What about the donor site morbidity – how invasive is the free latissimus dorsi flap?

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Cite this article:
Bone Jt Open 2024;5(12):
1114–1119.

DOI: 10.1302/2633-1462.512.BJO-2024-0058.R1

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Aims

The free latissimus dorsi muscle (LDM) flap represents a workhorse procedure in the field of trauma and plastic surgery. However, only a small number of studies have examined this large group of patients with regard to the morbidity of flap harvest. The aim of this prospective study was therefore to objectively investigate the morbidity of a free LDM flap.

Methods

A control group (n = 100) without surgery was recruited to assess the differences in strength and range of motion (ROM) in the shoulder joint with regard to handedness of patients. Additionally, in 40 patients with free LDM flap surgery, these parameters were assessed in an identical manner.

Results

We measured higher values for all parameters assessing force in the shoulder joint on the dominant side of patients in the control group. Moreover, LDM flap harvest caused a significant reduction in strength in the glenohumeral joint in all functions of the LDM that were assessed, ranging from 9.0% to 13.8%. Equally, we found a significantly reduced ROM in the shoulder at the side of the flap harvest. For both parameters, this effect was diminished, when the flap harvest took place on the dominant side of the patient.

Conclusion

LDM flap surgery leads to a significant impairment of the strength and ROM in the shoulder joint. Moreover, the donor morbidity must be differentiated with regard to handedness: harvest on the non-dominant side potentiates the already existing difference in strength and ROM. Conversely, if the harvest takes place on the dominant side of the patient, this difference is diminished.

Take home message

- The harvest of a free latissimus dorsi muscle flap leads to a significant impairment of the strength in the shoulder joint ranging between 9% and 14%. Additionally, the donor morbidity must be differentiated with regard to handedness: harvest on the non-dominant side potentiates the already existing difference in strength.
- Conversely, if the harvest takes place on the dominant side of the patient, this difference is diminished.

Introduction

Free latissimus dorsi muscle (LDM) flaps represent a workhorse procedure in the field of trauma and plastic surgery. Due to its consistent anatomy, including a reliable blood supply via the thoracodorsal vessels, and the large size of the muscle, the LDM flap can be used to treat a wide range of conditions. These include wound healing disorders, infections, and (functional) reconstructive procedures following trauma and tumour surgery.[1-5] Although this procedure is a standard reconstructive

approach, the number of studies that objectively assess donor site morbidity (a key element in the indication for surgery) is still limited.[6] In particular, with regard to the possible loss of muscle strength in key movements of the ipsilateral glenohumeral joint, such as internal rotation, adduction, retroversion, and pull-up exercises, data from previous studies are limited because of small study populations and/or lack of objective assessment of muscle function.[6-11] The aim of this prospective study was to objectively evaluate the donor morbidity of free LDM flaps in terms of potential loss of muscle strength and range of motion (ROM) at the glenohumeral joint.

Methods

Study design

In this single-centre, prospective study, we collected data from 100 healthy subjects (control group; no LDM flap surgery). In addition, patients who underwent free LDM flap reconstruction between September 2017 and December 2022 (study group) were prospectively enrolled in the study. The study design was chosen because our preliminary data, as well as studies by others, showed that patients requiring free LDM flap surgery could not be adequately assessed for muscle function and ROM prior to surgery because they often suffered from temporary upper limb dysfunction.[1-5] Ethical approval was granted by the local ethics committee (ID: 21-0475). The study was conducted in accordance with the tenets of the 2013 Declaration of Helsinki and good clinical practice. All patients in the study group were operated on by the same surgeon (DE). In addition, the clinical and functional evaluation of all participants was standardized and performed by the same person (MH).

Patients and data collection

The control group (no free LDM surgery) and the study group (free LDM surgery) were evaluated for muscle strength of standardized movements and ROM in the glenohumeral joint. Inclusion criteria were patients aged > 18 years, capacity to consent, and a minimum follow-up of three months (for the study group). Follow-up for the study group continued postoperatively until May 2023, or was terminated upon patient death. Source data, including medical records, operative reports, premedication records, and physician letters, were reviewed for demographics, patient characteristics, and perioperative details. Muscle strength and glenohumeral ROM were defined as outcome parameters.

