



## Gracilis muscle flap for reconstruction of extensive soft tissue damage to the palm

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**Objective:** The reconstruction of a large palmar soft tissue defect is a challenge to restore both aesthetics and functionality. Reconstruction with fascio-cutaneous and fascial flaps are the most widely used in the literature, few cases are reported using muscular free flap. We report our experience with the use of the free gracilis muscle flap for palmar soft tissue reconstruction in patients with complex hand traumas.

**Methods:** We review nine cases of complex soft tissue reconstruction to the palm of the hand using the free gracilis muscle flap performed over a period of 20 years. Eight cases involved acute trauma with damage to underlying structures, necessitating multiple surgical procedures.

**Results:** With an average follow-up of 36 months, the free gracilis muscle flap reconstruction enabled patients to achieve good grip, with skin quality resistant to chronic mechanical stress. All patients recovered a protective sensation to deep pressure. The hand's aesthetic appearance was restored in all cases. Flap harvesting altered neither the function nor silhouette of the donor site.

**Conclusion:** The optimal palmar reconstruction technique depends on patient characteristics, associated trauma, and defect size. In our opinion, the gracilis muscle flap technique is both straightforward and effective in restoring mechanical function of the hand, particularly when a large area of the palm has been impacted.

**Keywords:** Hand coverage, palm reconstruction, free flap, muscle flap, microsurgery, Gracilis flap.

### INTRODUCTION

The palm of the hand serves multiple functions and possesses complex skin anatomy.

Palmar skin is thick, with a predominant cornified layer that protects from ulceration<sup>1-3</sup>. Fibrous bands, connect the skin to the deep palmar fascia, providing stability to the palm<sup>1,2,4</sup>. Fat compartments protect against punctiform pressure and shock<sup>1,3</sup>. Numerous nerve endings, provide precise, protective sensitivity and are responsible for discrimination<sup>4-6</sup>.

Achieving “like-to-like” soft tissue reconstruction in the palm is challenging. A successful outcome should combine sensitivity, functionality, and aesthetics.

The tissue used for palm reconstruction must be supple, relatively thin, and able to withstand chronic pinpoint forces and friction<sup>1</sup>. It should be sufficiently immobile and inelastic to ensure mechanical stability yet flexible enough to allow adequate grip during hand function<sup>2-5</sup>.

Various techniques for palmar soft tissue reconstruction exist, their selection depending on individual patient parameters (age, dominant hand, profession, etc.) as well as the extent of the affected area<sup>1,4</sup>. Local, regional, and distant reconstruction options have been extensively documented in the literature. However, the literature on palmar soft tissue reconstruction using the free gracilis muscle flap is rare, despite being regularly mentioned as a viable option among reconstruction techniques. The gracilis muscle was first described in 2011 by Engelhardt et al. for the reconstruction of the central area of the palm<sup>1,3</sup>. Misani et al. compared the anterolateral thigh flap with the gracilis flap for the treatment of palmar and dorsal burn sequelae in the same patient<sup>7</sup>.

Here, we share our experience with palmar soft tissue reconstruction using the free gracilis muscle flap. Functional and aesthetic outcomes for nine cases

are reviewed and potential applications of the gracilis flap are discussed.

## PATIENTS AND METHODS

A retrospective study was conducted between 2003 and 2023 on the reconstruction of extensive palmar soft tissue defects using the free gracilis muscle flap. All reconstructions were performed by a single surgeon at the same surgical center. Data were extracted from patient records, radiographs, and clinical photographs. The analyzed data included age at the time of reconstruction, gender, anatomical region affected, trauma etiology, functional and aesthetic outcomes, and complications. Regarding early complications, we evaluated partial or total flap loss and post-operative infection, whereas late complications included bulky flap, local contracture, tendon adhesion, and neuroma. Data regarding the reconstruction included recipient vessels and the type of anastomoses. The donor site was also evaluated for the presence of seroma, post-operative infection, wound dehiscence, maintenance of functionality, and aesthetic appearance. Only patients with complete data and only those who provided consent were included in the study.

### Operative technique

Prior to any palm reconstruction procedure, de-vascularized tissues were extensively debrided to reach healthy tissue suitable for coverage. Structures such as bones, tendons, and the neurovascular pedicle were repaired whenever possible. The harvesting of the gracilis muscle was performed under general anesthesia as previously reported<sup>8</sup>. Primary closure of the donor site was achieved over a suction drain. Once the flap was at its recipient site, the muscle's epimysium was divided to evenly spread the flap and fill in all dead spaces. The artery was anastomosed end-to-side to the ulnar or radial artery, and the vein was anastomosed end-to-end to a superficial vein. A thin-mesh skin graft (0.3mm thick), harvested from the same thigh as the flap, was placed either immediately or in a second surgical procedure onto the muscle.

