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Review Article

Functional donor-site morbidity following reconstruction with pectoralis major flaps: A systematic review

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ABSTRACT

Background: Pectoralis major muscle/myocutaneous flaps (PMMFs) are commonly used in reconstructive surgery, but may result in shoulder disability on the donor side. A systematic review evaluating this morbidity could be beneficial for guiding patients and providers considering this procedure.
Methods: In October 2022, a systematic review of studies evaluating quantitative/qualitative measures of functional morbidity after PMMF was conducted. The results were categorized into PMMF's effect on range of motion (ROM), strength, and ability to complete shoulder-related activities/quality of life.
Results: Eleven studies were included for analysis, which analyzed standard PMMF and two PMMF variants that spared portions of the muscle. Three of five studies demonstrated reduced shoulder ROM for standard PMMF versus controls lasting at least 4 months after head and neck reconstruction. Two of five studies, including two prospective studies demonstrated reduced shoulder strength for standard PMMF versus controls lasting at least 3 months after surgery. Five of nine studies found significant impairment in the ability to conduct shoulder-related activities, including work, up to one year postoperatively for standard PMMF versus controls.

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Muscle-sparing PMMF variants exhibited more promising outcomes in some categories.

Conclusion: Standard PMMF results in prolonged reductions in shoulder ROM and strength, which may impair patients in shoulder-related activities. Other reconstructive options should be considered in patients who frequently participate in such activities. For patients requiring PMMF, muscle-sparing PMMF variants should be considered as alternatives to the standard PMMF.

Introduction

Since its first description, the pectoralis major muscle/myocutaneous flap (PMMF) has become a common choice in reconstructive surgery.[1] Originating from the medial clavicle and anterior sternum before inserting into the humerus, the pectoralis major can be mobilized into various wound locations, such as the neck, chest, and shoulder.[2] This muscle plays a crucial role in shoulder function, primarily coordinating adduction, and internal rotation at the glenohumeral joint.[3] In the standard PMMF, the muscle is elevated from the chest and released from both its origin and insertion, enabling advancement and rotation into the defect.[4] Thus, harvesting the PMMF may have significant consequences for shoulder function.

Several studies have attempted to quantify the functional impact on patients after PMMF. However, these studies analyze different surgical techniques and functional outcomes, making it challenging for providers to characterize the true functional morbidity of PMMF for patients. To aid in this discussion, we conducted a systematic review of the literature on functional donor-site morbidity following PMMF. Our study aimed to synthesize the effects on donor-site range of motion (ROM), muscle strength, and patient activities to provide more clarity for patients and providers considering the procedure.

Methods

A review protocol was registered on the International Prospective Register of Systematic Reviews, and the search strategy adhered to the Preferred Reporting Items for Systematic Reviews and Meta-analysis guidelines.[5,6]

In October 2022, a literature search of PubMed, Embase, and Web of Science databases was conducted. The search terms included *myocutaneous flap, muscle flap, musculocutaneous flap, myodermal flap, free tissue flap, free flaps, recovery of function, physical function, functional outcomes, functional implications, quality of life* (*QOL*), *sensory recovery, extremity dysfunction, range of motion*, and *strength.*

Figure 1 depicts the article selection protocol. After excluding duplicates, two authors conducted a full abstract review using Rayyan (Qatar Computing Research Institute, Doha, Qatar), with conflicting inclusions or exclusions resolved before the full article review. Article types excluded comprised conference abstracts, meta-analyses, systematic reviews, case reports/series with $<$10 patients, anatomical studies, and articles not reporting qualitative/quantitative measures of donor-site functional morbidity. After applying exclusion criteria, 11 articles were included. The primary outcomes of interest were categorized into three areas: ROM, muscle strength, and QOL.