Outcome parameters: measurement of force and ROM in the glenohumeral joint

Specific load pads (Novel Germany, Germany) were used to quantify force measurements for movements typical of LDM. Maximum muscle strength values were recorded for all patients.

A series of four standardized movements in the glenohumeral joint were used to evaluate the morbidity of LDM flap harvest in patients: internal rotation, adduction, retroversion, and a pull-up.[12] Briefly, the maximum force of all these movements was measured in Newtons for five seconds each in both shoulders of each patient. Measurements for internal rotation, adduction, and retroversion were obtained by positioning the patients next to a column in a standardized manner. This procedure was then repeated for the contralateral side. Patients were then asked to perform a pull-up (a combination of movements in the shoulder joint typical of the action of the LDM) from a seated position. The load pad was then placed between the palms of both hands and the pull-up bar.

The ROM of the shoulder joint was equally examined in a standardized fashion, always starting from a neutral position and by using a standardized goniometer (Bauerfeind, Germany).[7,10,13] During examination, the movements were performed in a standardized sequence: anteversion, retroversion, abduction/elevation, and adduction. Before performing the internal and external rotation, the elbow joint was flexed at 90° – this was defined as the starting position.

Statistical analysis

Data are presented as means with SD, unless stated otherwise. Data were assumed to have a normal distribution. The Student's paired *t*-test was used to determine group differences on continuous dependent variables for normally distributed data. GraphPad Prism v. 6 (GraphPad Software, USA) was used as software for statistical analysis. Results were considered statistically significant at a probability level ≤ 0.05.

Results

Patient demographic data

During the initial screening process, 228 patients were identified for inclusion in the study. Subsequently, 88 patients had to be excluded after the initial screening for various reasons (Figure 1). Thus, a total of 140 patients (100 for the control group and 40 for the study group) were included in this study. Both groups were comparable in terms of demographics. The control group had a mean age of 55.6 years (SD 17.6), and 41 (41%) were female and 59 (59%) were male. The study group had a mean age of 55.2 years (SD 18.3), and 22 (55%) were female and 18 (45%) were male. We observed no significant difference in the demographic details of the two groups.

The mean follow-up for the study group was 15.3 months (SD 12.6). The most common indications for free flap surgery were trauma, followed by tumour resection and chronic wound healing disorders (Figure 2).

Outcome parameters

We observed significant differences ranging from 9.0% to 13.8% in maximum force for all motions/exercises evaluated when comparing the donor side to the contralateral side of patients (Table I). Specifically, the differences were 9.0% for a pull-up, 12.0% for retroversion, 12.3% for internal rotation, and 13.8% for adduction. A more detailed analysis of our findings and the relationship of the handedness of subjects to the harvest site demonstrated that a significant loss of maximal muscle strength occurs only when the flap harvest was on the non-dominant side of the patient. This holds true for all motions/exercises that were assessed (Table I).

Table II shows the results of our control group that received no LDM flap harvest. Here, we see significant differences in the maximal force for all motions/exercises that were assessed when considering the handedness of patients.

Similar to our findings on maximum force, our results demonstrate that a LDM flap harvest impairs the ROM of