## RESULTS

Free gracilis muscle flaps were used to repair soft tissue defects on the palms of nine patients over a 20-year period. The study population consisted of eight men and one woman, aged 11 to 64 years (average age: 37 years). The post-operative follow-up period was an average of 3 years. There were five acute crush injuries,

three firearm accidents, and one planned amputation of the fifth ray. All soft tissue defects involved the palms. Three patients had defects extending into the first commissure. One patient had a transfixing defect involving both the dorsal and palmar aspects of the hand. Another patient had a skin and muscle defect limited to the thenar eminence. Clinical and defect characteristics are summarized in Table I.

In these nine cases, three arterial anastomoses were performed on the radial artery and six on the ulnar artery at the wrist. All venous anastomoses were made to a superficial vein. The free flap reconstruction was performed after one to three debridement procedures when healthy tissue was obtained.

Eight cases were associated with complex hand reconstruction (fractures, bone loss, dislocations, amputations, or tendon, muscle, or nerve injuries) (Table I). Four flaps had to be mobilized secondarily once or twice without any difficulties. None of these secondary mobilizations resulted in any flap loss (Table II). No total or partial flap loss or graft loss was reported. No cases of post-operative infection required surgical debridement (Table II).

From a functional standpoint (Table II), all patients exhibited good grip strength without object slippage or difficulties in handling. The motor impairments, observed in six patients, were related to the repair of the structures underlying the flaps and not to the flaps themselves. One flap was revised three times to correct scar contractures in the interdigital commissures. No skin damage related to chronic mechanical stress was reported. Aesthetic results were assessed with the Vancouver scar scale as satisfactory (one case of graft hyperpigmentation) (Table II). No contour abnormalities needed correction. No functional complications or pain were noted at the donor sites. Four minor scar enlargements were observed at the donor site, but they did not lead to complaints from the patients.

Two cases are presented and allow the results to be evaluated through a series of preoperative, intraoperative and postoperative photographs (case 1: Fig 1, 2, 3; case 2 Fig 4, 5, 6).

## DISCUSSION

Soft tissue reconstruction techniques are varied. Secondary intention healing of large soft tissue defects of the palm should be avoided due to the non-negligible risk of scar contracture<sup>2,3,6</sup>. In recent years, the advantages of dermal substitutes combined with a thin skin graft have been well established<sup>9</sup>. This method

**Table I.** — Patients/defects characteristics.

Patients Characteristics						Defects Characteristics			
Patient no.	Sex	Age	Smoker	Diabetes	Arterial problems	Etiology	Localization (Tubiana Functional Cutaneous Units <sup>1,3,5</sup> )	Surface Area (cm <sup>2</sup> )	Noble Structures Involved
1	M	33	+	-	-	Crushing	Palmar (U + C + R' + R + D)	58cm <sup>2</sup>	Bone Fractures (Metacarpals)
2	M	19	-	-	-	Crushing	Palmar + First Commissure (R' + R + C)	39cm <sup>2</sup>	Bone Fracture (Metacarpal)
3	M	33	+	-	-	Crushing	Palmar + First Commissure (U + C + R' + R + D)	120cm <sup>2</sup>	Tendon Section, Bone Fractures (Metacarpals)
4	M	64	+	-	Arterial Hypertension	Gunshot	Thenar Eminence (R' + R)	28cm <sup>2</sup>	Bone Fracture (metacarpal) Trapezo Metacarpal Joint Dislocation Thenar Muscles Loss
5	F	46	-	-	-	Planned Amputation	Palmar + Ulnar Edge (U + D)	15cm <sup>2</sup>	-
6	M	39	+	-	-	Gunshot	Palmar + Dorsal (C + R)	66cm <sup>2</sup>	Bone Loss (wrist) Tendon Loss Nerve Injuries Muscles Loss
7	M	11	-	-	-	Gunshot	Palmar (U + C + R' + R)	30cm <sup>2</sup>	Bone Loss, Tendon Loss Nerve Injuries Muscles Loss
8	M	38	-	-	-	Crushing	Palmar + First Commissure (U + C + R' + R + D)	71cm <sup>2</sup>	Bone Fractures (Metacarpals) Bone Loss (Metacarpal) Bone Dislocation (Wrist) Ligament Section
9	M	53	+	+	Arterial Hypertension	Crushing	Palmar + Ulnar Edge (U + D)	55cm <sup>2</sup>	Fifth ray traumatic amputation

results in high-quality functional coverage and can be applied directly to deep structures<sup>9,10</sup>. However, these substitutes are thin and, therefore, may not provide sufficient padding and protection against pressure. They are also challenging to mobilize in the case of secondary procedures<sup>10</sup>.

