Universal Library of Medical and Health Sciences **Case Report**

ISSN: 3064-6545 | Volume 3, Issue 4

Open Access | PP: 42-47

DOI: https://doi.org/10.70315/uloap.ulmhs.2025.0304006

Integrated Multistage Approach to Bilateral Complex Functional Upper Limb Reconstruction in a Patient with Major Functional Impairment: Case Report

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Abstract

We present the case of a 68-year-old patient with catastrophic bilateral upper limb impairment. On the left side, the patient suffered a post-traumatic brachial plexus palsy after a scapulohumeral dislocation six months earlier, resulting in high radial nerve paralysis and low-level median and ulnar nerve dysfunction. On the right side, previous grade IV frostbite led to amputations at the metacarpophalangeal joints of digits II–V and at the first phalanx of the thumb. These combined injuries produced a severe functional handicap in both upper limbs, dramatically limiting the patient's autonomy in daily living.

A multistage reconstructive approach was carried out. The surgical plan included soft-tissue releases, tendon transfers, joint stabilization, and selective nerve decompression, tailored to the distinct pathology of each limb. This was followed by an intensive, structured rehabilitation program focused on neuromuscular re-education and progressive functional integration.

Postoperatively, the patient achieved substantial improvements in motion, grasp strength, and overall autonomy. Functional restoration allowed significant social reintegration, highlighting that even in complex bilateral cases, individualized multilevel surgical reconstruction combined with rehabilitation can produce meaningful recovery.

Keywords: *Brachial Plexus Palsy, Upper Limb Reconstruction, Nerve Paralysis, Amputation, Rehabilitation.*

INTRODUCTION

Bilateral upper extremity impairments present significant challenges, including compromised functional abilities and reduced independence. Adopting a multistage reconstructive approach is essential to address these unique challenges, as it provides a framework for individualized surgical interventions and rehabilitation strategies aimed at improving patient independence. The multidimensional nature of these impairments requires comprehensive planning integrating both surgical and rehabilitation aspects tailored to the specific needs of the patient.

The importance of a multistage reconstructive approach lies in its ability to accommodate the complexity of anatomical and functional requirements. As highlighted in the literature, functional transfer of the latissimus dorsi has shown promise for upper limb reconstruction. In the case study presented by Sood et al., the integration of this method resulted in improved functional outcomes and patient satisfaction, addressing both aesthetic and functional deficits (Sood A et al, 2017). Such findings highlight the importance of selecting appropriate surgical techniques that match the individual characteristics of the impairments experienced by each patient.

Individualized surgical strategies, as an integral part of the multistage approach, are crucial to achieve optimal functional recovery. Each patient's condition requires a personalized assessment of the most effective surgical options, tailored not only to the physical demands but also to the psychosocial aspects of recovery. For example, DePamphilis et al. reported a comprehensive study of upper extremity reconstruction following high-voltage electrical injuries in pediatric patients. They emphasized personalized reconstructive strategies that took into account the unique anatomical and functional implications of their injuries. This case series illustrated the profound effect of individualized approaches on recovery

Citation: Turcu E. G, "Integrated Multistage Approach to Bilateral Complex Functional Upper Limb Reconstruction in a Patient with Major Functional Impairment: Case Report", Universal Library of Medical and Health Sciences, 2025; 3(4): 42-47. DOI: https://doi.org/10.70315/uloap.ulmhs.2025.0304006.

outcomes, reinforcing the principle that surgery should be a patient-centered endeavor (DePamphilis MA et al, 2022).

Rehabilitation is the cornerstone of effective recovery after surgical procedures. By emphasizing individualized rehabilitation strategies, clinicians can significantly improve patients' independence. Rehabilitation not only addresses physical limitations, but also plays a central role in psychological adaptation and social reintegration. Integrating specialized occupational therapy into rehabilitation plans can facilitate the development of adaptive techniques that allow patients to regain independence in their daily activities. Research has highlighted that tailored rehabilitation interventions lead to superior outcomes in terms of functionality and quality of life because they focus on the specific goals and needs of each patient.

Additionally, the multi-step approach allows for continuous assessment and modification of rehabilitation protocols in response to each patient's progress. Gupta et al. highlighted the importance of adjusting rehabilitation strategies based on individual recovery rates and goals. This adaptability can significantly improve the rehabilitation experience and outcomes, ensuring that patients are supported throughout their recovery journey (Gupta S et al, 2025).