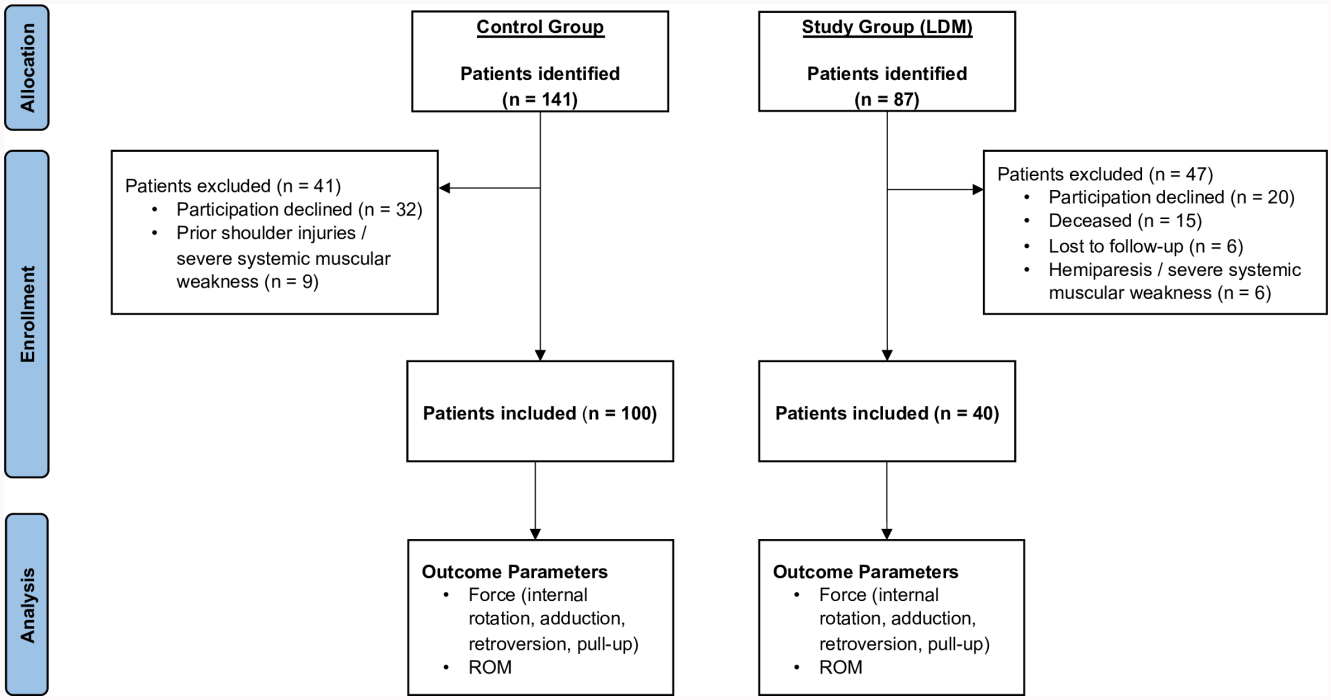

Fig. 1
Study flowchart. A total 140 patients were included in the study (n = 100 for the control group and n = 40 for the study group). For all patients, force (internal rotation, adduction, retroversion, and pull-up) and range off motion (ROM) (anteversion, retroversion, abduction/ elevation, and adduction, as well as internal and external rotation) in the glenohumeral joints were evaluated as outcome parameters. The mean follow-up for the study group with latissimus dorsi harvest was 15.3 months (SD 12.6). LDM, latissimus dorsi muscle.