PubMed, Web of Science & Embase search using:

'Myocutaneous Flap'	'Myodermal flap'	&	'Recovery of function'	'Functional implications'	'Quality of life'
'Muscle flap'	'Free tissue flap'		'Physical function'	'Range of motion'	'Sensory recovery'
'Musculocutaneous flap'	'Free flaps'		'Functional outcomes'	'Strength'	'Extremity dysfunction'

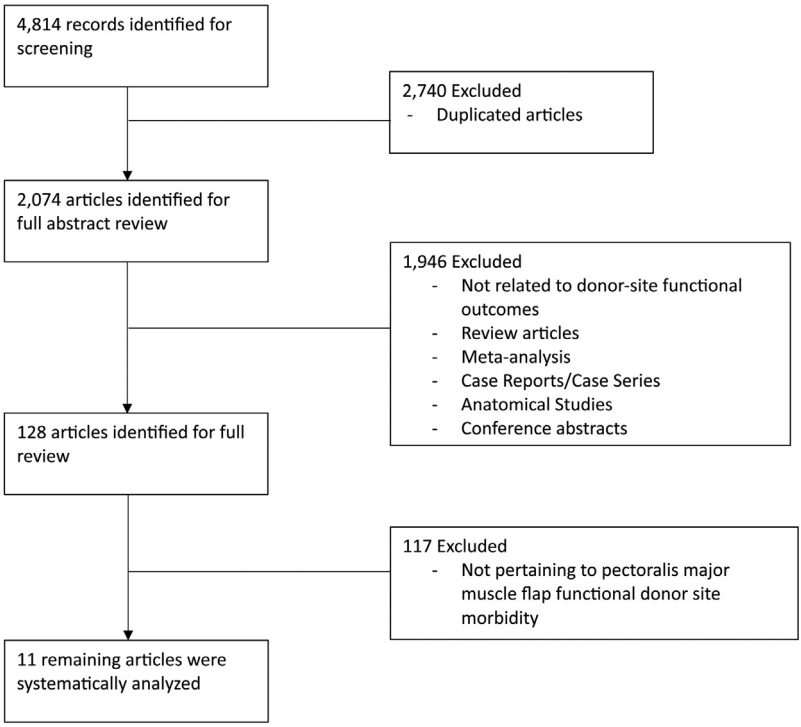

Figure 1. Flowchart of the selection of eligible articles.

Results

Included studies

Table 1 provides an overview of the included studies. Eleven articles were included for analysis. Along with the standard harvest technique, different variations of the pectoralis major flap were described in these studies. First, Rauchenwald described a modified muscle-sparing PMMF (mmsPMMF) that preserved the clavicular and upper sternocostal regions of muscle, elevating only a strip of the inferior portion.[7] Second, Chen used an extensive segmental PMMF (esPMMF), which involved the harvest of only the inferolateral portion of the pectoralis major along with a skin paddle extending over the abdomen.[8]

The PMMFs were primarily used for the reconstruction of wounds of the head and neck. However, two articles used PMMF for coverage of sternal wounds.[9,10]

Table 1
Detailed description of included articles.

Author, year	Study design	Treatment group		Control group		Reconstructive indication	Outcomes	Follow-up duration	CEBM LOE
		n	operative technique	*n*	operative technique				
Anehosur, et al., 2020	Prospective cohort	20	PMMF	20	Skin grafts and non-PMMF free flaps	Modified radical neck dissection	ROM, MMT, and SDQ,	6 months (mean)	2
Chen, et al., 2017	Prospective cohort	51	esPMMF	40	PMMF	Oral and oropharyngeal SCC resection	ROM	6–36 months (range)	2
Daigeler, et al., 2009	Retrospective cohort	69	PMMF	• 15 • 11	• Group 2: No PMMF; healthy patients • Group 3: No PMMF; patients treated for osteomyelitis	• None • Sternal debridement for osteomyelitis	MMT, ROM	1–9 years (range)	3
Moukarbel et al., 2010	Prospective cohort	8	PMMF	• 8 • 9	• Contralateral shoulder • Laryngectomy without PMMF	Laryngectomy for HNC	ROM, MMT, and SPADI to assess QOL	26.8 months (mean)	2
Rauchenwald et al., 2021	Retrospective cohort	6	Modified muscle-sparing PMMF	6	Contralateral shoulder	Salvage laryngectomy for HNC	ROM, MMT, and QOLQ	4–60 months (range)	3
Refos et al., 2016	Cross-sectional	• 9 • 26	• Group 1: Unilateral PMMF + ipsilateral neck dissection + similar contralateral neck dissection • Group 2: Unilateral PMMF + ipsilateral neck dissection + no or dissimilar contralateral neck dissection	47	• Group 3: No PMFF + unilateral or bilateral neck dissection	Neck dissection and/or other soft tissue defect	ROM and SDQ	4–226 months (range)	4