Furthermore, the psychological implications of maintaining bilateral upper extremity impairments cannot be overlooked. Patients frequently face emotional and psychosocial challenges, including depression and anxiety related to their functional limitations. The multi-stage reconstructive approach, alongside rehabilitation, offers the potential to alleviate these psychological impacts by promoting a sense of agency and control over one's recovery. By allowing patients to actively participate in decision-making regarding their surgical and rehabilitation journey, autonomy is enhanced, leading to improved mental well-being and overall satisfaction with the recovery process.

The multistage reconstructive approach offers a comprehensive and individualized framework for treating bilateral upper extremity deficiencies. Through strategically timed surgical interventions and tailored rehabilitation strategies, patients can benefit from significant improvements in their functional abilities and independence. By recognizing the importance of individualized care and adaptive rehabilitation, healthcare providers can better support patients on their journey to recovery and greater independence. This comprehensive approach is not only beneficial in optimizing physical outcomes, but also plays a crucial role in supporting the psychological well-being of individuals affected by bilateral upper extremity impairments.

CASE PRESENTATION

The article presents the case of a 68-year-old patient urgently admitted to our clinic with third- and fourth-degree frostbite injuries affecting digits I–V of the right hand and digits I and V of the right foot (Fig.1). The patient was in severe general condition, presenting with hypothermic shock. His medical history included chronic alcohol consumption, chronic hepatitis, and ischemic heart disease. Following laboratory investigations, cardiology evaluation, and chest and right-hand radiographic examination, systemic stabilization was initiated in the intensive care unit concurrently with local management of the frostbite lesion.

Fig 1. Frostbite of the right hand

Initial clinical assessment revealed a severe functional impairment of the left upper limb due to brachial plexus palsy, likely post-traumatic, secondary to a chronic scapulohumeral dislocation dating back approximately one year. This resulted in high radial nerve palsy and low median and ulnar nerve palsy (Fig. 2). Clinically, the patient demonstrated inability to actively extend the left elbow, complete loss of active wrist extension, and absence of active digital extension. Sensory loss was noted in the radial nerve distribution. Marked thenar, hypothenar, and interosseous muscle atrophy was present. Additional findings included absence of thumb opposition, loss of digital abduction–adduction, and anesthesia in the median and ulnar nerve cutaneous territories. MRI of the left brachial plexus demonstrated C5–C7 root avulsion and a postganglionic lesion at C8–T1. Electromyography confirmed absence of motor responses in radial nerve–innervated muscles and intrinsic hand muscles supplied by the median and ulnar nerves.

Fig 2. Left brachial plexus palsy

During the subsequent two weeks, local treatment of the third- and fourth-degree frostbite lesions of the right hand was carried out alongside systemic anticoagulant, antiplatelet, antibiotic, and anti-inflammatory therapy. After approximately 21 days, complete demarcation of the necrotic tissue was observed at the metacarpophalangeal joints of digits II–V and at the level of the first phalanx of the right thumb.

Surgical intervention was then undertaken, consisting of amputation of the necrotic fingers of the right hand under general anesthesia, resulting in what is referred to in plastic surgery as a "metacarpal hand" (Fig. 3). Postoperative evolution was favorable, with complete wound healing occurring approximately 14 days after surgery.

Fig 3. Right "metacarpal hand" after digital amputations

To achieve functional rehabilitation of both upper limbs, staged reconstructive procedures were planned. The first reconstructive stage targeted the paralyzed left upper limb. Considering the patient's age, the extended interval since the initial shoulder trauma responsible for the combined radial, median, and ulnar nerve paralysis, and the absence of motor reinnervation on electromyography, palliative reconstructive procedures were selected to restore partial function of the left hand.

The priority of the initial surgical stage was stabilization of the left radiocarpal joint through tenodesis using the tendon of the extensor carpi radialis longus. The tendon was transected at the musculotendinous junction, passed through the radial bone diaphysis, and sutured to the distal segment of the extensor carpi radialis brevis tendon and to the distal insertion of the extensor carpi radialis longus.

