SVOA Orthopaedics

ISSN: 2752-9576

ScienceVolks Open Access

Research Article

The Use of Free Flaps as a Surgical Treatment for Chronic Refractory Pain in the Upper Extremity

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DOI: https://doi.org/10.58624/SVOAOR.2024.04.065

***Received:** November 26, 2023* ***Published:** February 26, 2024*

Abstract

Objective: The objective of this study is to present our experience with free flaps as a treatment for recalcitrant neuropathic pain in the upper extremity.

Methods: The first case involved a woman who developed neuropathic pain following carpal tunnel release. After undergoing revision surgery, neurolysis, and Strickland's hypothenar fat pad flap, the patient still experienced persistent pain. Subsequently, after 8 years and 3 surgeries, a free sural flap was proposed. The second case involved a woman with partial amputation of the index finger. Following initial bone regularization and advancement flap, the patient developed refractory neuropathic pain. Three additional surgeries were performed, including resection of the remaining phalanx with denervation, metacarpal osteotomy with neurectomy, and resection of the neuroma followed by burying it into the metacarpal bone. After 3.5 years and 3 surgeries, a perforator artery fibular free flap was offered. The Visual Analog Scale (VAS), and Disabilities of Arm, Shoulder, and Hand (DASH) questionaries were used to evaluate the outcomes.

Results: Both patients experienced pain following nerve injury. The sural free flap and the perforator artery peroneal free flap were anastomosed to the radial artery and the volar branch of the radial artery, respectively, using end-to-side and end-to-end techniques. Both patients demonstrated significant clinical improvement, with VAS scores improving by 6 and 8 points, and DASH scores improving to 41 and 36, respectively. The follow-up period was 2.5 years and 1 year, during which no complications were observed.

Conclusions: Free flaps represent a viable option for the treatment of recalcitrant neuropathic pain in the upper extremity.

Keywords: *Free Laps, Chronic Refractory Pain, Treatment, Neuropathic Pain, Upper Extremity.*

Introduction

It is widely recognized that chronic refractory neuropathic pain constitutes a profoundly debilitating condition with significant implications for individual quality of life. This condition affects approximately 2-3% of the population, imposing substantial burdens on both the healthcare system and the individuals afflicted by it[1]. Notably, nerve injuries in the upper extremities predominantly impact the young and economically active demographic[2]. The etiology of this pain is typically attributed to nervous system lesions stemming from various factors, including but not limited to brain injuries, spinal cord injuries, radiculopathies, postherpetic neuralgia, neuropathy associated with cancer, complex regional pain syndrome, immune deficiencies, and ischemic disorders[3].

Evaluating neuropathic pain poses significant challenges, often necessitating a meticulous and time-consuming process. This undertaking demands expert proficiency, employing a combination of laboratory techniques, and typically calls for a comprehensive multidisciplinary evaluation and approach.

As previously indicated, the management of chronic neuropathic pain remains an area of uncertainty. Initial therapeutic interventions primarily revolve around pharmacological approaches or physical therapy modalities. Nonpharmacological treatments encompass various strategies such as physiotherapy, exercise regimens, transcutaneous electrical nerve stimulation (TENS), percutaneous electrical nerve stimulation (PENS), among others. However, their efficacy has yet to be conclusively demonstrated.

In the realm of pharmacological interventions, tricyclic antidepressants and anticonvulsants, such as carbamazepine and phenytoin, have exhibited utility in managing neuropathic pain, particularly in cases of diabetes-related neuropathy and trigeminal neuralgia. Gabapentin and pregabalin have demonstrated efficacy due to their role as calcium channel antagonists. Among the opioid analgesics, tramadol and methadone have been employed. Additionally, certain topical agents, including lidocaine patches (5%) and capsaicin cream or patches, have shown usefulness in this context.

