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## STAGED RECONSTRUCTION OF SEVERE POST-CRUSH HAND INJURY USING SCIP FREE FLAP AND ADJUNCTIVE LIPOFILLING: A CARE-COMPLIANT CASE REPORT

*Reconstrução em etapas de lesão grave da mão pós-esmagamento utilizando retalho livre SCIP e lipoenxertia adjuvante: um relato de caso em conformidade com o protocolo CARE*

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### Abstract

**Background:** Severe crush injuries of the hand represent a major reconstructive challenge due to extensive skeletal, articular, neurovascular, and soft-tissue damage. Secondary complications, including scar contractures, joint stiffness, and functional limitations, frequently require multiple surgical interventions and prolonged rehabilitation. Staged reconstruction combining microsurgical techniques and autologous fat grafting may contribute to functional recovery. **Aim:** To report a case of severe occupational crush injury of the hand managed through staged reconstruction, highlighting the surgical procedures, use of a superficial circumflex iliac artery perforator (SCIP) free flap, adjunctive autologous fat grafting, and postoperative functional outcomes. **Method:** A descriptive single-patient case report based on retrospective analysis of medical records, surgical procedures, postoperative assessments, imaging studies, and rehabilitation outcomes. The report was prepared in accordance with the CARE guidelines, with additional consideration of the SCARE recommendations for surgical case reporting. **Results:** A 42-year-old man sustained a severe occupational crush injury to the right hand, resulting in multiple fractures, carpal and carpometacarpal dislocations, neurovascular injuries, and extensive soft-tissue damage. Initial treatment included surgical debridement, fracture reduction, and stabilization with Kirschner wires. Subsequently, hypertrophic and retractile scars, joint stiffness, sensory disturbances, and restricted finger extension developed. Two sessions of autologous fat grafting were performed in April and July 2025, with 12 mL injected per procedure. Persistent functional limitations required extensive scar release, adhesiolysis, neurolysis, and reconstruction with a 15 × 6 cm SCIP free flap in October 2025. The flap remained viable, with progressive improvement in range of motion and hand function following rehabilitation. In May 2026, secondary flap debulking and additional fat grafting were performed to improve contour and symmetry. No acute complications were documented following the final procedure. **Conclusion:** Severe hand crush injuries may require individualized, sequential reconstruction to address complex anatomical damage and functional sequelae. This case demonstrates that the integration of skeletal stabilization, scar management, autologous fat grafting, SCIP free-flap reconstruction, and rehabilitation can provide sustained soft-tissue coverage and progressive functional improvement. Secondary refinement procedures may be necessary to optimize reconstructive outcomes.

**Keywords:** Crush Injury, Hand Injuries, Microsurgery, Surgical Flaps, Autologous Fat Grafting.

### Resumo

**Introdução:** Lesões graves por esmagamento na mão representam um grande desafio reconstrutivo devido aos extensos danos esqueléticos, articulares, neurovasculares e de tecidos moles. Complicações secundárias, incluindo contraturas cicatriciais, rigidez articular e limitações funcionais, frequentemente exigem múltiplas intervenções cirúrgicas e reabilitação prolongada. A reconstrução em etapas, combinando técnicas microcirúrgicas e enxerto de gordura autóloga, pode contribuir para a recuperação funcional. **Objetivo:** Relatar um caso de lesão grave por esmagamento ocupacional na mão, tratado por meio de reconstrução em etapas, destacando os procedimentos cirúrgicos, o uso de um retalho livre perfurante da artéria circunflexa ilíaca superficial (SCIP), enxerto de gordura autóloga adjuvante e resultados funcionais pós-operatórios. **Método:** Relato de caso descritivo de um único paciente, baseado em análise retrospectiva de prontuários médicos, procedimentos cirúrgicos, avaliações pós-operatórias, exames de imagem e resultados da reabilitação. O relato foi preparado