(*continued on next page*)

Table 1 (*continued*)

Author, year	Study design	Treatment group		Control group		Reconstructive indication	Outcomes	Follow-up duration	CEBM LOE
		n	operative technique	*n*	operative technique				
Merve et al., 2009	Prospective cohort	22	PMMF	35	Neck dissection without PMMF	HNC	Constant score	>4 months	2
Hsing et al., 2011	Prospective cohort	58	PMMF	42	Non-PMMF free flaps	Oral cavity cancer resection	UW-QOLQ	>13 months	2
Sun et al., 2015	Prospective cohort	46	PMMF	46	Non-PMMF flap	HNC	DASHQ	>1 year	2
Xiao et al., 2013	Retrospective cohort	46	PMMF	35	ALTFF	Oral cavity cancer resection	MOS SF-36 and UW-QOLQ	>1 year	3
Netscher et al., 2003	Prospective cohort	• 4 • 1 • 1	• Unilateral rectus muscle and unilateral PMMF • Bilateral PMMF • Unilateral rectus muscle	6	No reconstruction following uncomplicated coronary bypass grafting	Sternal wound infection following coronary bypass grafting	MMT, ROM, FIM, and QOLQ	>6 months	2

n, number of patients; HNC, Head and Neck Cancer; PMMF, Pectoralis Major Muscle/Myocutaneous flap; ALTFF, Anterolateral Thigh Perforator Free Flap; SCC, Squamous Cell Carcinoma; esPMMF, Extensive Segmental Pectoralis Major Myocutaneous Flap; ROM, Range of Motion; MMT, Manual Muscle Testing; SDQ, Shoulder Disability Questionnaire; UW-QOLQ, University of Washington Quality of Life Questionnaire; MOS SF-36, Medical Outcomes Study-Short Form-36; SPADI, Shoulder Pain and Disability Index; SDQ, Shoulder Disability Questionnaire; DASHQ, Disability of the Arm, Shoulder, and Hand Questionnaire; FIM, Functional Independence Measure; CEBM, Centre for Evidence Based Medicine; LOE, Level of Evidence.

Table 2
Articles assessing shoulder range of motion after pectoralis major flap harvest.

Author, year	Measurement method	n	Results
Anehosur, et al., 2020	Goniometer	40	• Reduced ROM in active flexion, extension, abduction, adduction, internal rotation, and external rotation for treatment and control groups at 3 months. • Greater reduction in shoulder adduction from baseline in treatment group versus control group at 3 months. • Increased ROM in active flexion, extension, abduction, adduction, internal rotation, and external rotation for treatment and control groups at 6 months. • Unclear if ROM returned to baseline.
Moukarbel et al., 2010	Goniometer	17	• Reduced ROM in flexion, internal, and external rotation for donor side shoulder compared to contralateral side after 3 months. • Non-significant reduction in range of abduction for donor side shoulder compared to the contralateral side after 3 months.
Refos et al., 2016	Inclinometer	61	• No difference in ROM of flexion, internal rotation, and external rotation between donor side of Group 1 and contralateral shoulder after 4 months. • No difference in ROM of flexion, internal rotation and external rotation between Group 2 and Group 3 after 4 months. • Reduced ROM in abduction for Group 2 compared to Group 3 after 4 months.
Daigeler, et al., 2009	Not specified	15	• Reduced ROM in eversion and inversion for the treatment group, measuring at 93% of the value observed in the healthy control group after one year.
Netscher et al., 2003	Goniometer	12	• No difference in ROM between the treatment and control group after 6 months. • No difference in shoulder ROM between the donor side and contralateral side shoulder of the treatment group after 6 months.
Chen, et al., 2017	Not specified	91	• Greater ROM in abduction for patients with extensive segmental pectoralis major myocutaneous flap compared to patients with standard pectoralis major myocutaneous flap after at least 6 months. • Unclear which other shoulder movements were assessed.
Rauchenwald et al., 2021	Not specified	6	• No difference in ROM in flexion, extension, and abduction between donor side shoulder and contralateral side after 4 months.