Finger extension was restored through tendon transfer using the flexor carpi ulnaris tendon, which was distally transected, transposed, and sutured to the extensor digitorum communis tendons. Thumb extension was re-established by transferring the palmaris longus tendon, which was distally sectioned and connected to the extensor pollicis longus tendon. Thumb abduction was restored using the flexor digitorum superficialis tendon of the fourth finger, sectioned at its insertion on the second phalanx and routed using the palmar aponeurosis as a pulley, then transposed to the dorsal aspect of the proximal phalanx of the thumb and sutured to the insertion of the abductor pollicis tendon (Fig.4, a-f).

Postoperative evolution was favorable, with immobilization for approximately four weeks followed by kinetotherapy for six months.

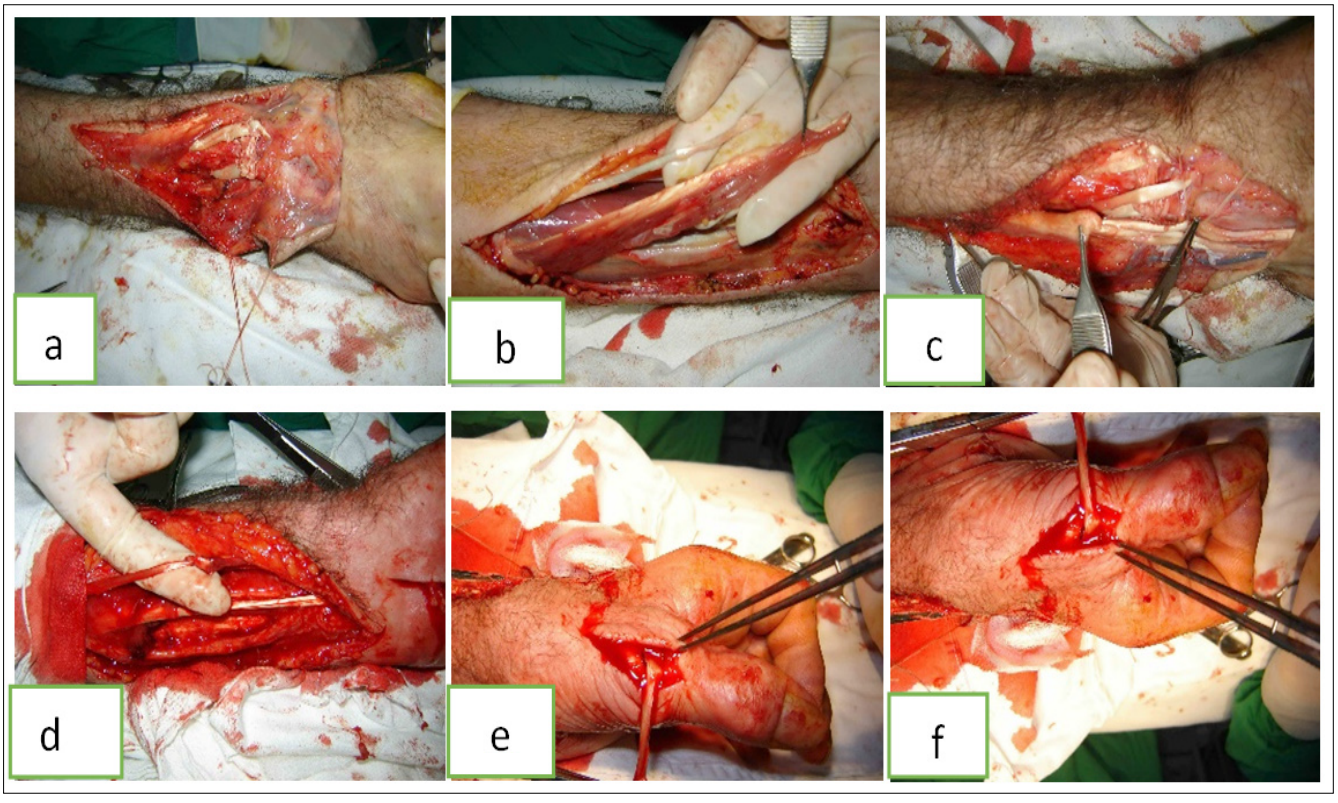

Fig 4 (a-f). Palliative functional reconstruction for the left hand after left brachial plexus paralisis

In a subsequent operative stage, reconstruction of right-hand function was initiated by restoring prehension through pollicization. The objective was to obtain functional grasp between the reconstructed thumb and an opposing digit (Fig. 5).

