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Reconstruction of Degloving Foot Injuries Performing Free Microvascular Muscle-Flap: Our Cases and A Comprehensive Literature Review

Katrin Stanger*

Department of Plastic and Hand Surgery, OKM Orthopedic Clinic Mark Groningen gGmbH, Germany

***Corresponding author:**

Katrin Stanger,
Department of Plastic and Hand Surgery, OKM Orthopedic Clinic Mark Groningen gGmbH,
Germany

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Degloving foot injuries; Microvascular free tissue transfer; Microsurgery; AOFAS

1. Abstract

1.1. Background

Degloving injuries are serious and potentially life-threatening traumas that often result from industrial or traffic accidents. The aim of this study is to consolidate the current literature into an overview that is intended to serve as guidance. Further, the study contains four case reports, including a follow-up period of over 10 years.

1.2. Methods

The entire PubMed database was screened in accordance with the PRISMA guidelines in May 2022, focusing on studies and reports of degloving injuries of the foot. Four cases included complex foot injuries treated between 2009 and 2022. Three of the four patients presented with multiple open fractures or amputations with uncovered tendinous or osseous structures. In one patient, the entire foot was affected, whereas in the other three patients, the skin was partially avulsed. Outcomes were evaluated using the American Orthopaedic Foot Association score questionnaire.

1.3. Results

All patients were treated interdisciplinaryly and underwent soft-tissue reconstruction using a free microvascular flap. Between 1973 and May 2022, 45 articles presented cases treated for degloving injuries incorporating 142 treated patients. Soft tissue reconstruction includes free tissue transfer, skin grafting with cryopreservation, and vacuum-assisted closure.

1.4. Conclusions

Degloving injuries are very demanding and rare injuries. Appropriate treatment should be planned individually in an interdisciplinary approach. The area of microsurgery enables the preservation of the limb with good functional outcomes.

2. Introduction

Degloving injuries are complex soft tissue injuries. Shearing forces disrupt the perforators at the fascial level, resulting in complicated soft tissue defects and sometimes exposing tendinous or bony structures [1]. Not only the reconstruction of the unique and complex structure of the plantar surface but also the demand for the reconstruction of a fully weight-bearing, resilient tissue on the foot is certainly challenging [2]. Surgeons reported their experience in treating these complex injuries as early as 1939. Over the century, techniques have improved, and with the availability of microsurgery, more reconstructive possibilities have become feasible [3-5]. Further classification of injuries by constructing patterns has led to a differentiated approach to such injuries [6]. However, the unique anatomy of glabrous skin presents a demanding challenge in achieving an acceptable result that allows the patient to walk again [7,8]. Preservation of sensation is often not possible or very difficult to rebuild, placing surgeons in an arduous position. If this is not enough, these injuries occur frequently in children [5]. Therefore, various surgical procedures have been discussed with regard to the best functional outcomes, considering ongoing growth. The enhanced complexity of these injuries indicates that the reconstructive method is best chosen based on individual evaluation of the present injury and the demands of the patient. As this represents a highly demanding task for a surgeon, it is crucial to be informed about the possible measurements, consequences, and results. In this study, the experience of four successful cases measured using the American Orthopaedic Foot and Ankle Society (AOFAS) score is documented. The aim of this review is to enhance the different treatment regimens for degloving injuries according to the complexity of the injury, providing a source of information for orientation and further evaluation.

3. Methods

A literature review was conducted in May 2022 according to the PRISMA guidelines. The National Library of Medicine was used to conduct the following search: degloving injury foot OR (degloving injury AND flap). A total of 376 studies were reviewed by the first and last authors based on the previously determined criteria. All studies, including the reasons for exclusion, were recorded using Microsoft Excel, Version 16.72 for Macintosh. There were no limitations regarding the time of publication. All studies in English or German reporting a treatment regime for degloving injuries and describing the extension of the injury were included. Studies that did not report injury patterns and those that were not available for retrieval were excluded. Studies analyzing degloving injuries other than those of the foot or animals and closed degloving injuries of the toes were excluded. Studies reporting injuries to both feet and hands were screened to determine the number of injuries affecting the foot (Figure 1). Both authors independently reviewed the titles and abstracts of the articles. The first author reviewed the selected studies and recorded the following key variables: injury pattern (involved part of the foot) and treatment strategies (skin graft, pedicled or cross-leg flaps, free tissue transfer, and applied VAC). Only patients in whom the injury pattern and treatment were clearly reported were included in this study. For a precise capture of the involved part of the foot, the following categories "total" and "partial" degloving injury were defined as well as the subcategories: involved heel, plantar side with heel, plantar side without heel, partial injury involving the forefoot circular, forefoot plantar side, dorsum, lateral or medial side of the foot. If documented, secondary key variables such as outcomes measured by an acknowledgment score or patient characteristics were registered. To follow the principle of evaluating each injury pattern separately, we did not perform statistical tests to determine the significance between different treatment strategies. Furthermore, the sample size was too small for statistical analysis. Data analysis and visualization were performed using Microsoft Excel, Version 16.72 for Macintosh. No registration or review protocols were used. Patients treated between 2009 and 2022 for degloving foot injuries at the Cantonal Hospital of Winterthur in Switzerland were analyzed. Patients received a written request inviting them to participate in the case series. Four patients provided informed consent to publish their data and photographs. The follow-up time was defined as the date of the first and latest presentation. Impairments in daily life and quality of life were assessed using the AOFAS questionnaire.