Due to the limited effectiveness of the treatments, a combination of modalities is often employed to enhance pain management while minimizing adverse effects[4]. Invasive pain management techniques encompass a range of interventions, including epidural or perineural injections of local anesthetics or corticosteroids, implantation of epidural and intrathecal drug delivery systems, neural ablative procedures, and the insertion of spinal cord stimulators[5].

Surgical management represents a final option and typically involves procedures such as surgical neurolysis, local flap coverage, or nerve transposition. The aim of this study is to present the utilization of free flaps as a surgical treatment modality for severe and refractory neuropathic pain in the upper extremity, particularly when previous therapeutic interventions have proven ineffective.

Methods

This is a clinical note including 2 cases of refractory neuropathic pain in upper extremity surgically treated with a free flap. The 2 procedures were performed by the same senior surgeon in 2 different medical centers.

Clinical Cases

The first case involves a 50-year-old right-handed woman who initially underwent carpal tunnel release surgery, subsequently developing neuropathic pain in the volar area of her right wrist. Initially, conservative treatments were prescribed, including oral analgesia, pregabalin, topical capsaicin cream, and local anesthetic blocks. However, these conservative measures proved ineffective. Subsequently, a revision surgery was performed, which also failed to alleviate her symptoms. A second surgical intervention was carried out, involving a new neurolysis procedure and the utilization of Strickland's hypothenar fat pad flap. Despite these efforts, the patient continued to experience intractable pain that significantly impaired hand function, necessitating her to keep it in her pocket. After eight years since the initial carpal tunnel release and following three prior surgeries, the patient's pain remained unmanageable. Consequently, a free sural flap was proposed to replace the area affected by allodynia area, measuring approximately 11x3cm in an elliptical shape (Fig 1). Free sural flap with elliptical shape in concordance with the allodynia area marked in the hand was designed (Fig 2).

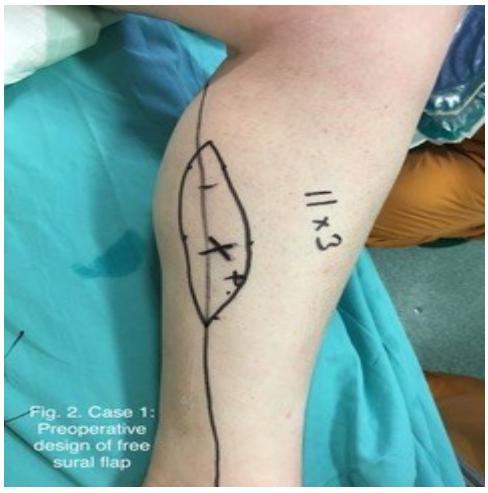
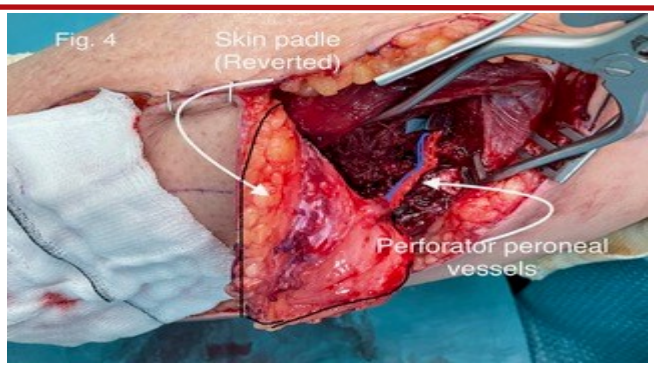