Fig 5. Right hand – preoperative markings

Pollicization and creation of a commissural space were achieved by transposing the second metacarpal to the level of the first metacarpal head, followed by secondary deepening of the commissural space between the first and fourth metacarpal bone by resecting the third metacarpal bone. The reconstruction of the space between the first ray and the fourth ray was done by dorsal fasciocutaneous flap plasty and split thickness cutaneous graft. The extensor indicis proprius tendon was used to restore extension of the newly created thumb, while the flexor digitorum profundus tendon of the index finger served for thumb flexion. The transposition preserved the vascular and neural supply of the second metacarpal, and osteosynthesis was performed using an obliquely placed axial Kirschner wire maintained for approximately six weeks (Fig. 6,a-i).

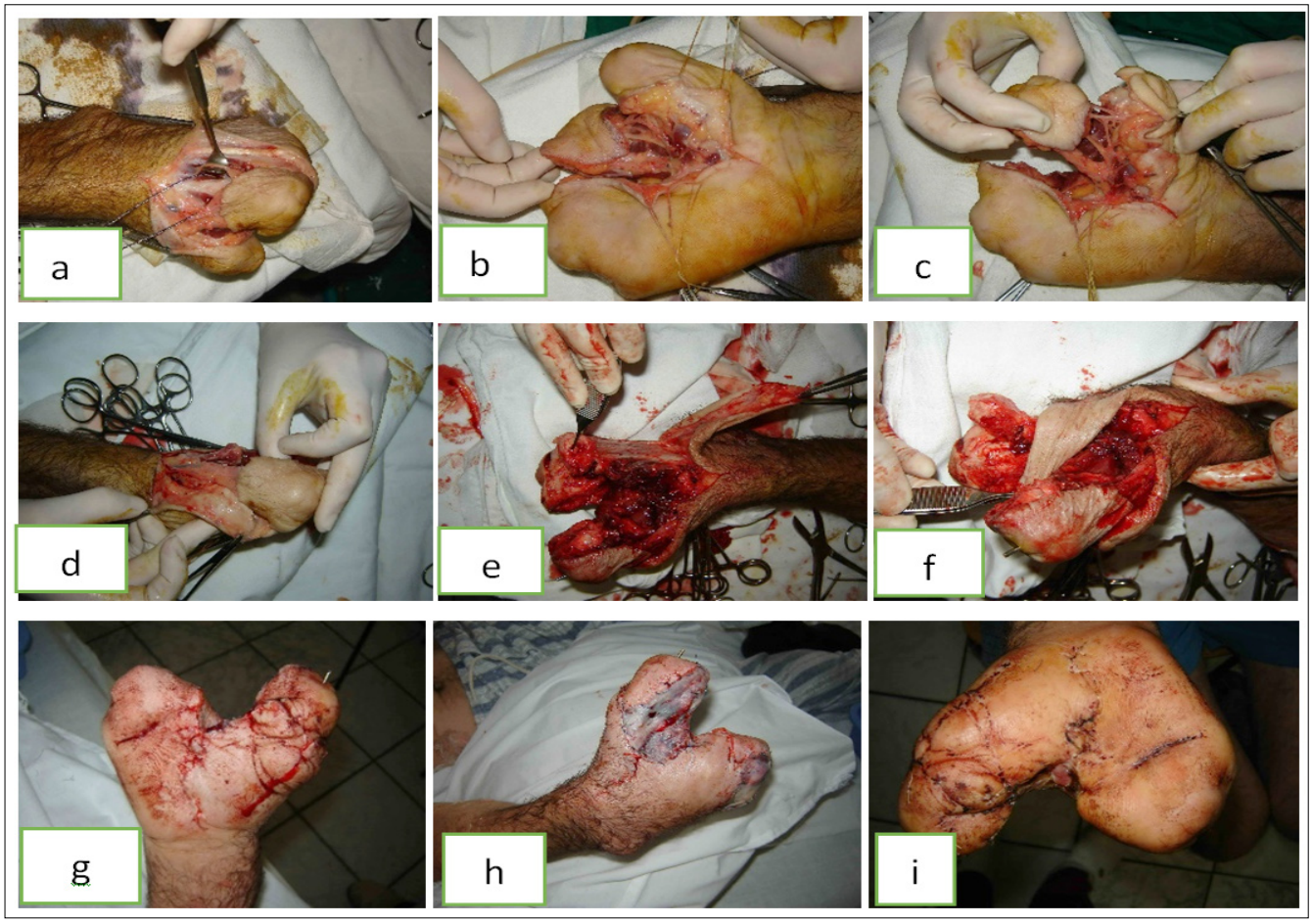

Fig. 6 (a-i). Pollicization of the right metacarpal hand

RESULTS

During the initial hospitalization, systemic stabilization and localized wound treatment resulted in the complete demarcation of the third- and fourth-degree frostbite lesions on the right hand within roughly 21 days. Surgical amputation of the necrotic digits (II–V and partial involvementof digit I) produced a functional "metacarpal hand," with easy postoperative healing reached by day 14.