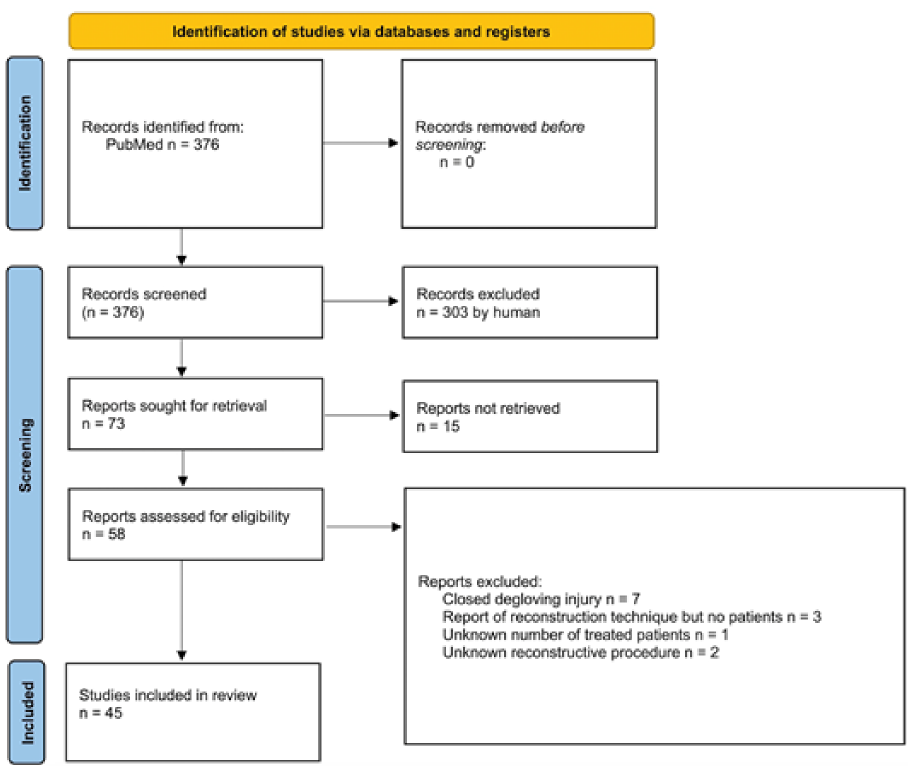

Figure 1: Study flow chart.

4. Results

5. Case Reports

Four patients were treated at the cantonal hospital of Winterthur between 2009 and 2022 for degloving injury. The details are summarized in Table 2.

5.1. Case 1

In a 9-year-old boy, the left foot was overrun by a lorry. The extent of the injury revealed fully detached skin of the entire foot at the level of the fascia, with multiple fractures and dislocation of the toes, exposing tendinous structures (Figure 2). The avulsed skin displayed a consistent perforator vessel. A replanting attempt was conducted, even though the chance for successful replantation was low. After initial repositioning, K-wire fixation, and replantation of the avulsed skin, the soft tissue showed necrosis. Soft tissue reconstruction with latissimus dorsi flap was realized (Figure 3). The muscle was placed in the form of a moccasin shoe, and the tibialis posterior artery was used as a recipient vessel. Figure 4 shows the outcome at 10 years follow up.

Figure 2: The extent of the injury of case 1.

Figure 3: Soft tissue reconstruction with latissimus dorsi flap.

Figure 4: Outcome at 10 years follow up.

5.2. Case 2

Presentation of a 48-year-old- male showing degloved skin over the dorsum and plantar side of the right forefoot, including exposed bone (Figure 5). Initially, the wound was surgically debrided, and toes I – V were amputated at the level of the metatarsal joint. Next, vacuum-assisted closure (VAC) therapy was established. On the sixth postoperative day, the soft tissue defect was reconstructed by a free microvascular latissimus dorsi flap from the left side with split-thickness skin grafts (STSG) from the left thigh. Figure 6 shows the result after 3 years. The patient reported restrictions in his daily life due to neuropathic pain. He required professional reorientation to perform his daily-life activities.

Figure 5: Degloved skin over the right forefoot.

Figure 6: Result after 3 years.

5.3. Case 3

A 64-year-old patient had a degloving injury in his left forefoot, including open fractures of the I-V (Figure 7). Soft tissue reconstruction was conducted with a free fasciocutaneous anterolateral thigh flap from the right side (Figure 8). Further surgery for debulking the flap was necessary for the correction of the contour.

Figure 7: Degloving injury of the left forefoot, including open fractures.

Figure 8: Result after reconstruction with a free fasciocutaneous anterolateral thigh flap.

5.4. Case 4

A 19-year-old patient was brought to the emergency department with a wound on the plantar side of his right foot at presentation. The computer tomography revealed a highly complex fracture of the Lisfranc joint with luxation and repealed articulation line. In addition, there was a luxation fracture of the upper ankle joint. The patient was taken to the operating theater for debridement and stabilization of the fractures. The absence of blood supply over the dorsolateral foot was demonstrated by indocyanin green during the second examination (Figure 9). Reconstruction was conducted with a latissimus dorsi flap from the right side. Figure 10 presents the outcome at the 1-year postoperative.

