

Case Report

Comprehensive reconstruction and rehabilitation of explosive hand trauma: a case report

Stephane Jabre*, Jose Maroun, Alexandre El Kazzi, Wissam El Kazzi

Department of Orthopaedic Surgery and Traumatology, Chirec Delta University Hospital, Université Libre of Brussels, Brussels, Belgium

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***Correspondence:**

Dr. Stephane Jabre,

E-mail: stephane.jabre@ulb.be

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ABSTRACT

Firework-related hand injuries can be devastating, resulting from a combination of blast forces, thermal impact, and penetrating trauma. These injuries result in extensive soft tissue damage, fractures, and partial or complete amputations, thereby posing complex challenges for surgical management and rehabilitation. We report the case of a 23-year-old male technician who sustained a severe explosive hand injury from fireworks. Initial treatment focused on thorough wound irrigation, debridement, skeletal stabilization, and prompt initiation of prophylactic antibiotics. Multiple staged procedures were performed, including open reduction and internal fixation of carpometacarpal dislocations, nerve and tendon repairs, and flap reconstructions to restore soft tissue integrity. Despite the complexity and extent of the injury, a staged approach facilitated optimal wound healing and partial functional restoration of the hand. This case underscores the multifaceted nature of blast-related hand injuries, where extensive tissue damage, compromised vascularity, and contamination necessitate a multidisciplinary approach. The hand surgery team collaborated to ensure appropriate skeletal stabilization, nerve and tendon repair, and soft tissue coverage. Early and intensive rehabilitation, encompassing both physical and psychological support, was critical in optimizing recovery. Although functional limitations persisted, the combination of modern surgical techniques and structured rehabilitation yielded a satisfactory outcome relative to injury severity. Successful management of severe hand trauma from fireworks requires coordinated, staged surgical interventions, and comprehensive rehabilitation. While advances in reconstructive surgery improve outcomes, complete recovery may remain elusive in profound blast injuries. Public awareness and preventive measures are paramount to reducing the incidence of such injuries.

Keywords: Nerve repair, Pedicled flaps, Rehabilitation, Reconstruction, Explosive hand injury

INTRODUCTION

Hand injuries caused by explosive devices are complex, involving blast forces, thermal effects, and penetrating trauma, often leading to extensive tissue damage, fractures, and amputations.¹ These injuries present significant challenges due to their severity and potential for long-term impairment. While military-grade explosive injuries are well-documented, increasing evidence highlights the impact of consumer-grade fireworks. Sandvall et al. reported that 37% of such injuries required partial or total amputations, with severe rates of impairment.² Injuries involve high-energy forces that

disrupt tissues, compromise vascular function, and spread contamination, often obscuring the true extent of damage. These injuries challenge reconstruction due to compromised vessel and nerve function, necessitating meticulous debridement to prevent complications.³ Also, there is a need for surgical interventions, including skeletal stabilization and soft tissue repair, with prolonged rehabilitation to restore function.²

Firework-related injuries present significant public health challenges, particularly during peak usage periods. These injuries disproportionately affect young men due to risky behavior and misuse. The increasing frequency and

severity of firework-related hand injuries underscore the need for effective management strategies to address the complex trauma these injuries entail.³ Psychological distress often accompanies physical trauma, requiring counseling alongside rehabilitation. Coordinated care among surgeons, hand therapists, and occupational therapists is essential for optimal outcomes, addressing immediate needs and long-term complications like stiffness and functional loss.

This case report provides a detailed account of the management of a severe explosive hand injury, offering insights into effective treatment strategies and emphasizing the importance of a multidisciplinary approach for achieving functional recovery.

CASE REPORT

A 23-year-old right-handed male technician, with no significant medical history, presented to the emergency department after sustaining a severe injury to his right hand from fireworks material he was handling. The patient was a smoker but otherwise in good health. Upon arrival, immediate priorities included stabilization and wound care. The image of the hand is shown in Figure 1.



Figure 1: (A-C) Pre-operative and per-operative images of the hand.

The injured hand underwent irrigation, debridement, and immobilization. Intravenous analgesia was administered for pain management. Prophylactic broad-spectrum antibiotics and tetanus immunoglobulin were given to prevent infection. Radiographic evaluation confirmed the extent of injuries requiring surgical intervention. The patient exhibited extensive soft tissue damage, including degloving injuries, multiple open fractures, dislocation of all carpometacarpal bones, and amputations of multiple digits. Vital signs were stable, and there were no other

injuries. Initial radiographs revealed dorsal dislocations of the metacarpal bases of the second, third, and fourth rays, multiple fractures, and significant soft tissue disruption (Figure 2).



Figure 2: Preoperative radiograph showing dorsal dislocations, multiple fractures, and significant soft tissue damage in the right hand following the explosive device injury.



Figure 3: Per-operative photo of the posterior interosseous advancement flap for coverage.



Figure 4: The final result of the hand.

Additional imaging showed scapholunate diastasis, ulnar dislocation of the fourth finger, and a comminuted fracture of the proximal phalanx of the thumb. During the first surgery, a comprehensive set of procedures was performed to address various injuries and complications. Lavage was carried out to cleanse the affected area. Fracture and dislocation management included the open reduction and internal fixation of dorsal carpometacarpal dislocations (2nd, 3rd, and 4th) with K-wire stabilization, as well as scapholunate ligament repair and pinning.

Nerve and tendon repairs involved core and epitendinous suturing of extensor and flexor tendons, alongside microsurgical epineurial repair of digital nerves. Soft tissue reconstruction was performed through debridement of necrotic tissues and pedicled flap coverage. Additionally, amputations and reconstruction efforts included the amputation of non-viable distal phalanges (thumb, 2nd, 3rd, and 4th digits) and arthrodesis of the 5th metacarpophalangeal joint with K-wire stabilization. The patient underwent several additional surgeries to address ongoing issues.