Fig. 3. Case 2: allodynia area marked in black



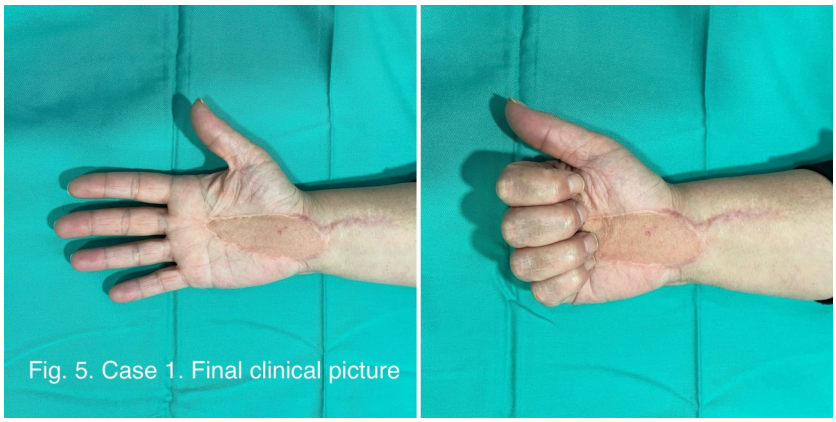


Fig. 5. Case 1. Final clinical picture

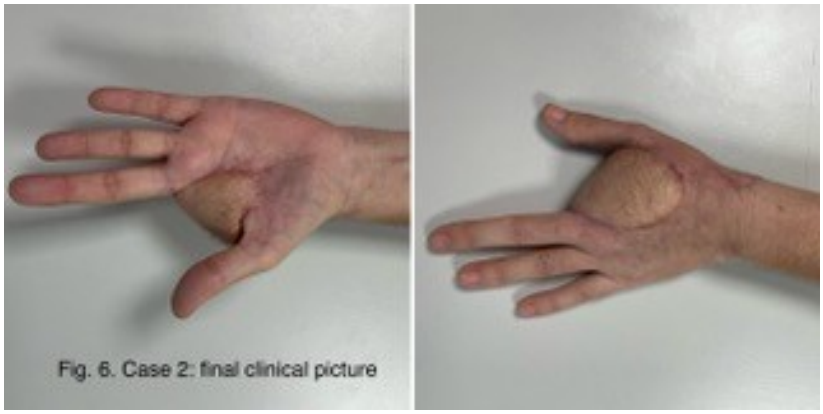


Fig. 6. Case 2: final clinical picture

The second case involves a 48-year-old left-handed woman who experienced an amputation through the middle phalanx of her left index finger because of a work-related accident. Following initial bone regularization and the implementation of a local advancement flap for coverage, she developed neuropathic pain affecting both sides of the finger. Despite attempts at conservative treatments, including oral analgesia, pregabalin, topical capsaicin cream and patches, and local anesthetic blocks, the patient's symptoms persisted. Consequently, she underwent a series of three surgeries. The first procedure involved the resection of the remaining portion of the middle phalanx and denervation of both nerves. This was followed by a second surgery, which entailed base metacarpal osteotomy and neurectomy of both digital nerves. The final surgery involved the resection of identified neuromas, followed by their burial into the base of the third metacarpal. As a result of the interventions, retraction of the first web space was observed to immobilize the finger and an area of allodynia - marked in black in Figure 3 - appeared. Finally, after 3.5 years and three surgeries, the patient was offered a perforator artery fibular free flap as a treatment option.

In preparation for the free flap surgery, a custom-made orthosis was meticulously designed to encompass the area affected by allodynia and simulate the anticipated postoperative outcome. This approach allows patients to gain insight into the potential overall functionality of their hand following the surgical intervention. Remarkably, the implementation of the custom-made orthosis in both cases resulted in notable improvements in pain levels and overall quality of life.

Both surgical procedures were performed by the same surgeon, employing surgical loupe and microscope magnification for enhanced precision.

It was imperative to accurately define and delineate the area affected by allodynia at the beginning of the surgical intervention. Subsequently, the skin and subcutaneous tissue outside of the defined area were excised, without performing neurolysis or neuroma resection. Following this preparatory step, the selected free flap was utilized to provide cover- age for the affected region in each respective case.