5.5. Systemic Literature Review

We identified 376 studies published between 1973 and May 2022 in PubMed. Forty-five studies with 142 treated patients were included in the analysis (Table 1). Most studies (42) focused on reporting their cases, except for three that presented a new technique for treating degloving foot injuries [6-8].

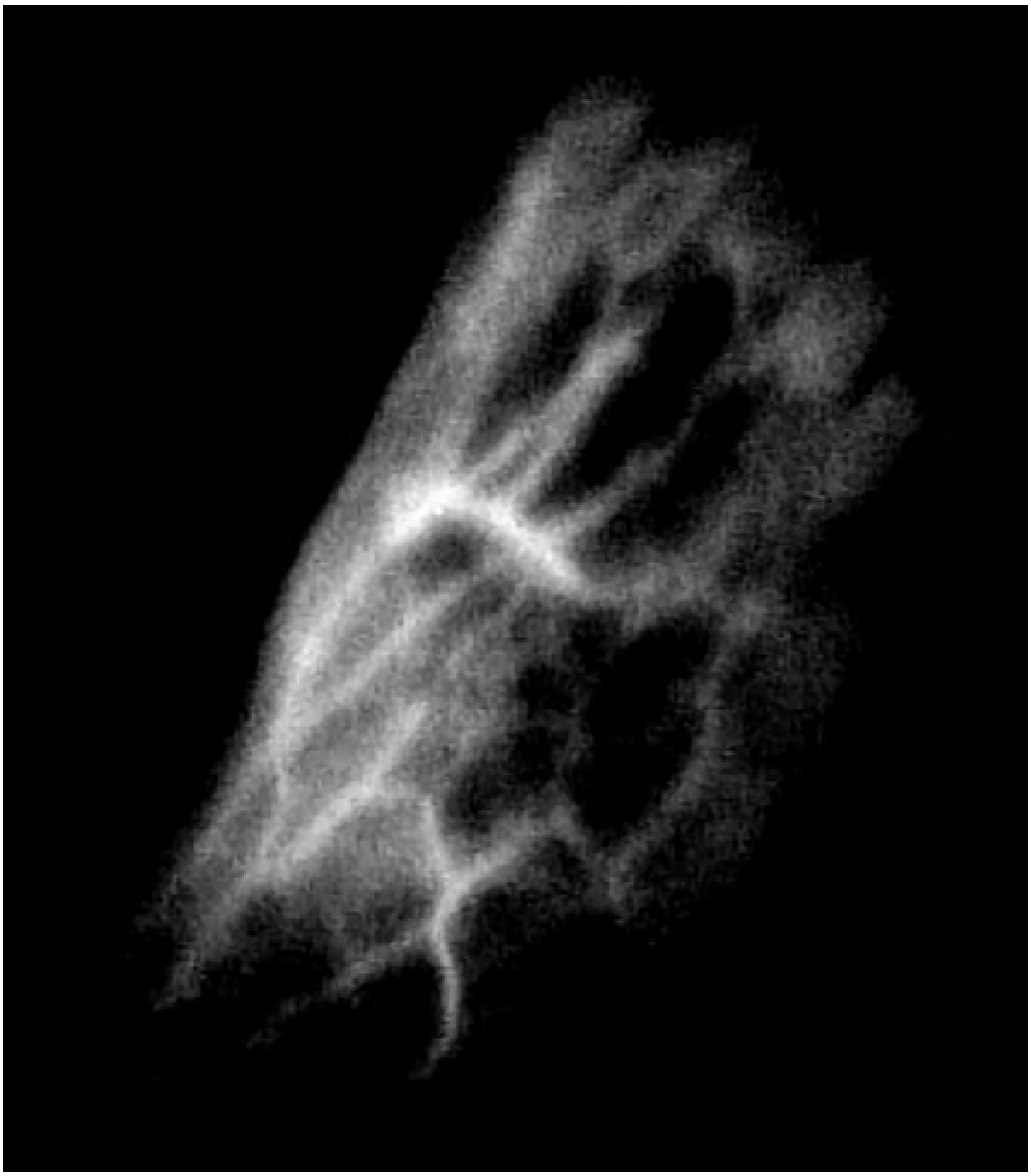

Figure 9: Indocyanine green fluoroscopy showing no perfusion over the dorsolateral foot.