ROM, range of motion.

Shoulder range of motion

Shoulder ROM after PMMF reconstruction was assessed in seven studies (Table 2). Five studies compared standard PMMF to controls. Three of these studies found statistical evidence of reduced ROM for PMMF donor shoulders in various directions.

In their prospective study comparing PMMF versus skin grafts and non-PMMF flaps for head and neck reconstruction, Anehosur found that at 3 months, both groups experienced a significant reduction in active ROM in all directions compared to baseline.[11] The reduced ROM of shoulder adduction was significantly greater for the PMMF group versus controls. At 6 months, both groups experienced significant improvements in ROM compared to 3 months. For patients undergoing laryngectomy and unilateral PMMF, Moukarbel compared donor and contralateral shoulders prospectively and found significantly reduced ROM for the donor shoulder's flexion, internal rotation, and external rotation (mean follow-up = 26.8 months).[12] No differences were observed between the sides of their laryngectomy-only control group. Also examining patients undergoing neck reconstruction, Refos made two comparisons in their cross-sectional study.[13] They compared donor versus contralateral shoulder in patients who underwent similar bilateral neck dissections and unilateral PMMF (Group 1). After 4 months, they found no difference in ROM of abduction, flexion, internal rotation, and external rotation. However, when comparing donor shoulders of patients who underwent unilateral or bilateral dissimilar neck dissections with PMMF (Group 2) versus shoulders of patients who underwent comparable neck

dissections without PMMF (group 3), they observed significantly reduced ROM in abduction for Group 2 at 4 months.

In a retrospective study, Daigeler compared a group of patients who underwent PMMF after sternal debridement with a group of healthy controls (1–9 years follow-up). After one year, they observed that the PMMF treatment group achieved 93% of the ROM values observed in their healthy controls, with no statistical measurement reported.[10] In another prospective study, Netscher's treatment group included patients who developed a sternal wound infection after coronary artery bypass grafting (CABG) that required either a bilateral PMMF ($n = 4$), a unilateral PMMF with a unilateral rectus muscle flap ($n = 1$), or a unilateral rectus muscle flap alone ($n = 1$).[14] These patients were compared to patients who received no reconstruction following uncomplicated CABG. Testing demonstrated no differences in ROM between the treatment and control groups, as well as between the donor side and contralateral side shoulder of the treatment group after 6 months.

Two studies also analyzed ROM after other variations of PMMF. In a prospective comparison of esPMMF versus PMMF, Chen found greater abduction ROM for esPMMF after 6 months.[8] However, they did not specify which other shoulder movements were evaluated. Rauchenwald retrospectively compared the donor and contralateral side in patients undergoing mmsPMMF and found no difference in ROM in flexion, extension and abduction between donor-side shoulder and contralateral side after 4 months.[7]

Strength assessments

Five articles assessed shoulder strength following PMMF (Table 3). Among them, three studies compared the strength of patients who had undergone standard PMMF to controls, with two statistically demonstrating reduced postoperative strength in various domains up to 6 months after surgery.

Using dynamometry, Moukarbel compared the PMMF donor shoulder to the patient's contralateral shoulder and demonstrated a significant reduction in strength of flexion, external rotation, and adduction in the donor-side shoulder compared to the contralateral side after 3 months.[12] Netscher used a Baltimore Therapeutic Exercise Machine to assess pectoral muscle strength, measuring static isometric contractions and maximum isometric strength over six-second intervals.[9] For patients in the treatment group, significant reductions in pectoral muscle strength in various domains were observed when compared to the control group after 6 months. However, there was no difference in pectoral strength testing between the donor side and contralateral side shoulders for the treatment group patients.

Using dynamometry assessments after 1 year, Daigeler analyzed adduction strength in patients undergoing PMMF for sternal reconstruction.[10] Compared to both healthy controls and patients with sternal osteomyelitis without PMMF, PMMF patients had decreased mean isometric strength across 5 min and were able to maintain maximal isometric strength for a shorter period. The maximal dynamic strength of PMMF patients was also slightly reduced compared to healthy controls. However, they again provided no statistics for any of these comparisons. In the Anehosur study, the authors evaluated shoulder strength using a grading system based on the patient's ability to hold the tested limb in a specific position against gravity.[11] They found both the PMMF and control groups exhibited a reduction in strength in all domains 3 months postoperatively, although these did not reach significance. At 6 months, improvements in strength were observed in both groups.