Functional restoration of the left upper limb resulted in a quantifiable enhancement in joint stability and hand positioning. After radiocarpal tenodesis, the wrist stayed in a stable extension position, which made it easier to do tasks that required a good grip. Tendon transfers successfully restored partial active extension of the fingers and thumb, along with partial abduction of the thumb. The patient did well during the surgeries, and after four weeks of immobilization and 3 months of kinetotherapy, the range of motion and functional alignment of the left hand improved, even though there was no motor reinnervation because of brachial plexus root avulsion (Fig.7, a-d).

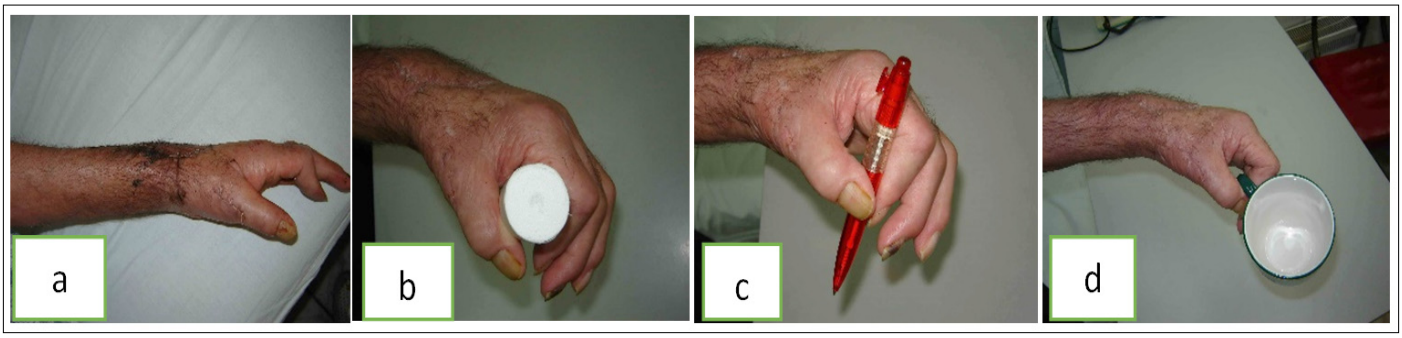

Fig.7, (a-d). Functional results at 3month after palliative reconstruction of the left upper limb

Reconstructive pollicization of the right hand enabled the formation of a functional opposable post. Transposing the second metacarpian bone with the extensor indicis proprius and flexor digitorum profundus tendons made the reconstructed thumb stable and useful. Radiographic and clinical assessment validated proper osteosynthesis and joint alignment, with the Kirschner wire ensuring adequate fixation until its removal at six weeks. The patient healed without any problems, and progressive physiotherapy helped them regain functional prehension between the repaired thumb and the other metacarpal parts (Fig. 8, a,b).

Fig. 8 (a,b). Postoperative result (6 weeks)

The stepwise reconstructive method led to significant functional improvements in both upper limbs, allowing for better prehension on the right and better posture and partial mobility on the left. This made the patient more independent in their everyday activities.