During the second surgery, debridement of necrotic tissue in the first web space and distal middle finger was performed, followed by the use of a palm dorsal advancement flap for coverage.⁴ The third surgery involved the removal of temporary wound covers and the application of an autologous thin skin graft harvested from the elbow crease. In the fourth surgery, a later digital flap for the middle finger and a palmar advancement flap for the thumb were created to enhance soft tissue coverage. The fifth surgery included the placement of a posterior interosseous flap to cover a cutaneous defect in the first web space that can be seen in Figure 3.

Finally, the sixth surgery involved the removal of the external fixator from the thumb after fracture consolidation and the thinning of the flap in the first web space. The outcome of the treatment is depicted in Figure 4. Postoperative management focused on pain control, infection prevention, and wound care. The patient received a combination of analgesics, continued antibiotic therapy, and regular dressing changes under sterile conditions. Flap viability was closely monitored.

DISCUSSION

Explosive hand injuries, such as those caused by fireworks, are particularly complex due to the combination of multiple trauma mechanisms, including blast forces, thermal effects, and penetrating trauma. These injuries often lead to extensive damage requiring a multidisciplinary approach involving orthopedic, plastic, and hand surgeons. Recent literature recognizes that blast injuries consist of several mechanisms, including primary overpressure injuries, secondary injuries from debris, tertiary injuries from the force of displacement, and quaternary injuries such as burns and inhalation trauma. Additionally, quinary injuries related to systemic hyper-

inflammatory responses have been identified in some cases, further complicating management.^{5,6}

In cases like the one presented, effective management depends on rapid triage, early surgical intervention, and comprehensive post-surgical rehabilitation. Blast injuries present significant surgical challenges due to extensive soft tissue destruction and contamination, as well as compromised vascularity and nerve integrity. These factors make the reconstruction process inherently complex and often necessitate the use of advanced techniques to achieve both functional and aesthetic outcomes. Studies have shown that patients with firework-related hand injuries often require multiple surgeries, including soft tissue reconstruction with pedicled or free flaps, to ensure proper healing and functional recovery.^{7,8}

The meticulous reconstruction of nerves and tendons, despite the limited regeneration potential, demonstrates the need for a balance between anatomical repair and functional expectations. Studies have highlighted the role of innovative techniques, such as nerve conduits and neurotrophic factors, in improving functional outcomes. This approach aligns with established peripheral nerve repair practices, as described by Griffin et al, who highlighted the challenges of traditional techniques such as end-to-end anastomosis.

While innovations such as nerve conduits and gene therapy are being explored, we adhered to primary repair in this case, consistent with current principles in the literature. Nerve and tendon repairs, although challenging, are vital for potential functional recovery. Primary nerve repair can enhance sensory outcomes, even though nerve regeneration is limited.⁹ Early and intensive rehabilitation is crucial to prevent stiffness and promote functional recovery. Lastly, a comprehensive program addressing physical and psychological aspects enhances the overall outcome.

The findings of Mohan et al. complement our case by reinforcing the principle that even devastating firework-related hand injuries can achieve functional outcomes with appropriate surgical and rehabilitative measures. In both cases, challenges such as neurovascular compromise, contamination, and extensive tissue damage necessitated a tailored approach to repair and reconstruction.

Notably, Mohan et al observed that digital ischemia and prolonged neuropraxia were common, even with intact vasculature and nerves, a phenomenon also encountered in our patient. The emphasis on early skeletal stabilization and careful flap coverage in their algorithm parallels our approach of staged surgeries and comprehensive rehabilitation. Together, these cases highlight the necessity of high-volume trauma centers with experienced hand surgeons to maximize the potential for recovery in such severe injuries. Additionally, they call for continued advancements in surgical techniques and public health initiatives to mitigate the impact of these preventable

injuries.³ The success of this case hinges on a coordinated multidisciplinary approach. The involvement of orthopedic, and hand surgeons, coupled with occupational and physical therapy, ensured that all aspects of the injury were addressed comprehensively.¹⁰ This collaborative effort allowed for a seamless integration of surgical interventions and rehabilitation protocols, which are essential for optimal recovery. Psychological support played a crucial role in mitigating the emotional trauma associated with such injuries, as evidenced by the patient's adherence to the rehabilitation plan. Involving the patient in the decision-making process further enhanced their engagement and commitment to achieving recovery milestones.

Despite achieving significant recovery, residual deficits persisted, including partial loss of hand function and sensory impairment. This underscores the inherent limitations in the current reconstructive techniques and the need for ongoing advancements in microsurgery and regenerative medicine. Continued research and development in these fields hold the potential to improve outcomes in similar cases, emphasizing the importance of integrating emerging technologies and refining surgical methods to optimize recovery in complex injuries.

CONCLUSION

This case highlights the complexity of managing blast-related injuries and emphasizes the critical role of early intervention, staged surgical management, and comprehensive rehabilitation. The application of pedicled flaps, nerve repairs, and tendon reconstructions facilitated functional recovery despite the severity of the injuries. It illustrates that while modern surgical techniques can restore significant function, complete recovery may remain elusive in severe cases. A multidisciplinary, patient-centered approach is crucial to addressing the physical and psychological challenges posed by such injuries.

Furthermore, this case underscores the importance of prevention and public awareness, particularly regarding the handling of fireworks and other explosive materials. Future research should explore the integration of advanced technologies, including tissue engineering and bioengineered nerve conduits, to enhance outcomes in similar cases. Long-term follow-up is essential to assess the durability of functional gains and address complications.

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