In their analysis of mmsPMMF, Rauchenwald compared the strength of both the donor and contralateral shoulders after 4 months and found reduced adduction force on the donor side.[7] However, the methods of strength evaluation and the specific shoulder movements assessed were not stated.

Assessments of quality of life and impairments in shoulder-related activities

Eight articles evaluated the QOL and impairments in various shoulder-related activities after PMMF harvest using a variety of assessments (Table 4). Eight studies compared standard PMMF with controls. When comparing patients who underwent PMMF to control patients and donor shoulders to contralateral shoulders, five studies statistically demonstrated functional morbidity associated with PMMF.

Table 3
Articles assessing shoulder strength after pectoralis major flap harvest.

Author, year	Measurement method	*n*	Results
Moukarbel et al., 2010	Dynamometry	17	• Significant reduction in strength of flexion, external rotation, and adduction for donor side shoulder compared to contralateral side after 3 months.
Netscher et al., 2003	BTEM	12	• Significant impairment in pectoral muscle strength for patients in the treatment group who received PMMF when compared to the control group after 6 months. • Reduced peak pectoral strength, average pectoral strength, supination ability, and strength of shoulder adduction for patients in the treatment group who received PMMF compared to the control group after 6 months. • Reduced overall results of pectoralis muscle strength testing for patients in the treatment group who received PMMF compared to the control group after 6 months. • No difference in shoulder pectoral strength testing between the donor side and contralateral side shoulder of patients in the treatment group.
Anehosur, et al., 2020	Strength against gravity	40	• Non-significant decrease in strength of flexion, extension, abduction, adduction, internal rotation, and external rotation for treatment and control groups at 3 months. • Increase in shoulder strength in all directions for treatment and control groups at 6 months.
Daigeler, et al., 2009	Dynamometry	15	• Patients in the treatment group achieved 98.5% of the maximal dynamic strength and 92.5% of the mean pectoral isometric strength of the healthy control group after one year. • Reductions of maximal isometric contraction time to 52.8% and mean isometric strength to 80.2% for the treatment group compared to the healthy control group after one year. • No difference in strength parameters between the treatment group and the control group of patients with sternal osteomyelitis treated without PMMF after one year.
Rauchenwald et al., 2021	Not specified	6	• Reduced adduction force for donor side shoulder compared to contralateral side after 4 months. • Unclear which other shoulder movements were assessed.

ROM, range of motion; BTEM, Baltimore Therapeutic Exercise Machine.

Hsing and Xiao both used the University of Washington QOL Questionnaire to compare head and neck reconstruction using PMMF versus unspecified free flaps and anterolateral thigh free flaps (ALTFF), respectively.[15,16] This questionnaire evaluated items such as pain, appearance, and shoulder function assessments, ranging from no problems to severe impairments limiting work capacity. After 13 months, Hsing found reduced scores in the shoulder function domain for PMMF versus free flaps, indicating worse outcomes.[15] Similarly, Xiao found reduced scores in the shoulder domain with additional reductions in the appearance domain when comparing PMMF to ALTFF after one year.[16]

Sun compared patients who underwent PMMF to control patients who received non-PMMF flap reconstruction for head and neck reconstruction using the disability of the arm, shoulder, and hand questionnaire (DASHQ), which studies upper extremity-related daily activity performance.[17] Higher scores indicate greater disability. The non-PMMF flaps included 33 ALTFFs, eight sub mental island flaps, and five plasma myocutaneous flaps. After one year postoperatively, researchers observed generally low DASHQ scores in both groups but significantly higher scores in the PMMF group.

