



# The extensor digitorum brevis muscle flap in lower limb reconstruction: A long-term follow-up

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**Summary Background:** The extensor digitorum brevis flap (EDB) is a small local muscle flap used primarily for the reconstruction of small tissue defects in the lower leg. Few studies investigate the long-term outcomes of the EDB flap, and concerns have been raised regarding long-term morbidity. The aim of this study was to investigate the long-term functional outcomes of the EDB flap.

**Methods:** All patients who had a lower limb reconstruction using a pedicled EDB muscle flap between 1997 and 2021 were identified and asked to participate in the study. Twenty-one patients agreed to participate and were invited for a long-term follow-up visit, including measurements of range of motion (ROM), foot sensibility, and the presence of deformities of the foot and ankle. Patient-reported outcome measures were collected using the foot and ankle outcome score (FAOS) and the self-reported foot and ankle score (SEFAS). The patients' non-reconstructed feet were used as controls.

**Results:** Decreased range of motion of the metatarsophalangeal joints was seen in the reconstructed side. None of the patients had a significant bowstringing phenomenon of the ankle or decreased sensibility of the foot dorsum. Six patients had some degree of lesser toe deformities. Worse SEFAS and FAOS scores were seen in patients who had EDB-reconstruction due to fracture-related soft tissue injuries.

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**Conclusion:** The long-term morbidity associated with the use of the pedicled EDB flap seems to be limited. This study may support the use of the EDB flap to reconstruct smaller defects of the lower leg; however, further studies including a larger number of patients would be of value. © 2026 The Author(s). Published by Elsevier Ltd on behalf of British Association of Plastic, Reconstructive and Aesthetic Surgeons. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

In modern reconstructive plastic surgery, there are many surgical options for the reconstruction of skin and tissue defects of the lower extremity.<sup>1-3</sup> Free microvascular flaps are often preferred reconstructive options in the lower leg due to their versatility and reliability.<sup>3,4</sup> However, microsurgery requires a considerable amount of resources, such as adequately trained personnel and sophisticated, costly equipment, which may not be available globally.<sup>5</sup> Furthermore, different salvage options should preferably be available in the case of free flap failure, even if a second free flap can be considered.<sup>6</sup> Due to these factors, local flaps are still a vital part of modern plastic surgery and should remain in every plastic surgeon's armamentarium.

A variety of local flaps can be used to reconstruct complex tissue defects of the leg, such as local perforator flaps and local muscle flaps, such as the soleus and gastrocnemius muscle flaps.<sup>7-9</sup> It can, however, be challenging to cover distal lower leg defects with the above-mentioned local flaps due to limited reach or the perforators being too close to the trauma zone.

The extensor digitorum brevis (EDB) muscle flap is a small muscle flap that can be used to reconstruct smaller defects primarily of the distal third of the lower leg, but it has also been used to reconstruct defects in the proximal third of the tibia.<sup>10-12</sup> It is usually harvested as a pedicled muscle flap, which is covered with a split-thickness skin graft after flap inset. Previous studies have shown good results regarding flap survival and short-term complications, although questions regarding long-term effects and donor site morbidity after the flap harvest have been raised, and few studies have focused on this aspect.<sup>13-16</sup>

The aim of this study was to investigate the long-term outcome of the pedicled EDB muscle flap when used for reconstruction of tissue defects in the lower extremity.

## Patients and methods

All patients who had a lower limb reconstruction using a pedicled EDB muscle flap between 1997 and 2021 were identified. The identified patients were sent a letter with information regarding the study and were asked to participate. The patients were also contacted by phone after the information letter had been sent. The study was approved by the Regional Ethics Review Board (No. 2018\18-31). All patient photographs are used with permission.