de acordo com as diretrizes CARE, com consideração adicional das recomendações SCARE para relatos de casos cirúrgicos. Resultados: Um homem de 42 anos sofreu uma grave lesão por esmagamento ocupacional na mão direita, resultando em múltiplas fraturas, luxações carpais e carpometacarpais, lesões neurovasculares e extensos danos nos tecidos moles. O tratamento inicial incluiu desbridamento cirúrgico, redução da fratura e estabilização com fios de Kirschner. Posteriormente, desenvolveram-se cicatrizes hipertróficas e retráteis, rigidez articular, distúrbios sensoriais e restrição da extensão dos dedos. Foram realizadas duas sessões de enxerto de gordura autóloga em abril e julho de 2025, com 12 mL injetados por procedimento. As limitações funcionais persistentes exigiram extensa liberação de cicatrizes, adesiólise, neurólise e reconstrução com um retalho livre SCIP de 15 × 6 cm em outubro de 2025. O retalho permaneceu viável, com melhora progressiva na amplitude de movimento e na função da mão após a reabilitação. Em maio de 2026, foram realizados desbastamento secundário do retalho e enxerto de gordura adicional para melhorar o contorno e a simetria. Nenhuma complicação aguda foi documentada após o procedimento final. Conclusão: Lesões graves por esmagamento na mão podem exigir reconstrução individualizada e sequencial para tratar danos anatômicos complexos e sequelas funcionais. Este caso demonstra que a integração de estabilização esquelética, tratamento de cicatrizes, enxerto de gordura autóloga, reconstrução com retalho livre SCIP e reabilitação pode proporcionar cobertura sustentada de tecidos moles e melhora funcional progressiva. Procedimentos de refinamento secundários podem ser necessários para otimizar os resultados reconstrutivos.

**Palavras-chave:** Lesão por esmagamento, Lesões na mão, Microcirurgia, Retalhos cirúrgicos, Enxerto de gordura autóloga.

## Introduction

Severe crush injuries of the hand represent a major reconstructive challenge because they may simultaneously compromise the skeletal framework, joints, tendons, neurovascular structures, and soft-tissue envelope (1,2). The extent and heterogeneity of tissue damage can make both initial management and subsequent functional recovery particularly demanding. In addition to the immediate consequences of tissue destruction and vascular compromise, patients may develop secondary complications such as wound healing problems, scar formation, joint stiffness, tendon adhesions, and contractures, which may further compromise hand function (1-3). Therefore, management of this type of injuries requires not only preservation of viable tissues and restoration of structural integrity, but also careful planning of soft-tissue reconstruction and subsequent functional rehabilitation (2,3).

The reconstruction of complex hand injuries frequently requires a staged approach in which different surgical procedures are performed according to the evolution of the wound, tissue viability, and functional requirements. Initial treatment is generally directed toward thorough debridement of devitalized tissue, skeletal stabilization, restoration of vascularity when necessary, and establishment of adequate soft-tissue coverage (1,3). Once the acute phase has been controlled, secondary procedures may be required to address scar contractures, adhesions, contour abnormalities, tendon or nerve dysfunction, and limitations in range of motion. This reconstructive strategy reflects the principle that successful treatment of a severely injured hand extends beyond wound closure or limb salvage, with functional restoration and the possibility of early and sustained rehabilitation being fundamental goals (2).

Among the available options for complex soft-tissue reconstruction, the Superficial Circumflex Iliac Artery Perforator (SCIP) flap has gained increasing attention because of its thin, pliable tissue, versatile design, and relatively low donor-site morbidity. These characteristics are particularly advantageous in hand reconstruction, where excessive flap thickness may interfere with contour, mobility, and function. The SCIP flap can also be tailored to the dimensions and requirements of the defect and may incorporate additional tissue components when necessary (4,5). Contemporary clinical series and systematic reviews have demonstrated its versatility and reliability across reconstructive applications, including complex defects of the upper extremity and hand, although its small-caliber vessels and anatomical variability require careful preoperative planning and microsurgical expertise (5-7).