Table 1. Summary of studies reporting degloving foot injury

	Patient characteristic		Involved structures		Injury characteristic			Treatment strategies	
authors, year	**Average age**	**Total number of patients with degloving injuries**	**Uncovered tendon or bone**	**Fracture**	**Total degloving**	**Partial degloving**	**Heel involved**	**Negative pressure wound therapy**	**Kind of reconstruction**
Segev et. al, 2007	9.25	3	yes	yes	3		1	no	Latissimus dorsi flap
William A. et. al, 2017	50	1		yes	1		1	yes	Defatted avulsed skin as full thickness skin graft
Hyoseob et. al, 2014	52.4	6		yes	1	5	1	yes	5 Defatted avulsed skin as full thickness skin graft, 1 free muscle flap
Damkat-Thomaset. al, 2019	72	1	yes	yes		1		yes	Acellular dermal matrix
Scaliseet. al,2017	48.5	2				2	2	yes	Acellular dermal matrix
Xu et. al, 2022	77	1	yes			1		yes	Cryoperserved autologous skin grafting
Attia et. al, 2020	28	4	yes			4		yes	Acellular dermal matrix
Herold et. al, 2022	46	1	yes	yes		1	1	no	Anterolateral thigh flap
Rautio et. al, 1992		30				30	20	NA	14 Latissimus dorsi flap, 5 radialis flap, 3 dorsalis pedis flap, 4 muscle flap with Split skin graft
Tian et. al,2019	56	1						yes	Cryoperserved autologous skin grafting
Letts, 1986	8.8	4			2	2	2	NA	Defatted avulsed skin as full thickness skin graft, one resutured avulsed tissue as microvascular musculocutaneos skin flap
Green et. al, 1988	20	1	yes	yes		1		NA	Split thickness skin graft
Kakagia et. al, 2021	19.3	3	yes	yes		3	1	yes	Acellular dermal matrix
Vasella et. al, 2021	21	2	yes	yes		2		yes	Latissimus dorsi flap
Guo et. al, 2019	3	1	yes		1		1	no	Sural free flap
Lutz et. al, 1999	36	1	Yes	yes		1	1	no	Latissimus dorsi flap
Dargan et. al, 2021	55	2	yes	yes		1	1	yes	Latissimus dorsi flap, gracilis flap
Basile et. al, 2008	28	2	yes			2	2	yes	Distal based sural artery fasciocutaneous cross-leg flap
Langat et. al, 2020	21	1		yes		1	1	yes	Propeller medial plantar flap
Merter et. al, 2017	2	1	yes			1		yes	Anterolateral thigh flap
Cap et. al, 2009	4	1	yes		1		1	NA	Defatted avulsed skin as full thickness skin graft
Husain et. al, 2003	43	1				1		no	Defatted avulsed skin as full thickness skin graft

Table 1. (continued)

	Patient characteristic		Involved structures		Injury characteristic			Treatment strategies	
authors, year	**Average age**	**Total number of patients with degloving injuries**	**Uncovered tendon or bone**	**Fracture**	**Total degloving**	**Partial degloving**	**Heel involved**	**Negative pressure wound therapy**	**Kind of reconstruction**
Huemer et al., 2004	19	1				1		yes	Defatted avulsed skin as full-thickness skin graft
Hede et al., 2013	23.6	21			14	7		no	Defatted avulsed skin as full-thickness skin graft
Zagrocki et al., 2013	56	1	yes		1			yes	Acellular, biological extracellular matrix (ECM)
Zhou et al., 2020	45	1	yes			1	1	yes	Anterolateral thigh flap
Giotis et al., 2021	30	1	yes			1	1	yes	Vacuum-assisted closure and split-thickness skin graft
Pilanci et al., 2013	15.8	5	yes			5		no	Defatted avulsed skin as full thickness skin graft
Kabakas et al., 2019	18.5	2	Yes		1	1		NA	perforator artery repair in revascularization
Boernerta et al., 2018	40.5	2	yes		2			yes	Defatted avulsed skin as full thickness skin graft
McGabe et al., 1973		8				8		no	Four split-thickness skin grafts, four patients cross-leg flaps
Liu et al., 2012	7	7	yes		7		7	yes	Three split-thickness skin grafts, four posterior tibial artery flaps, and defatted avulsed skin as full-thickness skin graft
Ou et al., 2022	19.8	10	yes		10			yes	Eight bilateral anterolateral thigh flap, one deep inferior epigastric perforator flap, one medial plantar artery perforator flap

Künzel et al., 2012	4	2	yes	yes	1			yes	Defatted avulsed skin as full-thickness skin graft
Kopriva et al., 2020	5	1	yes	yes		1		yes	Latissimus dorsi flap
Perry et al., 2020	26	1			1			NA	Distally based posterior tibial artery flap
Donegan et al., 2018	55	1				1	1	yes	Reverse sural artery flap
Saab et al., 2014	5	1	yes	yes		1		yes	Acellular dermal matrix
Ozturk et al., 2015	66	1				1		yes	Acellular dermal matrix
Zgonis et al., 2007	27	1				1		yes	Crossover reverse sural artery flap
Josty et al., 2001	55	1	yes			1		yes	Vacuum-assisted closure
De Franzo et al., 1998		1			1			yes	Defatted avulsed skin as full-thickness skin graft
Andres et al., 2016	68	1				1		yes	Split-thickness skin graft
Meara et al., 1998	83	1				2		yes	Defatted avulsed skin as full-thickness skin graft
Gu et al., 2017		1	yes	yes		1		yes	Defatted avulsed skin as full-thickness skin graft

5.6. Injury Pattern

A total of 142 patients who were treated for degloving foot injuries were identified. Most patients had partial foot degloving injuries (95 [67%]). Of the 95 patients with partial degloving injury, 37 (39%) patients showed involvement of the plantar side, the dorsum of the foot in 29 (31%), and mixed injuries in 24 (25%). Just five patients (5%) presented with forefoot degloving (Figure 11).

Figure 10: Outcome at follow up one year postoperative.