Moukarbel used the shoulder pain and disability index, which separately evaluates shoulder-related pain and disability, with higher scores indicating higher morbidity.[12] Regarding disability, PMMF patients experienced higher scores on the donor-side shoulder compared to the contralateral side after 3 months, with mean scores indicating moderate shoulder disability.[12]

In Netscher's study, multiple unique questionnaires were employed at 6 months postoperatively.[9] According to their study-specific questionnaire, patients in the treatment group were less satisfied

Table 4
Articles assessing quality of life and impairments in shoulder-related activities after pectoralis major flap harvest.

Reference	Measurement method	n	Results
Hsing et al., 2011	UW-QOLQ, Version 4	100	• No difference found in the global quality of life score between the PMMF and free flap group after 13 months. • Reduced scores in the shoulder domain of the quality of life assessment in the PMMF group compared to the free flap group after 13 months. • Thirty-three percent of patients considered their global quality of life to be good to excellent, while 36% reported having the same or worse health status than prior to treatment after 13 months.
Xiao et al., 2013	MOS SF-36 and UW-QOLQ	81	• Reduced scores in the shoulder and appearance domains of the quality of life assessment in the PMMF group compared to the ALTFF group.
Sun et al., 2015	DASHQ	92	• No difference between pre- and postoperative DASH scores in the control group after one year. • Increased postoperative DASH score compared to the preoperative DASH score in the treatment group after one year. • PMMF size was significantly associated with postoperative DASH score.
Moukarbel et al., 2010	Shoulder Pain and Disability Index (SPADI) questionnaire	17	• Higher SPADI scores on the donor side shoulder compared the contralateral side after 3 months. • Non-significant increase in pain scores on the donor side shoulder compared to the contralateral side after 3 months. • No difference in SPADI or pain scores between the treatment and control group after 3 months.
Netscher et al., 2003	25-item questionnaire, SFMPQ, VAS, PPI, and FIM	12	• Increased VAS and PPI scores in treatment group compared to the control group after 6 months. • Non-significant increase in SFMPQ scores in the treatment group compared to the control group after 6 months. • Less satisfaction in appearance and general functional capabilities for treatment group compared to the control group after 6 months. • No difference between groups when assessing general work capacity, ability to transition from sitting to standing, supinating to sitting, and ability to perform tasks such as opening a door and carrying a grocery bag after 6 months. • No differences found on FIM testing for activities evaluating pectoral or rectus muscle function between the treatment and control groups after 6 months.
Refos et al., 2016	SDQ and VAS	81	• SDQ score $>$ 0 for 56% of assessed donor side shoulders after 4 months. • No difference in SDQ scores between donor side of Group 1 and contralateral shoulder after 4 months. • No difference in SDQ scores between Group 2 and Group 3 after 4 months. • Greater SDQ scores for Group 3 compared to Group 2 in patients who received selective neck dissection as compared to radical neck dissection and modified radical neck dissection, after 4 months. • Patients reported a VAS score $>$ 0 in 33% of assessed donor side shoulders after 4 months. • No difference in VAS score between all groups after 4 months. • Non-significant increase in VAS score for donor side of Group 1 and contralateral shoulder after 4 months. • Shoulder stiffness scores $>$ 0 in 48% of assessed shoulders after 4 months. • No difference in shoulder stiffness scores between donor side of Group 1 and contralateral shoulder after 4 months. • Higher prevalence of shoulder stiffness for Group 3 compared to Group 2 after 4 months.
Anehosur, et al., 2020	SDQ	40	• No difference in SDQ scores between the treatment and control groups at 3 and 6 months. • Increased SDQ score at 6 months for both treatment and control groups.

(*continued on next page*)

Table 4 (*continued*)

Reference	Measurement method	n	Results
Merve et al., 2009	Constant Murley score	57	• No difference in scores between treatment and control group after 6 months.
Rauchenwald et al., 2021	EORTC QLQ-C30 and H&N35 and Constant Murley score	6	• Three of 180 total questions were answered with the subjective feeling of strong shoulder restrictions after 4 months. • The majority of questions about shoulder restrictions were answered with no or mild restrictions after 4 months. • No difference in Constant Murley score between donor and contralateral shoulders at a median 24.5 months follow-up.