Autologous reconstructions using local and regional flaps are easily achievable and essential to the surgeon's therapeutic arsenal. However, they can be debilitating for the upper limb and sometimes involve sacrificing the vascular axis of an already compromised hand<sup>6</sup>. Distant flaps (i.e., MacGregor flaps) require immobilization of the limb for several weeks, and after dividing the main pedicle, the flap relies entirely on local vascularization.

Since the development of free flaps, there have been numerous therapeutic options that can be anastomosed to a vascular axis of the upper limb without sacrificing it. In 1996, Tubiana described palmar cutaneous functional units corresponding to areas of high or low mobility<sup>1,3,5</sup>. In 2012, Engelhardt and al. defined primary, secondary,

and tertiary palmar tactile regions<sup>1,3</sup>. Algorithms have been established to assist in selection of the most appropriate procedure based on the affected functional units and tactical regions. Engelhardt et al. suggest using a sensory flap for reconstruction of the thenar and hypothenar eminences, preferring a stable, non-sensory flap for the reconstruction of the central unit alone. In cases where both the central unit and eminence are affected, whether reconstruction requires a stable flap, a sensory flap, or both depends on individual patient characteristics<sup>3</sup>.

Although fascio-cutaneous and fascial flaps are the most widely used in the literature for palmar soft tissue reconstruction, they have disadvantages. Fascio-cutaneous flaps have a thick and bulky subcutaneous tissue which leads to instability when gripping<sup>1,3,11,12</sup>. Flap thinning is possible but limited by the cutaneous perforator and with the risk of partial flap loss<sup>12,13</sup>. Conversely, fascial flaps have a thin and pliable tissue that does not provide sufficient padding and resistance

**Table II.** — Complications, results.

Patient no.	Flap Mobilization	Early Complications		Late Complications	Sensibility	Results		Scar Quality (Vancouver Scar Scale)
		Partial/ Total Flap Loss	Infection	Contour Anomaly/ Scar Contracture		Function		
						Mobility	Prehension	
1	1	None	None	None	Deep Pressure	Partial (Arthrodesis)	Good	2
2	-	None	Local	None	Deep Pressure	Total	Good	3
3	-	None	Local	3 Plasty for Interdigital Contracture	Deep Pressure	Total	Good	6
4	-	None	None	None	Deep Pressure	First Finger Opposition Loss	Good	2
5	-	None	None	None	Deep Pressure	Total	Good	2
6	2	None	None	None	Deep Pressure	Low (Wrist Arthrodesis, Tendon Adhesion)	Good	2
7	2	None	Local	None	Deep Pressure	Low (Arthrodesis, Tendon Adhesion, Muscle Injuries)	Good	2
8	1	None	None	None	Deep Pressure	Partial (Joint stiffness)	Good	3
9	-	None	Local	None	Deep Pressure	Total	Good	2

to mechanical stresses when used on the palm<sup>12</sup>. They are ideal for the dorsal side of the hand<sup>14</sup>.

In our view, muscle flaps represent the best compromise. The flexible and pliable muscle tissue adapts perfectly to dead spaces and allows for good contouring, which is improved over time by muscle atrophy<sup>1,7</sup>. The skin coverage of these flaps requires the harvesting of a split-thickness skin graft, which can lead to unaesthetic pigmentation disorders<sup>2</sup>. Nevertheless, fascio-cutaneous flaps with bulky tissue, skin coloration, and the presence of hair on the surface can also result in an unsightly outcome<sup>3,15</sup>. Moreover, closure of muscle donor site is direct and without tension, reducing the risk of complications and unaesthetic scar. The thickness of the muscle flap, combined with coverage by a thin skin graft, provides both a stable grip and durable tissue<sup>1,3,11</sup>. The absence of fascia does not compromise tendon gliding when compared to fascial flaps<sup>15</sup>. The major disadvantage of muscle flaps is the absence of sensitivity<sup>2,3</sup>. However, there is a sensitivity to deep pressure<sup>1,3</sup>. It is important to note that the sensitivity of neurocutaneous flaps is not guaranteed<sup>1</sup>, and the collateral innervation of fascio-cutaneous flaps is unpredictable<sup>3,16</sup>. In our experience,

it is preferable to have a painless flap with protective sensitivity to pressure rather than a sensory and painful flap.