## Follow-up visit

At the follow-up visit, all patients were examined according to the study protocol. All measurements were done by the

same personnel. Standardised photographs and video recordings were obtained. The range of motion (ROM) of the ankle joint and toe joints was examined using goniometers. Sensibility on the dorsum of the feet supplied by the superficial peroneal nerve (SPN) and the deep peroneal nerve (DPN) was assessed using the monofilament test (10 g, Semmes-Weinstein 5.7). Pain perception in the same areas was assessed with the sharp/dull discrimination test using safety pins. Any deformities in the toes or ankle were noted, as well as the presence of hypertrophic scarring, altered sensation, wounds, and swelling. The patients were asked if they needed to use customised footwear and if there were any differences in shoe sizing. All variables were obtained for both feet, using the other foot as a control. The patients were also asked to complete the patient-reported outcome measures Self-reported Foot and Ankle Score (SEFAS) and Foot and Ankle Outcome Score (FAOS), which evaluate disorders of the foot and ankle, as well as the EuroQol 5-dimensions (EQ-5D) questionnaire, which measures health-related quality of life.<sup>17-19</sup>

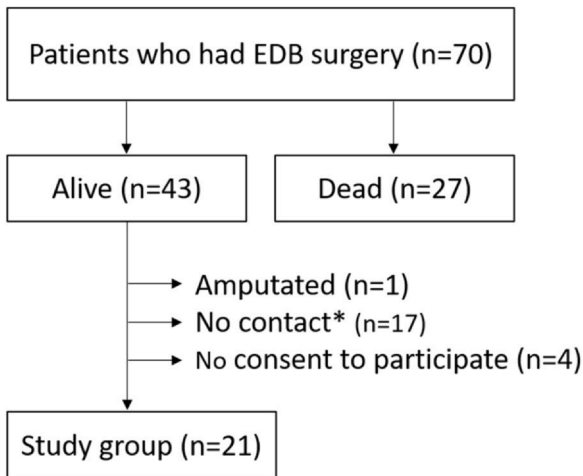
## Statistics

Distribution was tested with the Lilliefors test for normality. Descriptive data are presented as median (25th-75th centiles) unless otherwise stated, as most of the variables were not normally distributed. Probabilities of less than 0.05 were accepted as significant. Comparisons between the operated side and the control foot in the same individual were analysed using the Wilcoxon signed rank test and the McNemar test. Comparisons between groups were made using the Mann-Whitney *U* test and Fisher's exact test.

## Results

Forty-three patients were included in the study. Out of these, 17 patients could not be reached, four patients did not want to participate in the study, and one patient had a lower leg amputation of the reconstructed side before follow-up. Twenty-one patients remained and agreed to participate (Figure 1). One of the patients had a contralateral lower leg amputation due to another traumatic injury. A few of the patients are described in Figure 2.

Median follow-up time was 9.1 years, and the mean age at follow-up was 66.4 (SD 12.6) years. Fifteen (71%) of the patients were men. Most defects were located in the distal tibia area (33%), followed by the achilles tendon area (19%), the lateral malleolus (14%), the medial malleolus (14%), the heel (10%), the lateral foot (5%), and the proximal tibia (5%). Mean defect size was 13.1 (SD 10.6) cm<sup>2</sup>. EDB



**Figure 1** Patient selection. \*No response or no contact information. EDB, extensor digitorum brevis flap.

reconstruction was performed to cover complex soft tissue defects related to fractures in 12 (57%) of the cases, while 9 patients had reconstruction due to delayed wound healing, not related to a fracture. When comparing the two groups, a difference was observed regarding the prevalence of different shoe sizes between the patients' feet (6 vs. 0

patients,  $p=0.02$ ), which was higher in the fracture cohort. There was a tendency for reduced ability to stand on the affected leg in the fracture group (Table 1).

The range of motion in the metatarsophalangeal (MTP) joints and ankle joints was generally decreased in both groups, when compared with the non-reconstructed side (e.g., MTP2 ROM 61 vs 22 degrees,  $p < 0.001$ ; ankle ROM 54 vs 32 degrees,  $p < 0.001$ ). Regarding the MTP joints, primarily the ability to extend the toes was significantly lower on the EDB side (Table 2). No significant difference in range of motion was observed when directly comparing the fracture group and the delayed wound healing group. (e.g., ankle ROM 30.5 vs 32 degrees,  $p=0.60$ ) However, there was a significant decrease in ankle ROM compared with the control foot in the fracture group, which was not seen in the delayed wound healing group (Supplemental Tables 1-3).