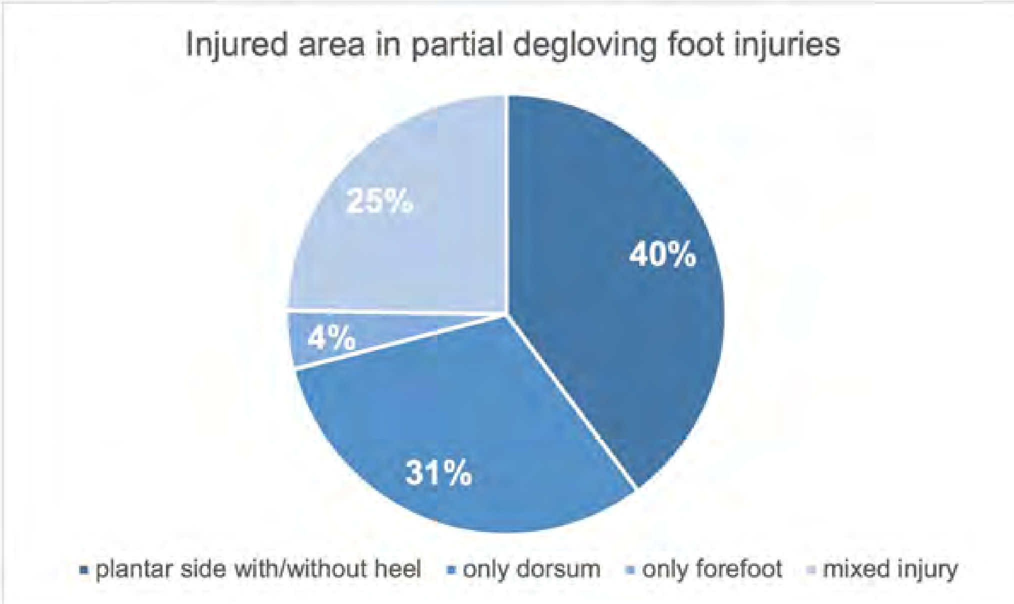

Figure 11: Injured area in partial degloving foot injuries.

Table 2: Outline of our cases.

category	Case 1	Case 2	Case 3	Case 4
age	9 years	48 years	64 years	19 years
accident mechanism	traffic accident	industrial accident	traffic accident	traffic accident
injury pattern	circular degloving of the whole left foot	circular degloving involving the whole right fore- and middle foot	circular degloving involving the whole left forefoot	partial degloving involving the dorsolateral aspect of the foot with highly complex fractures
performed reconstruction	LD flap	LD flap	ALT-flap	LD flap
duration of hospitality	56 days	34 days	28 days	34 days
footwear	normal	orthopedic	orthopedic	normal
restriction in everyday life	no	yes	no	slightly
reoperation	one operation due to growth process after 3 years	one operation for a wound break down with prolonged healing	two operations for debulking	no
patients satisfaction with reconstruction	high	low	high	high
follow- up time	11 years	3 years	3 years	1.5 year
AOFA-Score	60 points	30 points	64 points	75 points
pain	no	neuropathic pain	yes sometimes	yes sometimes

5.7. Reconstruction Method

Forty-seven percent (57 patients) were treated with skin grafts, and free tissue transfer was performed in 37% (52 patients). Predominantly, defatted avulsed skin grafts (48 patients, 83%) and split-thickness skin grafts (STSG) were used in 10 patients (17%) for primary coverage. The dermal matrix was recorded in 11% of patients, pedicled flap in 8%, and cross-leg flaps in 5% (Figure 12). In most cases, reconstruction was performed using the Latissimus dorsi muscle flap (LD) (23 patients, 43%), followed by the anterolateral thigh flap (ALT) (13 patients, 25%), radialis forearm flap (5 patients, 9%), dorsalis pedis flap (3 patients, 6%), Suralis flap (2 patients, 4%), and Gracilis flap (1 patient, 2%). In 25% of the cases, the flap used was not traceable (Figure 13). Negative pressure wound therapy (NPWT) was described in 31 studies, not used in 10 studies, and was not mentioned in four. Only three studies measured outcomes using the AOFAS or Maryland Foot Score [9,10]. A detailed analysis of the results based on the scores was not performed.