Secondary procedures aimed at improving the quality and function of the reconstructed hand may include scar release, contour refinement, debulking, and autologous fat grafting. In this context, lipofilling has emerged as an adjunctive technique in reconstructive surgery because adipose tissue may provide both volume restoration and potential improvements in scar quality and tissue pliability

(8) Available evidence suggests that autologous fat grafting can be used safely in selected traumatic and scar-related conditions, although the current literature remains heterogeneous and definitive evidence regarding its functional benefits is limited. Consequently, serial fat grafting and subsequent flap refinement may represent complementary strategies within a staged reconstructive plan, particularly when soft-tissue quality, contour, and mobility remain compromised after initial reconstruction (9,10).

In this context, we report a severe occupational crush injury of the hand managed through a prolonged staged reconstructive strategy combining initial skeletal and soft-tissue reconstruction, serial lipofilling, SCIP free flap coverage, secondary flap refinement, and functional rehabilitation. By presenting the clinical course, reconstructive decision-making, challenges, and outcomes over an extended follow-up period, this case aims to contribute to the continuing education of clinicians involved in the management of complex hand trauma, provide practical insights into staged reconstructive planning, and support knowledge sharing regarding the integration of surgical reconstruction, adjunctive soft-tissue procedures, and rehabilitation in the pursuit of functional recovery.

### Aim

To report a case of severe occupational crush injury of the right hand managed through a staged reconstructive approach, highlighting the initial skeletal stabilization, management of post-traumatic scar contractures, serial autologous fat grafting, microsurgical reconstruction using a superficial circumflex iliac artery perforator (SCIP) free flap, secondary flap refinement, and postoperative functional recovery, with emphasis on surgical decision-making and clinical outcomes throughout follow-up.

### Method

This study was conducted as a single-patient case report and was prepared in accordance with the CARE (CAse REport) guidelines, with additional consideration of the SCARE (Surgical CAse REport) recommendations for surgical case reporting (11,12). The present report was structured to provide a chronological and comprehensive description of the patient's clinical course, with particular emphasis on the decision-making process underlying the staged reconstructive strategy. Clinical data were retrospectively obtained from the patient's medical records and reconstructed chronologically from the time of the initial occupational injury through the most recent postoperative follow-up. The reviewed records included emergency department documentation, operative reports, postoperative assessments, outpatient surgical follow-up notes, radiographic examinations, medication records, wound-care documentation, and records describing rehabilitation and functional progression.

### Results

A 42-year-old male patient sustained a severe occupational crush injury to the right hand, resulting in multiple fractures, carpal and carpometacarpal dislocations, extensive soft-tissue damage, and neurovascular injuries. Initial surgical management included extensive debridement, fracture reduction, and skeletal stabilization with Kirschner wires, allowing preservation of the injured hand and progressive wound healing. During follow-up, the patient developed hypertrophic and retractile palmar scars, joint stiffness, sensory disturbances, and restricted extension of the first three digits, particularly the third finger. Two sessions of autologous fat grafting were performed in April and July 2025, with 12 mL of adipose tissue injected during each procedure. Despite satisfactory postoperative healing and the absence of infectious complications, persistent scar contractures and functional limitations required further reconstruction. In October 2025, extensive scar excision, adhesiolysis, neurolysis, and soft-tissue coverage with a 15 × 6 cm superficial circumflex iliac artery perforator (SCIP) free flap were performed. The flap demonstrated satisfactory intraoperative perfusion and remained viable throughout postoperative follow-up. Postoperative recovery was characterized by progressive improvement in wound healing, range of motion, and hand function following rehabilitation. Donor-site serohematic collections were managed with drainage and aspiration, while minor superficial wound-healing abnormalities were treated conservatively. By March 2026, the flap remained viable, with improved functional range of motion. However, residual flap bulk required secondary debulking and additional autologous fat grafting in May 2026 to improve contour and symmetry. At the latest documented follow-up, no acute complications related to flap revision were reported. Overall, the staged reconstructive approach achieved preservation of the

injured hand, sustained flap viability, progressive functional improvement, and refinement of the reconstructed soft-tissue contour. Figures 1-4 shown the stages of recovery.