The choice of flap is crucial upon the location of the allodynia area. Factors such as the size of the painful region, flap thickness, mobility of the donor site, and other considerations influence the decision-making process regarding the most suitable flap option to be offered. In both cases, a flap with ample adipose tissue compared to the recipient area was chosen, while also prioritizing optimal cosmetic appearance and the absence of transferred sensitive nerves. In these two clinical pictures (figures 5 and 6) we can observe the cosmetic appearance of both flaps and can notice the good functional outcome after the surgery.

Postoperative care:

Both patients were immobilized with a cast for the first 2 weeks, after which they were able to start physical therapy.

Results

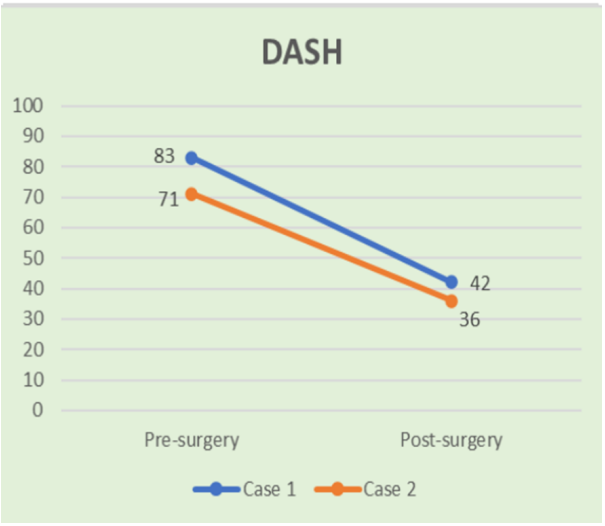
Two patients: 2 women of 50 and 48 years old, respectively. In both cases the affected hand was the dominant hand. In both patients the incoercible pain was presented after a nerve injury in the upper extremity. In the first case, the pain was presented after an elective surgery and in the second case, the pain was presented after a traumatic accident resulting in a catastrophic finger. The duration of the pain before the surgery of the free flap was 8 years and 3.5 years, respectively. All the patients underwent through multiple surgeries - a total of 3 surgeries - before being selected for a free flap surgery. Both flaps survived. These results are resumed in table 1.

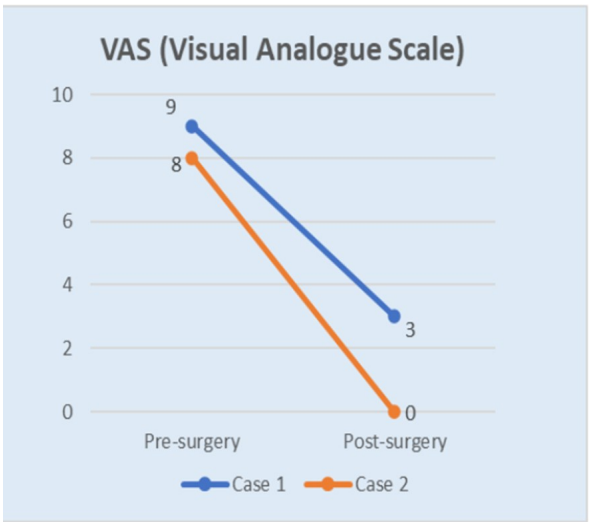
Both patients presented good clinical results improving significatively the pain and the functional scores. The VAS improved in 6 and 8 points Table 1, and the DASH score in 41 and 36, respectively Table 2.

Both patients stated that they would have this surgery again. Both patients were satisfied with the aesthetic result. The first patient was unemployed but returned to her normal life, the second patient was successfully reincorporated to her previous work at a bakery. The follow-up was 2.5 years and 1 year in case 1 and case 2, respectively. No complications were found to date. Final clinical results are shown in Fig 5 and Fig 6.