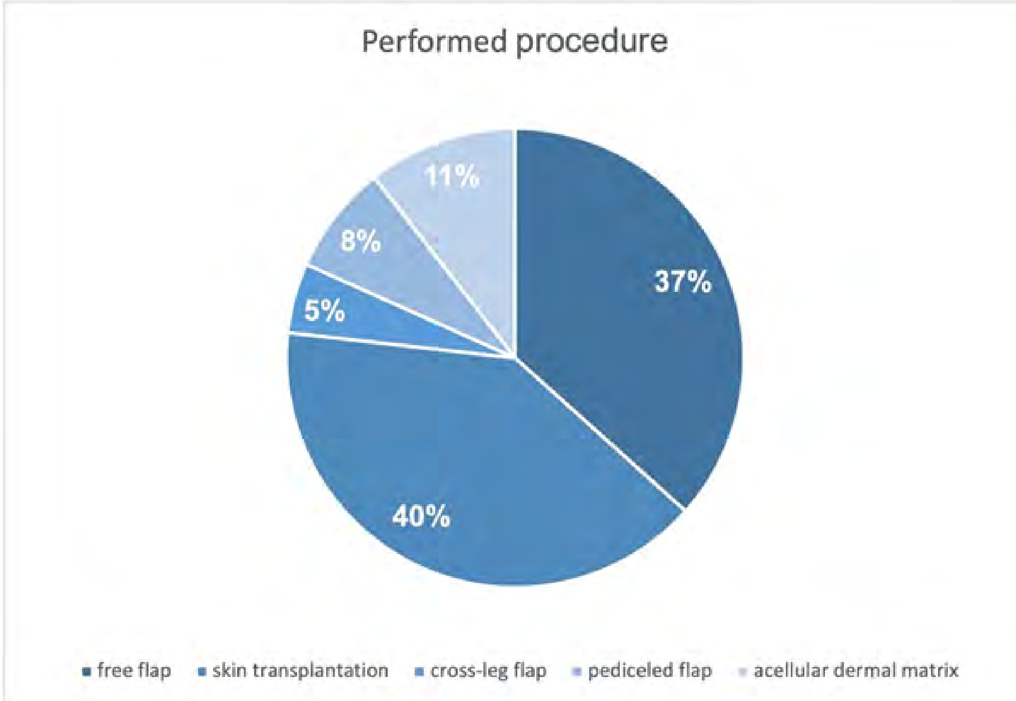

Figure 12: Performed procedures for reconstruction.

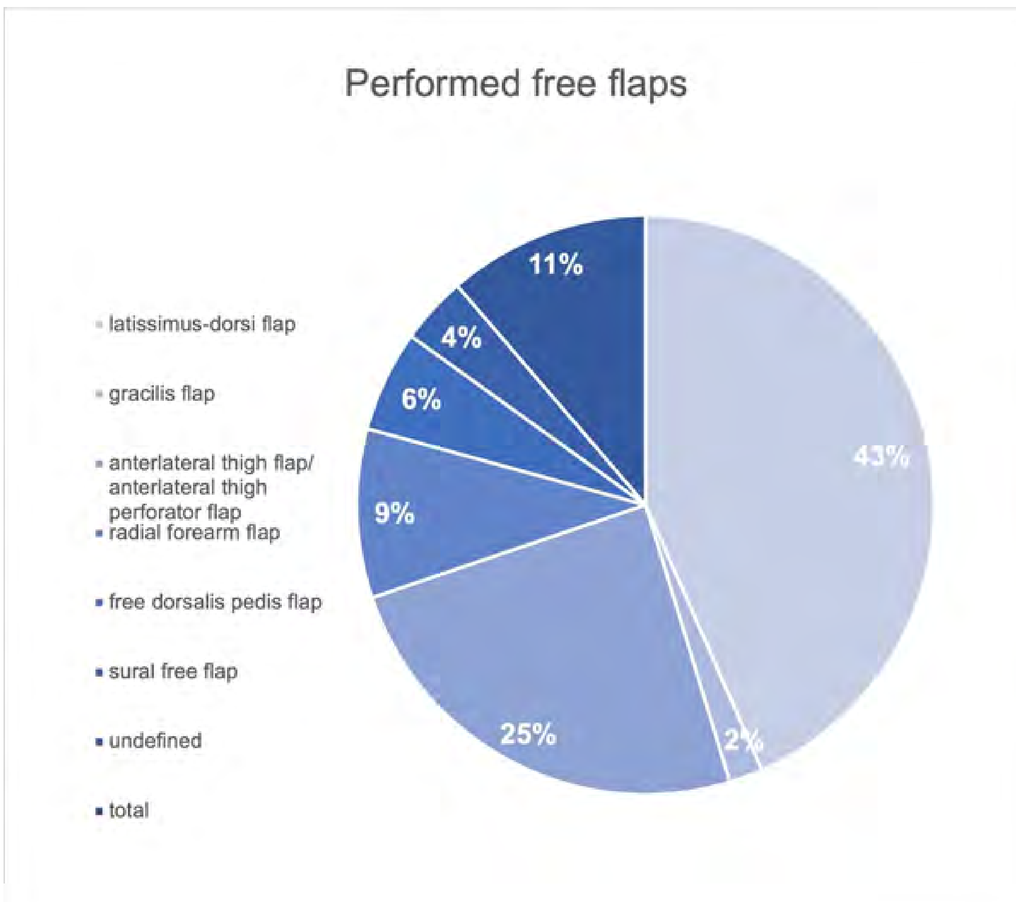

Figure 13: Performed free flap.