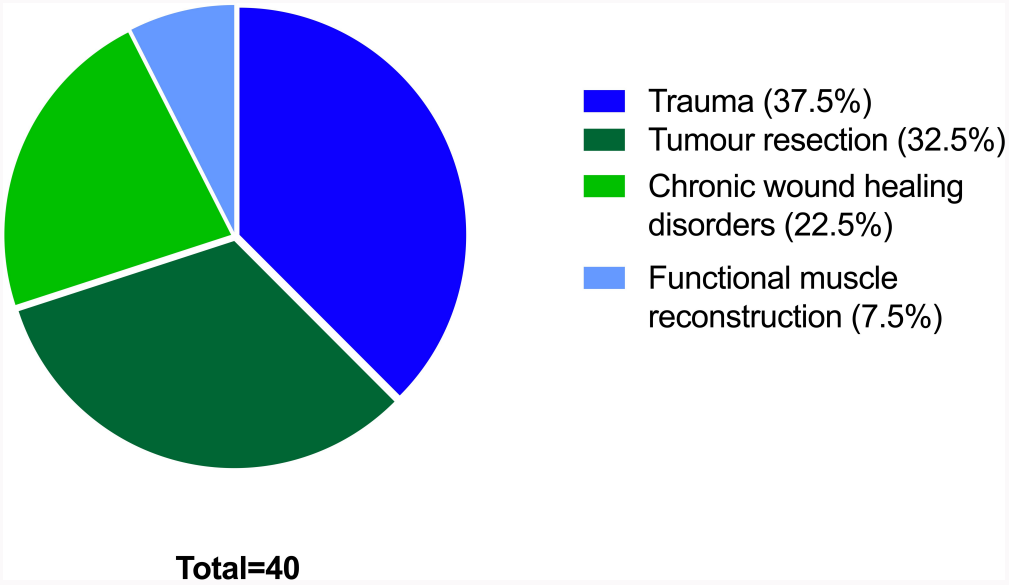

Fig. 2
Indication for free flap surgery (study group).

anteversion and abduction/elevation in the glenohumeral joint (2.0 and 2.9%, respectively; Table III). Again, when considering the relationship of the handedness of subjects to the harvest site, we were able to demonstrate that the loss of ROM only takes place when the harvest is on the non-dominant patient side. In the control group, we observed no significant differences between the ROM of the dominant and the non-dominant side of patients.

Discussion

This prospective study demonstrates that patients who underwent free LDM flap surgery have a significant difference in postoperative maximum force for several key glenohumeral joint motions (Table I). Free LDM flap surgery is rarely planned as an elective procedure and therefore possibly precludes a temporary functional impairment of patients.[1-5] We recognized these limitations in our initial data collection and

Table I. Maximum force of various movements in the glenohumeral joints 15.3 months (SD 12.6) after free latissimus dorsi muscle harvest.

Variable	N	Mean (SD)*	p-value†
Internal rotation			
Donor site (all patients)	40	56.2 (23.6)	**0.005**
Contralateral side (all patients)	40	64.1 (27.3)	
Donor site at non-dominant side	13	57.2 (23.1)	**0.010**
Contralateral side	13	75.5 (28.6)	
Donor site at dominant side	27	55.7 (24.3)	0.201
Contralateral side	27	58.6 (25.3)	
Adduction			
Donor site (all patients)	40	43.8 (18.2)	**0.007**
Contralateral side (all patients)	40	50.6 (24.6)	
Donor site at non-dominant side	13	46.3 (17.8)	**0.004**
Contralateral side	13	59.6 (26.3)	
Donor site at dominant side	27	42.6 (18.6)	0.214
Contralateral side	27	46.2 (23.0)	
Retroversion			
Donor site (all patients)	40	59.6 (23.0)	**0.001**
Contralateral side (all patients)	40	67.7 (26.1)	
Donor site at non-dominant side	13	58.8 (18.7)	**0.001**
Contralateral side	13	75.9 (25.4)	
Donor site at dominant side	27	60.0 (25.1)	0.133
Contralateral side	27	63.7 (26.0)	
Pull-up			
Donor site (all patients)	40	486.7 (236.4)	**0.013**
Contralateral side (all patients)	40	534.9 (265.7)	
Donor site at non-dominant side	13	485.1 (274.5)	**0.008**
Contralateral side	13	605.8 (343.5)	
Donor site at dominant side	27	487.5 (221.4)	0.456
Contralateral side	27	500.7 (218.5)	

Significant p-values are shown in bold.
Students *t*-test (paired) was used to determine group differences.
*Mean and SD are expressed in Newtons.
†Students *t*-test (paired) to determine group differences.

Table II. Results for maximum force of the control group.