Table 1&2

	CASE 1	CASE 2
Sex	Woman	Woman
Age	50	48
Affected hand	Right	Left
Dominant hand	Yes	Yes
Pain source	Surgery	Trauma
Duration of the pain previous to free flap	8 years	3.5 years
Number of previous surgeries	3	3
Type of flap	Free sural flap	Perforator artery peroneal free flap
Peroperatory complications	No	No
Flap survival	Yes	Yes
Postoperatory complications	No	No
Follow-up	2.5 years	1 year





Discussion

Chronic refractory neuropathic pain is a debilitating condition that profoundly impacts individuals' lives, often stemming from lesions within the nervous system that can arise from various initial causes. While conservative treatments may offer some relief, a subset of patients experiences persistent and intractable pain that persists for extended periods, spanning years.

The management of chronic neuropathic pain remains an ongoing challenge, lacking a standardized approach. Addressing this complex pathology necessitates a multidisciplinary approach involving pain management physicians, physical therapists, surgeons, and the invaluable support of psychologists or psychiatrists.

As previously mentioned, surgical management of pain typically involves surgical neurolysis, local flap coverage, or nerve transposition. However, despite these interventions, some patients continue to experience pain, which can have a profound impact on their quality of life and may even lead to functional impairment or limb loss as a desperate measure to alleviate the pain.

The objective of this study is to present the utilization of free flaps as a surgical treatment modality for severe and refractory neuropathic pain in the upper extremity, as demonstrated in two cases. In alignment with existing literature, our primary goal with this surgical procedure is to establish a scar-free, tension-free, well-cushioned, and adequately vascularized environment to facilitate pain reduction within the affected nerve[6]. We agree with previous authors on the criticality of patient selection as a prerequisite for any surgical pain management intervention[7].

By employing non-sensitive free flaps, such as those utilized in the cases, it becomes feasible to replace the area of allodynic skin. This approach effectively prevents the triggering of pain upon direct contact with the affected skin. Additionally, the simultaneous transfer of well-vascularized subcutaneous tissue replaces the scar tissue that surrounded the affected nerve and creates a better environment and, in consequence, helps to improve its function.

The initial application of free flaps for neuropathic pain was pioneered by Kirikuta, who employed pedicled flaps of the greater omentum to cover the brachial plexus in patients with neuritis resulting from radiotherapy for breast cancer[8]. In this other work, Uhlschmid et al. also utilized free flaps of the greater omentum to address radiation-induced neuritis of the brachial plexus in seven patients who had previously undergone radiotherapy. Their study demonstrated a significant reduction in pain levels[9].

In these patients, the pain source encompassed scarred skin tissue affected by radiotherapy, which may have contributed to potential confounding factors in pain reduction. In our cases, although there was scarred subcutaneous tissue due to multiple prior surgeries, the skin itself remained structurally intact and presented a favorable appearance, albeit with hyperalgesia. While the exact etiology of this hyperalgesia remains unknown, it is noteworthy that different dermatomes were affected in both cases. Nonetheless, the substitution of the allodynic area has allowed for renewed contact of the skin with various stimuli.

Other authors, such as Holmberg[10,11], Goitz and Steichen[12], and Jones[13], have also implemented combined surgical approaches involving extensive neurolysis and flap coverage to optimize the nerve environment, yielding promising outcomes in pain reduction within the allodynic area.

Our surgical approach utilizing free flaps aims to serve as a salvage procedure for patients who have demonstrated refractoriness to previous conservative and surgical treatments. Notably, certain surgical interventions not only prove ineffective but can even exacerbate the allodynic area, as observed in our patients prior to the implementation of free flap surgery. By resecting the allodynic area and replacing it with a free flap, we effectively disconnect the involved nerves within this cutaneous region, enabling the reception of external stimuli without eliciting pain. However, this comes at the cost of sacrificing sensory function in the substituted skin area, given that a non-sensitive free flap is employed. Consequently, this surgical technique is not recommended for areas where sensory perception is crucial. It is important to note that applying deep pressure to the flap can still trigger pain; hence, we opt to transfer a free flap with a thicker subcutaneous layer than the recipient area to minimize this effect.