There was a significantly higher degree of pain in the foot and ankle area at rest and during ambulation as measured with the numeric rating scale (NRS) in the EDB foot compared with the control foot in the whole study group (2.0 vs 0 points during ambulation,  $p=0.007$ ). In the subgroup analysis, this difference was only significant in the fracture group (Supplemental Tables 1 and 2).

There was no difference in sensibility on the dorsum of the foot when comparing the EDB side with the non-reconstructed side. A tendency of decreased sensibility to



**Figure 2** A: Male patient who had extensor digitorum brevis flap (EDB) flap reconstruction of a wound on the lower medial side of the right leg due to an open distal tibia fracture, Gustilo-Anderson 3B, treated with intramedullary nailing, 6 years post-operatively. B: Male patient who had EDB flap reconstruction of a dorsal right ankle wound due to skin necrosis and infection following a calcaneal tongue fracture treated with osteosynthesis, 8 years post-operatively. C: Male patient who had EDB flap reconstruction due to a trimalleolar fracture in the right ankle with subsequent skin necrosis. Mild hammer toe deformity, particularly of the second toe, is noted 13 years post-operatively. D: Male patient who had EDB flap reconstruction due to a hard-to-heal ulcer on the dorsal side of the right ankle following Achilles tendon repair, 6 years post-operatively. Moderate hammer toe deformity in multiple lesser toes is noted. E: Male patient who had reconstruction with a long-pedicle EDB muscle flap due to a hard-to-heal wound and fistula formation on the medial aspect of the proximal tibia following extensive soft tissue injury and osteomyelitis after a war injury, 5 years post-operatively. A gastrocnemius flap was initially used to cover the wound but failed. Hypertrophic scarring is noted on the donor site. The patient's left leg has been amputated due to another traumatic injury.

**Table 1** Details of the patients, by group.

	All	Hard to heal wound	Fracture	p value
No. of patients	21	9 (43)	12 (57)	-
Male sex	15 (71)	6 (67)	9 (75)	1.00
Age at EDB operation, years	59.5 (51.1-65.7)	60.4 (49.6-67.7)	56.9 (50.8-64.2)	0.55
Age at follow-up, years	70.8 (58.6-73.9)	73.1 (64.3-78.4)	66.3 (57.4-73.1)	1.15
Follow-up time, years	9.1 (5.7-12.2)	11.3 (5.8-17.6)	7.5 (4.6-9.8)	0.11
Defect size, cm <sup>2</sup>	12 (6-16)	6 (4.5-12)	15 (8.5-16)	0.13
Other flap before the EDB	6 (29)	2 (22)	4 (33)	0.66
Hammer/claw toes <sup>a</sup>	6 (29)	3 (33)	3 (25)	1.00
Hypertrophic scar <sup>b</sup>	4 (19)	1 (11)	3 (25)	0.83
Recurrent wound <sup>c</sup>	3 (14)	0 (0)	3 (25)	0.23
Altered skin sensibility dorsal foot <sup>b</sup>	14 (67)	4 (44)	10 (83)	0.16
Less able to stand on one leg (EDB side)	8 (38)	1 (11)	7 (58)	0.07
Different shoe size	6 (29)	0 (0)	6 (50)	0.02
Specially adapted shoes	9 (43)	2 (22)	7 (58)	0.18
Increased swelling on the EDB side	15 (71)	5 (56)	10 (83)	0.33
Open fracture <sup>d</sup>	5 (24)		5 (42)	-

EDB, extensor digitorum brevis. Data are presented as median (25th-75th centile) or n (%). Differences between the two groups were analysed with the Mann-Whitney *U* and Fisher's exact test.