UW-QOLQ, University of Washington Quality of Life Questionnaire, SDQ; Shoulder Disability Questionnaire, EORTC; European Organization for Research and Treatment of Cancer; DASHQ, Disability of the Arm, Shoulder, and Hand Questionnaire; MOS SF-36, Medical Outcomes Study-Short Form-36; ALTFF, Anterolateral Thigh Perforator Free Flap; SFMPQ, Short-Form McGill Pain Questionnaire; VAS, Visual Analog Scale; PPI, Present Pain Intensity.

with their overall appearance and general functional capabilities. The functional independence measure (FIM) was also employed, measuring the ability to complete certain daily tasks independently. No differences were found in the FIM scores for activities evaluating pectoral or rectus muscle function between the treatment and control groups after 6 months.

In terms of pain, Netscher observed increased pain levels based on the visual analog scale (VAS) and the present pain intensity scores in the treatment group; however, there was a non-significant rise in Short Form McGill Pain Questionnaire pain levels, compared to the control group after 6 months.[9] Refos also used the VAS scores and found there was only a non-significant increase for the donor side of Group 1 versus the contralateral shoulder.[13] No differences in the VAS scores were found between all groups after 4 months.

Anehosur and Refos both used the Shoulder Disability Questionnaire (SDQ), a pain-related questionnaire that evaluates common physical activities such as driving or typing, which may elicit shoulder-related symptoms.[11,13] Higher scores indicate greater impairment. Anehosur found both groups exhibited overall score increases at 6 months, but no differences in scores between the treatment and control group.[11] Refos administered SDQs at 4 months, along with surveys assessing pain and stiffness.[13] In 56% of patients, SDQ scores indicated some degree of shoulder morbidity. However, when comparing the donor versus contralateral shoulder in Group 1, no significant differences in SDQ scores were observed. Additionally, no significant differences were found when the donor sides of patients in Group 2 were compared to the shoulders of patients in Group 3.

Merve employed the constant score, which is derived from a questionnaire that evaluates pain, activities of daily living, ROM, and power via a composite scoring system.[18] No statistically significant differences were found in the Constant Murley Score between neck dissection patients who underwent PMMF and controls who did not.

Finally, Rauchenwald analyzed QOL following the harvest of the modified muscle-sparing PMMF using multiple questionnaires.[7] Also using the Constant Murley Score, there was no difference in composite scores between donor and contralateral shoulders at a median 24.5 months follow-up. Furthermore, there was no difference in the ability to conduct activities of daily living.

Discussion

PMMF is widely used due to its versatility, vascularity, and ease of mobilization to address various defects.[19] However, PMFF harvest may result in significant functional morbidity for patients. To help guide surgeon decision-making and improve the accuracy of patients' postoperative expectations, we conducted a systematic review of studies on functional morbidity after PMMF. The key findings of our study are that PMMF harvest results in (1) reduced ROM in the donor shoulder for at least 4 months after head and neck reconstruction, (2) reduced strength in the donor shoulder for at least 3 months, and (3) challenges with shoulder-related activities that last for at least one year.

Given its prominent role in shoulder mobility, it was unsurprising that most studies showed statistical evidence of reduced ROM after standard PMMF. These included measurements using both goniometry and inclinometry and comparisons to multiple different controls. However, two studies, by Daigeler and Netscher, did not demonstrate this difference.[9,10] These two studies were much smaller, so they may not have been adequately powered to show statistical significance. Furthermore, these were also the only two studies evaluating ROM after PMMF for sternal reconstruction, which may require a less extensive flap elevation, reducing postoperative edema and scarring that may contribute to reduced ROM.

Interestingly, there was less consensus regarding the effect of standard PMMF harvest on shoulder strength. Although Anehosur and Daigeler reported reductions in strength after PMMF, these were not reported as statistically significant.[10,11] Again, this could be due to a small sample size, and it is also unclear if the Daigeler study performed any statistical comparisons based on their methods. Moreover, it is also important to mention that only one of these studies was prospective, with two prospective studies by Moukarbel and Netscher reporting statistically significant reductions in shoulder strength.[9,12] When significant weaknesses were detected, they were primarily related to the strength of shoulder adduction, flexion, and external rotation. Considering the role of the pectoralis major muscle in shoulder strength, as well as the quality of the studies in this review, the evidence supports counseling patients that they will have reductions in shoulder strength after PMMF.