6. Discussion

In foot reconstruction, an experienced plastic surgeon would probably admit that the plantar side of the foot is one of the most difficult body regions to successfully reconstruct. These patients require realistic pre- and postoperative education in which the anatomical uniqueness of the sole cannot be restored to 100%. The foot requires lifetime medical monitoring for pressure ulcers and eventually, pain treatment (Figure 14). The literature review presented diverse reconstructive methods to overcome this challenge and enhance the variety of degloving injuries. Arnez et al. [11]. Classified degloving injuries into four patterns: abrasion/avulsion, non-circumferential degloving, or circumferential degloving, while the latter was subdivided into single-plane or multi-plane degloving [6]. They retrospectively reviewed 79 complex limb injuries, and their results showed a significant difference in the healing rate between circumferential and non-circumferential injuries, with better outcomes in the latter [6]. Ozturk et al. [12]. Developed an algorithm for the management of complex foot avulsion injuries based on the injury pattern of suprafascial or subfascial avulsions [9]. This algorithm incorporates step-by-step escalation, similar to a reconstruction ladder [9]. Both authors highlighted key points, such as the specification of the injury pattern intended to regulate treatment decisions. With the use of avulsed skin, different techniques have been reported over the years, such as immediate reattachment of defatted skin or cryopreservation [10,11]. Previous studies have reported the importance of defatting avulsed skin to prevent necrosis [1]. Our results showed that most patients were treated with defatted avulsed skin as a graft (40%). Likewise, in our cases, an attempt to preserve the avulsed skin with reattachment was not successful. We concluded that the skin damage was too extensive. With the turn of the century, several studies reported the use of NPWT as a game changer, resulting in greater grafts taken by removing the seroma and hematoma [12]. Furthermore, it clears bacteria, increases blood flow, and stimulates the production of granulation tissue [13,14]. According to D'Alleyrand et al. [15]. NPWT should no longer be applied than 7 days. Their study showed a higher risk of bone infection after seven days in open tibial fractures [15]. To protect exposed structures, such as bones, tendons, and muscles, from infection, desiccation, or other further impairments, we consider it necessary to aspire to definitive wound coverage as soon as possible [16]. This aspect leads to the concept of "fix and flap" for open fractures and soft tissue defects proposed by Gopal et al [17,18]. However, this approach is limited by patient stability with respect to long operation times or unpredictable further demarcation of the injured tissue. Therefore, intraoperative supporting measures for viable tissue evaluation, such as the intravenous administration of fluorescein dye combined with Wood's lamp illumination, were implemented [19-21]. Lim et al. and Vasella et al. [22]. Pointed out the precious frugal debris of glabrous tissue obtained using fluorescein dye-assisted marking of nonviable tissue [19,20]. A long working life experience provides the same quality of treatment, but especially in such rare injury patterns and especially for less experienced surgeons, a tool like this enables better treatment by reducing the number of recurrent stays at the operating theater or even revealing the presence of closed degloved tissue, as in our case. For degloving injuries involving the heel pad, reconstructive methods depend on the remaining soft tissue and vascular supply provided by the lateral calcaneal branch of the peroneal artery and the medial calcaneal branch of the posterior tibial artery [22]. Cantrell et al. [23]. Reported a case in which the avulsed, defatted skin of the heel was repositioned and secured using K-wires. After several debridements and using a negative pressure dressing, the skin healed, and the K-wire was removed after ten weeks, allowing the patient to start ambulating with partial weight bearing using a gel heel pad [23]. Herold et al. [24]. Presented a case in which the heel pad was disrupted between the periosteum and fascia; they renounced the degreasing of the heel pad and performed fixation using K-wires [8]. In the reported case, the sensation at the level of the heel pad was preserved, resulting in a satisfactory result with no disturbance of the gait. In our opinion, such a therapeutic approach must be evaluated carefully and can only be successfully performed if the remaining anatomy, especially the corresponding blood supply, is available. There are different dermal matrix products on the market, including Integra® (Integra Life Sciences, Plainsboro, New Jersey, USA), MatriDerm® (MedSkin Solutions Dr. Suwelack), and NovoSorb® (Biodegradable Temporizing Matrix) (Polymedics Innovations GmbH) are well known [24]. Damkat-Thomas et al. performed a 9 months follow-up after soft tissue reconstruction on the dorsal side of the foot with a synthetic biodegradable temporizing matrix and demonstrated unimpeded movement of the tendon under the newly grown soft tissue layer by sonography [25]. Ozturk et al. [26]. Reported a case showing satisfactory results using a dermal matrix on the dorsal side of the foot to cover small areas of exposed tendons and reattached defatted avulsed skin on the plantar side. Their case showed no ulceration during the 3-year follow-up period. Many other studies have reported successful cases using a dermal matrix on the dorsal side of the foot as a substitute for the missing soft tissue, performing coverage with a split-thickness skin graft [27]. Because the dorsal side of the foot represents a less exposed and demanding area of the foot, we found it to be a feasible treatment method to achieve good results. However, these products are expensive. Scalise et al. [28]. Described two cases of heel reconstruction using a dermal matrix with consecutive skin reconstruction using split-thickness skin [28]. They conducted a five-year follow-up performing gait analysis to study function and kinematics. Their results showed impaired sensation leading to an overload under the foot, as shown by the pressure distribution analysis, resulting in small ulcerations [28]. Considering the limited resilience of the dermal matrix, we consider it less suitable for heel reconstruction.

Figure 14: Long-term-outcome (10 years) showing ulcerations.

Although there is an increasing number of patients treated using dermal matrices, there are no long-term data regarding durability available, and most studies present cases reconstructing the dorsal side of the foot. Major disadvantages are the high cost and lack of remuneration [27]. To date, the gold standard for reconstruction of extended injuries to the sole of the foot is free tissue transfer. While diminished sensation after reconstruction is often present, Ou et al. performed soft tissue reconstruction using an ALTP flap, including its lateral femoral cutaneous nerve [30]. They reported a Maryland foot score of excellence in seven patients and a good ranking in three patients. If there are any possibilities to preserve or restore sensibility, we consider this approach favorable and part of a successful surgery. Preserved sensitivity protects the skin, resulting in better outcomes [7]. In 2001, Banis described the use of plantar split-thickness skin grafts (PSTSG) and observed superior results regarding function and sensation compared to normal skin grafts [31]. Assuming that the defect is limited in size and a granulated wound bed without exposed structures is provided, this technique should be considered for heel defects.