<sup>a</sup> Number of patients with hammer/claw toes on the EDB side only, or more pronounced on the EDB side.

<sup>b</sup> At the operated area (the EDB-donor site).

<sup>c</sup> At the EDB recipient site.

<sup>d</sup> At the primary injury.

monofilament in the deep peroneal nerve distribution area was noted on the EDB side (Supplemental Table 4).

Lesser toe deformities, such as hammer or claw toe configuration, were more pronounced on the EDB side than on the control side in six patients. Only one patient had a significant claw toe deformity. This may have been due to

an undiagnosed compartment syndrome, which was discussed in the medical records of the patient. No significant bowstring phenomenon of the tendons anterior to the ankle was noted in any patient. Wound recurrence at the recipient site of the EDB flap was observed in three patients.

**Table 2** Range of motion (ROM) and pain, the difference between the extensor digitorum brevis (EDB) and control side in the whole study group.

	EDB side	Control	Diff (EDB minus control)	p value
No. of patients	21	20	20	
ROM MTP1	42.0 (23.0-59.5)	60.0 (44.5-76.0)	-14.5 (-31.3 to -4.0)	< 0.001
ROM MTP2	22.0 (10.5-41.0)	61.0 (38.5-72.0)	-22.0 (-49.0 to -15.8)	< 0.001
ROM MTP3	28.0 (20.0-43.0)	62.0 (35.8-69.5)	-22.0 (-38.0 to -13.0)	< 0.001
ROM MTP4	24.0 (9.0-40.0)	52.0 (32.0-68.5)	-18.0 (-35.5 to -6.0)	< 0.001
ROM MTP5	28.0 (9.0-44.0)	46.0 (35.0-56.8)	-14.0 (-32.3 to -1.3)	< 0.001
ROM ankle	32.0 (19.0-43.0)	54.0 (42.0-63.8)	-21.0 (-26.0 to -10.5)	< 0.001
Flexion MTP1	10.0 (2.0-22.0)	13.0 (4.0-27.5)		0.07
Flexion MTP2	-11.0 (-22.0-2.0)	7.0 (-11.0-13.5)		0.03
Flexion MTP3	-2.0 (-19.0-4.0)	6.5 (-5.5-13.5)		0.15
Flexion MTP4	0.0 (-18.0-6.0)	5.0 (-10.0-14.0)		0.37
Flexion MTP5	10.0 (-1.0-18.0)	12.0 (-4.0-19.0)		0.45
Extension MTP1	32.0 (14.0-47.0)	44.0 (31.5-56.0)		0.004
Extension MTP2	38.0 (24.0-46.0)	58.0 (38.5-65.0)		< 0.001
Extension MTP3	38.0 (21.0-48.0)	59.0 (36.5-65.0)		< 0.001
Extension MTP4	32.0 (21.0-43.0)	49.0 (38.5-60.0)		< 0.001
Extension MTP5	12.0 (1.0-33.0)	36.5 (26.0-45.8)		< 0.001
Flexion ankle	40.0 (30.0-46.0)	50.0 (43.0-60.0)		< 0.001
Extension ankle	-8.0 (-10.0-0.0)	2.0 (-4.0-8.0)		0.007
Pain at rest, NRS	0.0 (0.0-2.5)	0.0 (0.0-0.0)	0.0 (0.0-2.0)	0.045
Pain at walking, NRS	2.0 (0.0-3.5)	0.0 (0.0-0.0)	1.5 (0.0-3.0)	0.007

MTP, metatarsophalangeal; NRS, numeric rating scale. Data are presented as median (25th-75th centile). Differences between the EDB and control side were analysed with the Wilcoxon signed rank test.

**Table 3** Self-reported scores, the difference between the extensor digitorum brevis (EDB) and control side in the whole study group.