Variable	N	Mean (SD)*	p-value†
Internal rotation			
Dominant side	100	75.8 (32.9)	0.017
Non-dominant side	100	72.0 (30.6)	
Adduction			
Dominant side	100	61.4 (28.8)	< 0.0001
Non-dominant side	100	54.5 (25.6)	
Retroversion			
Dominant side	100	82.6 (29.7)	0.041
Non-dominant side	100	79.5 (26.7)	
Pull-up			
Dominant side	88	635.3 (231.2)	0.040
Non-dominant side	88	599.1 (242.3)	

The control group consisted of 100 subjects who had not undergone free latissimus dorsi muscle surgery. Overall, 12 patients were unable to perform a pull-up; the results were therefore excluded for the pull-up exercise. All p-values are significant.
*Mean and SD are expressed in Newtons.
†Students *t*-test (paired) to determine group differences.

designed our study accordingly (no preoperative evaluation of patients and implementation of a control group without prior LDM harvest). Indeed, prospective studies with preoperative assessment of the morbidity of LDM flap surgery predominantly include patients with pedicled LDM flaps for elective breast reconstruction.[6,8,9,14,15]

In their review, Lee and Mun[6] evaluated studies on donor site morbidity of LDM harvest. Of the 22 studies included, 11 evaluated possible effects on shoulder strength after LDM harvest. The authors concluded that it is likely that shoulder strength is decreased after LDM harvest, but they were unable to determine the extent of the decrease or the type of movement affected. The different quality in strength assessment, as well the limited number of participants in these studies, is a likely reason for the inhomogeneous and overall inconclusive results. Indeed, only seven studies, all with small study populations of a maximum of 26 patients, performed instrumented muscle testing or quantification using a Salter spring balance after pedicled or free LDM harvest.[8–10,14–17] Several other studies only assessed a loss in muscle function with the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH),[18] or by manual muscle testing.[6] For the studies that used objective instrumented muscle testing, Saint-Cyr et al[14] and Laitung and Peck[17] reported no loss of muscle function.[14,17] However, only pedicled, muscle-sparing LDM flaps for breast reconstruction were assessed by Saint-Cyr et al,[14] while Laitung and Peck[17] only analyzed adduction in the shoulder (using a Salter spring balance). Both studies had a limited number of patients (24 and 19 patients, respectively). Indeed, a different surgical technique, as well as deficits in the study design, are the most likely reasons for the different results reported by these authors.

The authors of the five other articles reported a significant loss of force, predominantly for retroversion, adduction, and internal rotation.[8–10,15,16] These ranged between 11% and 45%.[8,9] We can confirm these results in a significantly larger study population. We observed a significant loss in muscle strength for all motions/exercises that were assessed. The reduction in force ranged from 9.0% (pull-up) to 13.8% (adduction) (Table I). In addition, to our knowledge, this study is the first to evaluate patient handedness in a significant study population with regard to donor site morbidity of LDM flaps. For this, we included a control group (n = 100) with no LDM flap surgery. Here, we observed a significant difference in all parameters that assessed force in the glenohumeral joint when comparing the dominant to the non-dominant side of the patient (Table II).

Interestingly, our analysis on the relationship of the handedness of subjects with morbidity of LDM flap surgery to the harvest site demonstrated that a significant difference

Table III. Significant differences in the range of motion in the glenohumeral joints when comparing latissimus dorsi muscle donor site to the contralateral side.

Variable	N	Mean (SD)*	p-value†
Anteversion			
Donor site (all patients)	40	161.6 (10.9)	**0.042**
Contralateral side (all patients)	40	165.0 (11.0)	
Donor site at non-dominant side	13	158.1 (12.5)	**0.015**
Contralateral side	13	166.9 (4.3)	
Donor site at dominant side	27	163.3 (9.9)	0.659
Contralateral side	27	164.1 (13.0)	
Retroversion			
Donor site (all patients)	40	37.9 (4.7)	0.070
Contralateral side (all patients)	40	39.3 (2.7)	
Donor site at non-dominant side	13	36.9 (4.8)	**0.040**
Contralateral side	13	40.0 (0.0)	
Donor site at dominant side	27	38.3 (4.6)	0.523
Contralateral side	27	38.9 (3.2)	
Abduction/elevation			
Donor site (all patients)	40	166.5 (21.5)	**0.004**
Contralateral side (all patients)	40	171.5 (20.0)	
Donor site at non-dominant side	13	165.8 (16.2)	**0.031**
Contralateral side	13	175.4 (6.3)	
Donor site at dominant side	27	166.9 (23.9)	0.053
Contralateral side	27	169.6 (23.9)	