In our cases, extensive injuries were observed, and free tissue transfer was recommended. Because of the extensive injury to the sole in Case 1, reconstruction with a muscle flap was considered superior because of the trend of scarring and shrinking of the muscle, providing more stability than a fasciocutaneous flap. Increased shifting ability of the fasciocutaneous tissue leads to reduced stability of the weight-bearing surface of the sole. Furthermore, there is often a need for further flap-debulking operations [27]. However, as our long-term results show, a lack of sensitivity can lead to ulceration. We recently discussed the present situation with our adult patient and recommended lipofilling for improved soft tissue quality or performing an innervated fasciocutaneous flap for coverage of the most affected area. In the latter case, we would have planned to harvest it very thinly. The patient currently refuses any surgery or long recovery time, as he is very active and treats the ulcerations successfully with conservative measurements. Despite the ulceration, we were convinced that a muscle flap was the right choice to provide this young patient with full stability, which allowed him to have a normal childhood and be as active as his peers. Due to the growing process, one bone segment of toe II was resected because it caused a chronic wound. Although one surgery was required, we believe that free tissue transfer is superior to skin grafts in terms of the growth process. For the stability of the weight-bearing surface, we advocate the use of a muscle flap and recommend the use of a fasciocutaneous flap for coverage of the plantar side involving smaller parts or dorsum of the foot. Considering the results of our literature review, the majority of partially degloved injury cases were reconstructed using a free flap, followed by avulsed skin. Most of the total degloving injuries were reconstructed by the avulsed skin; a detailed look at the results reveals that the study by Hede et al. reported 14 cases of total degloving injuries reconstructed with avulsed skin. Considering the results without this particular study, the majority of cases were reconstructed using a free flap. Overall, the results confirmed our observation that a free flap was the preferred type of reconstruction for extended degloving injuries (Table 3). Yan et al. [28-31]. Reported in their study a higher potential for sensation restoration in children than in adults [32]. Thus, free flaps are recommended for the reconstruction of degloving foot injuries, even though the procedure is challenging because they show greater vasospasticity and smaller vessels [33,34]. Liu et al. [35]. Emphasized the healing power and importance of proper soft tissue reconstruction in children [5]. They treated seven children who underwent soft tissue reconstruction with skin grafts in 3 patients and a distally based posterior tibial artery flap in 4 patients. The follow-up duration ranged from 12 to 24 months. Surprisingly, there was a large difference of 40–60 points in the Maryland Foot Score to the detriment of the skin graft group [5]. Compared to the AOFAS score, the Maryland foot score evaluates pain and function in detail, whereas the AOFAS score evaluates four different regions of the foot and within them, including function, pain, and alignment. Although the present study used a score different from those used by Liu et al. [36] and Ou et al. [37], their results were outstanding. Comparing their patients with ours, it appears that our patients had complex fractures over the midfoot area. The authors assume that concomitant complex fractures of the midfoot considerably affect outcomes, resulting in a limited ability to assess reconstructive achievement. From this perspective, careful and differentiated evaluation of such patients must be performed to evaluate short- and long-term outcomes. In addition, there is a substantial difference in the prevalence of neuropathic pain between children and adults [35]. Further studies must be conducted with a focus on a detailed analysis of the outcomes after orthopedic foot interventions in combination with plastic surgical reconstructive procedures. Finally, financial aspects must be considered when choosing treatment. Replantation and reconstruction attempts are primarily decided by the patient and the patient's family, and in some cases, for psychological reasons. As specialists, it is our responsibility to make a reasonable decision. The time taken for rehabilitation, time taken to return to work and perform normal life activities, gait impairment, and pain are different aspects that must be considered in the treatment plan. Sometimes, lifelong prostheses are more expensive as complex treatments for replantation [36, 37]. The authors believe that reconstruction attempts must be carefully evaluated before the choice for amputation is made. If an unbearable situation results from reconstruction, amputation is still possible. However, from a psychological perspective, the decision-making process can help cope with the trauma caused by losing a limb, which remains a difficult and complex challenge.

Table 3: Summary of the literature review

Extension of injury	Type of reconstruction												Total
	Avulsed Skin		Splithickness Skin graft (STSG)		Dermal Matrix/ other wound matrix and STSG		Pedicled Flap		Free Flap		Other		
	Exposure of critical structures (bone, tendon)		Exposure of critical structures (bone, tendon)		Exposure of critical structures (bone, tendon)		Exposure of critical structures (bone, tendon)		Exposure of critical structures (bone, tendon)		Exposure of critical structures (bone, tendon)		
	yes	no/not described	yes	no/not described	Yes	no/not described	yes	no/not described	yes	no/not described	yes	no/not described	
Total	2	18	6				4	1	14	1	1		47
Partial	14	15	2	8	4	3	2	11	8	27	1		95

6.1. Limitation

The results presented in the literature review are limited by the choice of one database, PubMed. Furthermore, by selecting a specific search algorithm, the results obtained may not include all studies reporting degloving foot injuries.

7. Conclusion

Based on the literature, the use of defatted avulsed skin for wound coverage is advocated whenever possible. If a complex reconstruction is necessary, free tissue transfer is recommended for degloving foot injuries. Although the patient may need amputation after many years, the effort of complex reconstruction is justified. The presented patients gratefully appreciate the reconstruction regarding the quality of life. In case 1, through the reconstruction, the patient was able to have an unrestricted childhood compared to amputation. However, the cases presented by the authors do not provide general recommendations for the treatment of degloving injuries. Thus, the treatment must be carefully considered individually, as described in the literature. In conclusion, an interdisciplinary approach to this injury pattern is crucial for successful treatment.

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