While further studies with larger patient cohorts are necessary to definitively recommend or discourage the utilization of this surgical technique, it is currently a viable option for patients experiencing recalcitrant pain that remains unresponsive to conventional therapies. One hypothetical explanation for the phenomenon we are addressing is that the initial nerve injury, as well as subsequent surgeries, may have contributed to the development of microscopic neuromas within the subcutaneous tissue. These neuromas could potentially account for the subsequent cutaneous hyperalgesia and allodynia observed. This hypothesis provides a plausible rationale for why these patients may benefit from the substitution of the affected skin and subcutaneous area.

Misdiagnosis of the pain source can result in an incorrect treatment approach, potentially exacerbating the pain. In patients with a prolonged history of pain, it is not uncommon to experience multiple sources of pain simultaneously[14]. Therefore, an accurate diagnosis is crucial prior to surgical intervention.

To provide patients with a realistic understanding of the potential sensory changes following free flap surgery, we propose the utilization of a customized orthosis that covers the allodynic area. This allows patients to visualize and experience the sensation of reduced or absent sensitivity in the affected area, offering a preview of the potential outcomes of the free flap procedure.

It is well-established that a longer duration of pain is significantly associated with poorer postoperative outcomes and persistent pain following surgery. This may be attributed to alterations in pain processing within the central nervous system (CNS) that occur during the chronic phase of neuropathic pain11. In our cases, both patients had endured pain for a considerable period, with one experiencing 8 years and the other 3.5 years of pain, rated at VAS 9 and 8, respectively, prior to undergoing surgical treatment. This extended duration of pain underscores the significant suffering these individuals had endured.

Although this surgical procedure is technically demanding and carries a negligible risk of complications, we believe it has substantially reduced the pain experienced by our patients. However, it is important to emphasize that absolute pain reduction cannot be guaranteed.

The patients' history of multiple prior surgeries adds a layer of technical complexity to the free flap procedure. This complexity arises from factors such as inflammatory changes, extensive scarring, compromised skin and soft tissues, varying surgical approaches (which can be further complicated when performed by different surgeons), and even potential vascular compromise.

These characteristics contribute to the high-demand nature of the surgery and increase the risk for complications15. In our cases, both patients had undergone three previous surgeries, all of which were performed by a senior surgeon.

The selection of an appropriate free flap is a complex decision that requires careful consideration of multiple factors. These factors include the size of the allodynic area, the thickness of the recipient area's skin, the mobility of the donor site, the ease of flap elevation, the reliability of the vascular pedicle, the feasibility of achieving favorable patient positioning, and the patient's personal preferences, among other considerations.

The size of the allodynic area is crucial in determining the extent of tissue coverage required. The thickness of the recipient area's skin is considered to ensure optimal functional and aesthetic outcomes. Donor site mobility is evaluated to minimize potential complications and ensure adequate tissue supply. The simplicity of flap raising is considered to optimize surgical efficiency and reduce operative time. The reliability of the vascular pedicle is of utmost importance to ensure adequate blood supply to the flap. Favorable patient positioning is considered to facilitate flap inset and optimize postoperative outcomes. Finally, the patient's preference is taken into consideration to ensure patient satisfaction and adherence to the treatment plan.

Considering all these factors helps in making a well-informed decision regarding the choice of the most suitable free flap for each individual case.

Conclusion

In conclusion, based on our experience, we believe that free flaps can be considered as a viable option for the treatment of chronic refractory neuropathic pain. However, it is important to note that this technique is highly demanding and should be performed by expert surgeons.

Conflict of Interest

The authors have no conflicts of interest to declare.

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Citation: Chanes C, Aparicio P, Andrés M, Torres J, Castellanos J, Izquierdo O. The Use of Free Flaps as a Surgical Treatment for Chronic Refractory Pain in the Upper Extremity. *SVOA Orthopaedics 2024,* 4:1, 17-23.