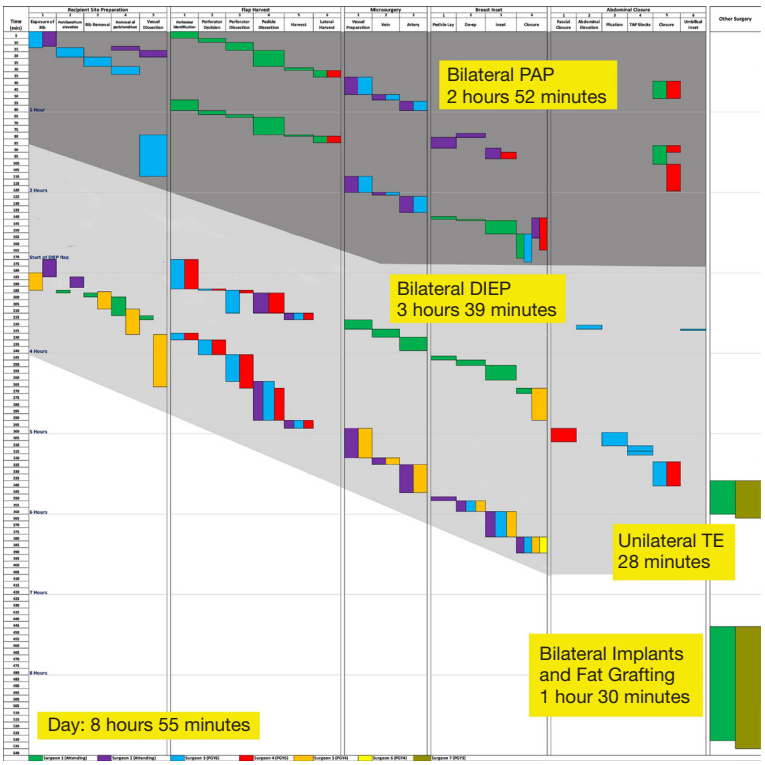

Figure 1 Example of process mapping for two cases of bilateral breast reconstruction with PAP flaps and DIEP flaps performed in the same day and same operative room. PAP, profunda artery perforator; DIEP, deep inferior epigastric perforator; TE, tissue expander.

of breast reconstructive microsurgeons would allow for comparisons and improvement in different centers worldwide. Further studies following the Standards for Quality Improvement Reporting Excellence (SQUIRE) guidelines could scientifically validate results obtained (34). Improved communication between team members and coordinated work between them are reported as the main advantages of process mapping with improvements in operative time, cost, quality measures, and staff satisfaction with a comparable complication rate (24). The use of different techniques and devices among mapped and non-mapped groups to reduce operative time can be considered a confounding variable.

Aside from intraoperative mapping, additional factors involving the preoperative and postoperative phases are known to improve autologous breast reconstruction efficiency and are commonly applied. Preoperative strategies proposed include a two-stage breast reconstruction approach, preoperative planning, and a multiple surgeon operating team. The reconstruction in 2 stages, initially proposed to manage the impact of post mastectomy radiotherapy in autologous breast reconstruction (35), has been shown to reduce operative time and improve efficiency in unilateral and bilateral DIEP flap breast reconstruction (36). Preoperative planning and selection of perforators guided by computed tomographic angiography imaging is associated with a significant reduction in overall operative time and flap harvest (7). The operating team is made up of at least two surgeons that usually work simultaneously in different steps of the surgery allowing different procedures to be performed at the same time (such as recipient site preparation and flaps harvesting or microsurgery and donor site closure). The co-surgery model, based on two expert microsurgeons working together has been shown to further optimize surgical efficiency and outcomes in DIEP breast reconstruction (37). Furthermore, flap perfusion evaluation, postoperative monitoring, and enhanced recovery after surgery (ERAS) protocols have optimized post-operative care (10,11).

The great benefits in terms of efficiency and outcomes offered by process mapping applied to DIEP flap breast reconstruction support its application also to secondary options for autologous breast reconstruction (i.e., Profunda

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Artery Perforator Flap, Lumbar Artery Perforator Flap, etc.). In addition, multiple donor sites and position changes can be needed with increased complexity of surgical flow (38-40).

Easton *et al.* (32) did include in their retrospective review several different types of flaps [i.e., DIEP, TRAM, profunda artery perforator (PAP), transverse upper gracilis (TUG)]. However, the different steps of the process did not apply equally to all flaps thus quantitative analysis were performed only with DIEP/TRAM flaps.

Utilization of process mapping is ideal for these procedures and should be implemented as they become more common at centers of excellence.

Process mapping is one of many quality improvement strategies and instead of being considered an endpoint in efficiency optimization it should be considered one of the multiple tools available (41). Additional active quality improvement strategies such as deliberate practice, Plan-Do-Study-Act—PDSA, and Six Sigma or Lean Six Sigma can be used to further reduce wasted time and implement error recognition strategies, taking advantage of constant feedback systems and information provided by mapped surgeries (31,42).

Although aimed in limiting operative time and complications, quality improvement strategies in breast reconstruction should not distract surgeons from the final aesthetic shape of the breast. In fact, the ultimate goal of the surgery is to obtain the ideal aesthetic result for each patient limiting morbidity and time waste. With proper control of the operating environment there is no need to compromise in any of these goals.

The main limitation of this review is related to the scarce amount of paper available in the literature dealing with process efficiency and to the fact that the majority of papers deal with DIEP flap.

Conclusions

Process mapping is a valid strategy when seeing to implement efficiency in autologous breast reconstruction. Identification of surgical steps and implementation of each phase of surgery are effective in reducing operative time and increasing outcomes. The continuous feedback offered with the constant analysis of surgical procedures represent a valuable source of information for team members to evaluate and improve their practice. Still, autologous breast reconstruction aims to restore and potentially enhance the patient aesthetic outcomes after mastectomy and this goal is of paramount importance. Efficiency does not have to compromise the overall outcome for patients.

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