Although ROM and strength are certainly important traits on their own, perhaps even more important is how reductions in these areas may affect patients' abilities to conduct shoulder-related activities and their overall QOL. Three of eight studies demonstrated no relative impairment for PMMF versus controls, all using questionnaires that focused on pain.[9,12,13] The minimum follow-up time in these studies was 4 months, so it is possible that any additional postoperative pain incurred by PMMF harvest had resolved at this point.

However, studies that focused more specifically on the ability to complete various activities showed more harmful effects of PMMF. Netscher noted greater overall functional dissatisfaction without specifying activities, while Sun found a significant but small negative effect on the ability to complete daily activities, such as opening a jar or making a bed.[9,17] Moukarbel focused more specifically on the shoulder, demonstrating moderate shoulder disability in activities such as washing one's back or placing objects on shelves.[12] One year postoperatively, Hsing investigated the impact of shoulder morbidity on work capability and found a severe effect, causing some patients to change or even quit their occupation, a result echoed by Xiao.[15,16] Together, these findings suggest that patients should be counseled that they will have prolonged or possibly permanent disability in shoulder-related activities. Furthermore, providers should consider other available reconstructive options in patients who frequently participate in shoulder-related activities.

For patients with an absolute indication for PMMF, additional helpful findings of our review were strategies for improving functional outcomes. In the Anehosur study, the role of physiotherapy was highlighted.[11] Authors reported significant improvements in ROM, strength, and SDQ scores for patients who received PMMF at 6 months compared to an initial evaluation at 3 months.[11] This study uniquely provided a consistent physiotherapy regimen to patients in the treatment group, a factor that authors attributed to most of their observed improvements. Although the quality of this study was low, physiotherapy is a low-risk intervention that should be strongly considered in all patients undergoing PMMF.

Furthermore, our search identified two novel surgical variants of PMMF intended to reduce shoulder-related morbidity. Patients who underwent the esPMMF demonstrated improved ROM compared to patients who received standard PMMF. This favorable outcome may be explained by the specific harvest technique, which involves resectioning only the inferolateral portion of the pectoralis major, together with a skin paddle extending over the superior abdomen. Furthermore, the modified muscle-sparing PMMF exhibited a significant reduction solely in the strength of adduction relative to the contralateral side, with no reductions in ROM or QOL questionnaire scores. These results may also be attributed to the unique harvesting technique, which involved only resecting a strip of muscle, ensuring that the lower and inferior sternocostal parts of the muscles are preserved. Taken together, a conservative approach at pectoralis major flap harvest with the use of flap variants may contribute to preserving donor-site function.

There are several limitations of this study that must be acknowledged. First, some of the included articles had relatively small sample sizes, making it challenging to identify statistical significance in their findings. Second, there was considerable variability in the objective and subjective measurement tools used to evaluate donor-site functional morbidity, limiting the ability to compare outcomes between studies. Additionally, most studies lacked a baseline functional evaluation of patients' donor-side shoulders. Instead, functional analyses were mainly compared to either control patients or contralateral shoulders, potentially introducing confounding variables. Furthermore, this lack of baseline information obviates any analysis regarding the role of pre-habilitation.

Conclusion

Standard PMMF for head and neck reconstruction results in a significant reduction in shoulder ROM for at least 4 months after surgery. Additionally, standard PMMF also results in a significant reduction in shoulder strength for at least 3 months. These deficits may result in considerable impairment in shoulder-related function, suggesting that PMMF should be used cautiously in those who participate in shoulder-related activities. However, it is crucial to recognize the indispensable role of the PMMF in some clinical scenarios, such as treating severe sternum infections, where it often serves as a vital treatment strategy and a last line of defense. In these instances, the overall benefits of PMMF may outweigh the drawbacks of temporary shoulder morbidity. Physiotherapy and the use of PMMF variants that spare portions of the pectoralis major muscle may reduce functional morbidity for those requiring PMMF. For future directions, we recommend adopting standardized measurements of functional outcomes and encourage collecting data on baseline functional status. This approach would enable more meaningful comparisons among Level 1 studies and could provide further insights into the role of pre- and post-rehabilitation.

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Not required

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