	EDB side	Control	Diff (EDB minus control)	p value
No. of patients	21	20	20	
SEFAS score sum	33.0 (24.5-46.0)	46.5 (40.0-48.0)	-10.5 (-15.8-0.8)	0.02
FAOS symptoms	60.7 (46.4-89.3)	100.0 (89.3-100.0)	-19.6 (-50.9 to -2.7)	< 0.001
FAOS pain	80.6 (63.9-94.4)	100.0 (90.3-100.0)	-16.7 (-31.3 to -3.5)	0.01
FAOS ADL	83.8 (65.4-97.1)	98.5 (71.3-100.0)	-6.6 (-21.3-0.0)	0.04
FAOS sports	50.0 (25.0-90.0)	92.5 (51.3-100.0)	-15.0 (-37.5-0.0)	0.007
FAOS QoL	50.0 (37.5-93.8)	93.8 (62.5-100.0)	-15.6 (-50.0-0.0)	0.008
EQ-5D mobility	1.0 (1.0-2.0)			-
EQ-5D self-care	1.0 (1.0-1.0)			-
EQ-5D usual activities	1.0 (1.0-2.0)			-
EQ-5D pain	2.0 (1.0-3.0)			-
EQ-5D anxiety/depression	1.0 (1.0-2.0)			-
EQ-5D VAS	80.0 (70.0-85.0)			-

ADL, activities of daily living; QoL, quality of life. Data are presented as median (25th-75th centile). Differences between the EDB and control side were analysed with the Wilcoxon signed rank test. SEFAS, self-reported foot and ankle score, higher values indicate a better state. FAOS, foot and ankle outcome score, higher values indicate a better state. EQ-5D, EuroQol five dimensions, higher values indicate a worse state, while the EQ-5D VAS, EuroQol five dimensions visual analog scale, has a positive direction (higher values indicate a better state).

### Patient-reported outcome measures

In the whole study group, better scores on SEFAS and multiple domains of the FAOS were seen for the control foot compared with the reconstructed side (SEFAS score sum 46.5 vs 33,  $p=0.02$ , Table 3). After subgrouping the reconstructed side into a fracture group and a hard-to-heal wound group, significantly worse scores for the reconstructed side were observed exclusively in the fracture group. Better scores on SEFAS and multiple FAOS domains were also seen in the hard-to-heal group when directly compared with the scores of the fracture group, but no significant differences were seen in the EQ-5D questionnaire domains (Supplemental Tables 5-7).

### Discussion

Tissue defects of the lower extremity, both due to trauma and delayed wound healing, often pose a reconstructive challenge to plastic surgeons. There is a scarcity of available local tissue, and the anatomy itself is challenging with an abundance of tendons, bony prominences, and differences in skin constitution. Furthermore, wound healing in the lower extremity is heavily affected by patient factors and comorbidities such as smoking, diabetes, and peripheral vascular disease. Nonetheless, successful treatment of wounds in the lower extremity is vital since the outcome for the individual patient may otherwise be serious wound infections, possibly resulting in amputation. The burden of frequent wound dressings is also high, both for the individual patient and the healthcare system.<sup>20</sup> The prognosis and long-term morbidity of complex lower extremity injuries are often unclear; however, promising attempts have been made towards creating classification systems that may contribute to prognostic guidance.<sup>21</sup>

The pedicled EDB flap has been described as a reliable option for the reconstruction of small lower extremity

tissue defects, particularly around the foot.<sup>10,15,22</sup> It has been shown to have acceptable healing rates, is relatively easy to perform, and requires neither advanced instruments nor facilities. Thus, the flap is still a versatile, viable option for some patients, even if there are other reconstructive alternatives such as local perforator flaps or free microvascular tissue transfers.<sup>2</sup>

Few studies have investigated the long-term effects and morbidity of harvesting the EDB flap. Some studies describe the long-term effects of harvesting the dorsalis pedis flap, including delayed healing of the donor site, pain at ambulation, and altered sensation on the foot dorsum. However, the dorsalis pedis flap usually includes a skin island, and the donor site is mostly covered with a skin graft, which may be associated with a higher morbidity, in contrast to the EDB flap, in which no skin is removed.<sup>23-25</sup>