Different muscle flaps have been reported in the literature including the serratus anterior muscle flap<sup>4,12,17-19</sup>, sometimes harvested with the latissimus dorsi muscle<sup>20</sup>, and the free rectus abdominis muscle flap<sup>21</sup>. In 2010, Medalie et al. described the free iliac muscle flap<sup>22</sup>. In 1993, Dautel and Merle described a free pronator quadratus muscle flap<sup>11</sup>.

Our preference is for the gracilis muscle flap, which is easy and quick to harvest. It results in a less conspicuous scar compared to the serratus flap and a lower risk of local complications<sup>23</sup>. Unlike some other muscles, the absence of the gracilis muscle does not lead to functional impairment and does not alter the silhouette<sup>24</sup>. Its location allows for simultaneous work by two surgical teams, significantly reducing operating time. Although it is long and narrow, its width can be increased threefold by epimysiotomy. This not only allows for flap thinning but also better adjustment to the recipient site<sup>7</sup>. Motor reconstruction can be easily achieved by harvesting the motor nerve and its tendon as described by Wink et al. and El-Gammal et al.<sup>6,25</sup>.





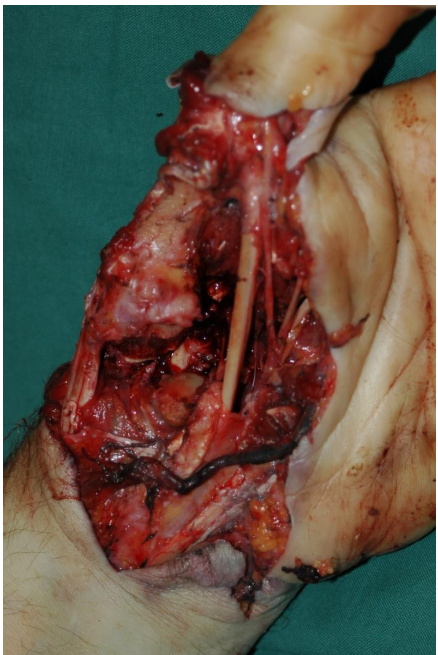
*Fig. 1 — Case 1: 33-year-old manual worker, hand crushed in a press with a large soft tissue loss involving the entire palm and the first commissure.*



*Fig. 2 — Case 1: Intraoperative photo showing coverage of the entire soft tissue defect with a free gracilis muscle flap during a third procedure. Anastomoses were performed end-to-side on the radial artery. A thin skin graft was applied secondarily to the flap.*



*Fig. 3 — Case 1: Soft tissue reconstruction using a free gracilis muscle flap and thin skin graft, 12 months postoperative. Hyperpigmentation of the graft with good contouring. Contractures on the first, second, and third web spaces were improved by local flaps, Z-shaped plasty, and a full-thickness skin graft.*



*Fig. 4 — Case 2: 64-year-old male, gunshot injury with muscular and cutaneous loss in the thenar eminence. Associated fracture and dislocation of the trapezo metacarpal joint. Attainment of healthy tissue after one procedure of debridement.*



*Fig. 5 — Case 2: Intraoperative photo showing reconstruction of the entire musculocutaneous defect with a free gracilis muscle flap. Anastomoses were made end-to-side on the ulnar artery. The motor nerve of the gracilis muscle was sutured to a motor branch of the median nerve. A thin skin graft was applied to the flap during a third procedure.*



*Fig. 6 — Case 2: Musculocutaneous reconstruction using a free gracilis muscle flap and thin skin graft, 16 months postoperative. Good mobility of the thumb with complete flexion and partial opposition. Good aesthetic result.*

A limitation of our study is the lack of a control group. Each clinical case is different. A prospective study comparing the same types of defects with a large sample size would be necessary to compensate for this variability. Although not employed here, a satisfaction questionnaire and an external expert opinion could be used to objectively assess the functional and aesthetic outcomes. Conducting such a study is challenging due to the rarity of these complex cases and the diversity of underlying injuries associated with soft tissue loss.

## CONCLUSION

We evaluated the functional and aesthetic results obtained for the reconstruction of large palmar soft tissue defects of the hand using the free gracilis muscle flap. The gracilis flap, in our opinion, is the best option for palm coverage. It provides an ideal tissue: well-vascularized, resistant, and stable. Its protective sensitivity to deep pressure and lack of pain makes the reconstruction comfortable for the patient. This procedure, which can be readily performed by microsurgery-trained practitioners, should be an integral part of the various possibilities for hand soft tissue reconstruction.

*Conflict of interest:* The authors declare that they have no competing interests.

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