DISCUSSIONS

Taking care of a 68-year-old patient with severe frostbite and a brachial plexus injury shows how hard it can be to deal with medical problems that involve making a diagnosis, coming up with a treatment plan, and figuring out how to help the patient get better. Frostbite is a cold-related illness that mostly affects the ends of the fingers and toes. It can have terrible effects on both function and quality of life when it happens with brachial plexus injuries (Saraoui et al, 2025)

The way people treat frostbite has changed over time. Recent studies have emphasized the significance of early intervention and a collaborative approach. Warming of affected tissues remains a cornerstone of management; however, techniques vary from conservative methods, such as warm water immersion, to more advanced mixed strategies that may include pharmacotherapy. For patients with serious injuries, surgery, such as fasciotomy and debridement, is often needed to stop more tissue from being lost. In this situation, timing of surgery is very important. If surgery is delayed, it could make things worse, especially for older patients who may already have trouble healing (Chandran GJ et al, 2010).

A brachial plexus injury makes things even harder on top of these problems. This kind of nerve damage usually happens because of trauma, like falls or accidents, and it affects the upper limb's ability to move and feel. The resulting disability often has big effects on people's lives, especially older people who may already have trouble getting better. In these cases, doctors usually use electromyography and nerve conduction studies to see how bad the nerve damage is. This can change the treatment options (Franzblau LE et al, 2014).

The first thing to do for brachial plexus injuries is to verify that the patient is stable and see if surgery is needed. Surgical methods like nerve repair, grafting, or neurolysis are often used to restore function, especially when there is complete avulsion (Saraoui et al, 2025).

After surgery, physical rehabilitation is also crucial. Patients who acquire myoelectric prostheses after a traumatic injury often do better on tasks and are happier with their care. This suggests the potential benefit of integrating advanced rehabilitation techniques to improve recovery outcomes.

Cognitive and emotional needs must also be addressed in elderly patients facing the dual challenges of frostbite and brachial plexus injuries. Mental health can significantly influence recovery trajectories, and healthcare providers need to be alert to signs of psychological distress. Open communication about realistic outcomes fosters trust and

cooperation between patients and their caregivers, which is vital for long-term recovery.

As medical technology has improved, there have been some exciting new developments in the area of nerve repair and regeneration. Experimental treatments, such as stem cell therapy and advanced prosthetic technologies, are being studied to improve recovery in patients with severe nerve injury. However, large clinical trials are needed to facilitate widespread adoption, especially among vulnerable groups such as older adults who may show different responses to treatments (Saffari TM et al, 2025).

Recovery outcomes are highly variable and can be affected by numerous factors, including pre-existing health conditions, timeliness of surgery, and extent of injury. A retrospective study indicated that patient satisfaction is strongly related to functional recovery and perceived quality of life after surgery. The management of a 68-year-old patient with severe frostbite and brachial plexus injury presents a complex scenario of medical challenges. A comprehensive understanding of dual diagnoses is critical to optimizing outcomes. A multidisciplinary approach, combining surgical, medical and psychological interventions, remains the best strategy to improve recovery outcomes and improve the quality of life of these patients.

CONCLUSIONS

The case presented illustrates the complex situation of simultaneously managing a severe acute pathology—third- and fourth-degree frostbite of the right hand—and an extensive, severe post-traumatic paralysis of the brachial plexus of the left upper limb, resulting in major functional impairment. The therapeutic approach was complex and staged, aiming to restore functionality in both upper limbs. Management integrated intensive care treatment, emergency surgery for the severe frostbite of the right hand, and progressive functional reconstructions, ultimately achieving a favorable functional outcome despite the initial "functional disaster."

The complex palliative reconstructions performed in the absence of any possibility for reinnervation in the left upper limb demonstrated the value of tendon transfer procedures and wrist joint stabilization through tenodesis in restoring a functional and useful prehension. Reconstruction of the "metacarpal hand" resulting from multiple digital amputations after frostbite, through pollicization, enabled the recovery of gross prehension in the right hand.

This case highlights that when neurological recovery is no longer possible, well-selected palliative reconstructive techniques can yield satisfactory functional outcomes, improve quality of life, and support the patient's social reintegration. An individualized approach that takes into account patient comorbidities as well as local and systemic factors represents an essential characteristic in managing complex cases that combine chronic trauma with severe dysfunction and acute injuries.

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