Among the described complications after EDB flap harvest are hypertrophic scarring at the donor site, delayed wound healing, persistent sensory loss in the distribution area of the deep peroneal nerve, and reduced ankle mobility. However, these complications were only noted in a minority of cases, and most authors describe the flap as not being associated with significant morbidity.<sup>12,14,26,27</sup>

The flap survival rate and healing of the EDB flaps performed in our institution have been described in a previous study.<sup>10</sup> Regarding long-term sensory disturbances, no significant difference in sensibility on the dorsum of the foot was noted in the EDB group when compared to the non-reconstructed side, which is in line with other studies.<sup>22</sup> However, a tendency towards decreased sensibility in the distribution area of the DPN was noted, which might have been significant if the study group had been larger. Theoretically, branches of both the SPN and the DPN are at risk of injury during the elevation of the flap due to their proximity to the vascular pedicle during dissection.<sup>28</sup>

The patients in the fracture group had significantly worse scores on SEFAS and FAOS for the EDB side compared with the non-reconstructed side. This was not seen in the delayed wound healing group and may reflect that most

limitations in the activities of daily living of the patients are possibly due to sequelae of the fracture rather than morbidity related to the harvest of the EDB muscle. A clear decrease in the range of motion of the MTP joints, primarily regarding the ability to extend the toes, was seen in both groups, which may have been due to scar formation on the dorsum of the foot and reduced strength due to the harvest of the EDB muscle. However, the superior results on SEFAS and FAOS in the delayed wound healing group, despite the decreased ROM, suggest that the harvest of the EDB muscle is probably not a determining factor for the foot and ankle function or satisfaction of the patients. Reduced ankle ROM was only seen in the fracture group when dividing the groups, which may indicate that the reason for the reduced ankle ROM was the prior ankle fracture rather than the harvest of the EDB muscle.

It has been speculated that harvest of the EDB muscle may lead to a risk of the bowstringing phenomenon in the ankle, toe deformities, and inability to use normal shoes or even ambulate.<sup>15,22</sup> Six of the patients reported different shoe sizes between their feet. However, they were all in the fracture group, suggesting that the cause of this might be the fracture rather than the EDB flap harvest. Some of the patients had developed some degree of toe clawing, which was more prominent on the reconstructed side. However, none had any wound issues related to toe deformities, and none had required any surgical corrections because of this. It could be possible that, with time, the lack of the EDB muscle and scarring on the dorsal surface of the foot might contribute to an imbalance between foot flexors and extensors, causing minor deformities. No patient had a significant bowstringing phenomenon at the ankle. Three patients had wound recurrence in the flap recipient site, but the wounds were shallow and most likely a result of shearing of the sensitive skin grafted onto the muscle.

### Limitations

There are some limitations of this study to consider. The study group is small; however, an attempt was made to partly compensate for this by using the patients' other feet as controls. Many patients from the original study population could not be reached to be included in the study. Some of the patients had their surgery many years ago and might have changed both phone numbers and addresses since then, making it more difficult to reach them. Naturally, most patients had other previous conditions or injuries affecting their foot and ankle function, which makes the results more difficult to interpret.

### Conclusion

Reconstruction of wounds and tissue defects in the lower extremity with the pedicled EDB muscle flap does not seem to be associated with any major long-term complications of the donor site regarding foot and ankle function and patient quality of life. However, most patients had other concomitant or previous injuries and surgical procedures, which makes interpretation of the results more difficult.

More studies with a larger number of patients would be of value. The results of this study may support the continued use of the EDB muscle flap as a reconstructive option for small tissue defects of the lower leg.

### Ethical approval

The study was approved by the Regional Ethics Review Board (No. 2018\18-31).

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### Declaration of Competing Interest

None declared.

### Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.bjps.2026.02.057](https://doi.org/10.1016/j.bjps.2026.02.057).

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