Measurements for adduction, internal rotation, and external rotation showed no significant differences between the two sides. Follow-up was 15.3 months (SD 12.6). Significant p-values are shown in bold.
*Mean and SD are expressed in degrees.
†Students *t*-test (paired) to determine group differences.

of strength occurs only when the flap harvest was on the non-dominant side of the patient (Table I). Thus, we conclude that the harvest of a free LDM increases the already existing difference in maximum force in the glenohumeral joint when the surgery takes place on the patient's non-dominant side. Consequently, when the harvest takes place on the dominant side of the patient, the prior existing difference in maximum force is diminished and becomes similar to the contralateral, non-dominant, side.

A similar conclusion, albeit to a much lesser extent (i.e. loss of ROM between 2.0% and 2.9%), can be drawn regarding the ROM. Here, LDM flap harvest significantly impaired the ROM of the glenohumeral joint for anteversion and abduction/elevation (and to a lesser extent retroversion) (Table III). This difference became more pronounced when the harvest took place on the non-dominant side. Conversely, we observed no difference in ROM when the harvest took place on the patient's dominant side.

The same surgeon (DE) operated on all patients in the study group. We believe this may add to the quality of the presented results. By including a control group, we aimed to minimize the possibility of a confounding effect on our observations with regard to the relationship of handedness of patients to impairment of muscle function after LDM flap surgery. In addition, to our knowledge, this study includes the largest study population with an objective assessment of LDM donor site morbidity. Therefore, we believe that our results add significantly to the quality of data assessing morbidity of this common procedure.

However, several aspects of the study design may be seen as a limitation. Data collection before and after surgery would have provided superior data, as it would have provided a more comprehensive understanding of the procedure's effects. In the current study, patients requiring free LDM flap surgery could not be adequately assessed for muscle function and ROM prior to surgery. Indeed, the procedures were not planed as elective surgeries and often precluded a temporary functional impairment of patients.[1-5] This is a clear limitation of the study.

Moreover, we only report on a mean follow-up of 15.3 months. A longer follow-up period, as well as multiple follow-up intervals, would significantly help in understanding the long-term morbidity associated with LDM free flap surgery. Nevertheless, as previous studies, albeit with smaller study populations, demonstrated muscle function impairment of up to 92.5 months after surgery, we believe that the observed loss in muscle force after LDM harvest must be seen as permanent morbidity of this procedure.[6,10] Additionally, the current study should have assesed the prevalence, as well as duration, of postoperative physiotherapy. As this is very likely to have a significant effect on the force and ROM of the patients' donor site, future studies should include the assessment of this variable in their study design.

In the current study, we were able to validate implications of previous articles on donor site morbidity after free LDM flap surgery in the largest study population to date. In addition, by including a control group without LDM harvesting, weevaluated our results with regard to the handedness of the patients. Indeed, LDM flap harvest not only significantly impairs muscle strength in the shoulder joint (ranging from 9.0% for a pull-up to 13.8% for adduction in the shoulder), but also increases the already existing difference of the dominant and non-dominant side (when the harvest takes place on the weaker non-dominant side). Thus, surgeons must consider these findings when choosing the side from which the flap will be harvested. This is especially true for professional athletes and/or physically active patients.

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Funding statement

The authors received no financial or material support for the research, authorship, and/or publication of this article.

ICMJE COI statement

The authors have no conflicts of interest to declare.

Data sharing

The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

Acknowledgements

Presented at the 53rd Annual Congress of the German Society of Plastic Surgeons (DGPRAEC)/27, and the Annual Congress of the Society for German Aesthetic Surgery (VDAEPC) (14 September 2023).

Ethical review statement

Ethical approval was provided by the Local Ethics Committee (21-0475, LMU Munich, Germany).

Open access funding

Financial support for open access funding was provided by the authors' institution (LMU Open Access Fonds), LMU Munich, Germany; Grant Number: 491502892.