**Figure 1. Intraoperative appearance of the right hand following the severe crush injury. Extensive destruction of the palmar and dorsal soft tissues with exposure of deeper structures, extensive tissue devitalization, and associated skeletal and soft-tissue injuries.**



**Figure 2. Early postoperative appearance of the right hand following initial surgical management. The photograph demonstrates the reconstructed soft-tissue envelope and surgical incisions after debridement, skeletal stabilization, reduction of the carpal and carpometacarpal relationships, and wound closure.**



**Figure 3. Postoperative radiograph of the right hand demonstrating skeletal stabilization.** Multiple Kirschner wires are visible, maintaining the reduction of the carpal, carpometacarpal, and phalangeal injuries following the initial reconstructive procedure.



**Figure 4. Preoperative planning for definitive soft-tissue reconstruction.** The right hand demonstrates extensive post-traumatic palmar scarring and contracture, with surgical markings outlining the planned areas of scar release and soft-tissue reconstruction.

### Discussion

Severe crush injuries of the hand can result in extensive skeletal, neurovascular, and soft-tissue damage, often leading to complex functional sequelae that require staged reconstruction and prolonged rehabilitation (1-3). In this context, the SCIP flap offers a thin and pliable option for complex soft-tissue reconstruction, while adjunctive procedures such as lipofilling, scar release, and secondary flap refinement may contribute to improving tissue quality, contour, and mobility during the reconstructive process (5,8).

The present case describes the staged reconstruction of a severe occupational crush injury of the right hand involving extensive skeletal, articular, soft-tissue, and neurovascular damage. Initial emergency management included extensive debridement, reduction and Kirschner wire fixation of multiple fractures and carpal and carpometacarpal disruptions, followed by treatment of a secondary soft-tissue defect involving the flexor *carpi radialis* tendon. Despite preservation of the hand and satisfactory initial healing, the patient subsequently developed extensive hypertrophic and retractile palmar scarring, joint stiffness, sensory disturbances, and impaired extension of the first three digits, requiring a prolonged reconstructive strategy. Serial lipofilling was initially performed to improve the soft-tissue envelope and address scar-related impairment, followed by extensive scar release, adhesiolysis, neurolysis, and reconstruction with a 15 × 6 cm SCIP free flap. Subsequent rehabilitation resulted in progressive improvement in range of motion and functional status, although residual flap bulk required secondary debulking and additional autologous fat grafting for contour refinement and symmetry.

Al-Hayder et al. (13) reported the case of a 7-year-old girl with a longstanding post-burn scar contracture of the left palm. The patient had sustained a deep partial-thickness burn six years earlier and had subsequently undergone debridement and split-thickness skin grafting. At presentation, she had a tight, adherent, and thick scar across the proximal palm, associated with decreased thumb extension and functional limitation during school activities. Surgical treatment consisted of Z-plasty to release the contracture combined with autologous fat grafting, with the objective of improving skin quality and reducing adhesions between the scar and underlying tendons. Fat was harvested from the inner thighs following infiltration with Klein's solution, and 5 mL of processed fat was transferred to the affected hand. The postoperative course included transient necrosis at the tips of the Z-plasty flaps; however, at 12 months, the authors reported improvement in the scar and functional characteristics of the hand (13).

Jain et al. (14) reported a series of seven patients with devastating blast-related hand injuries who underwent reconstruction using a SCIP flap. The patients were between 16 and 58 years of age, with body mass indices ranging from 19 to 48 kg/m<sup>2</sup>, and more than half were classified as obese. The authors emphasized the challenge of providing sufficiently thin soft-tissue coverage for functional hand reconstruction, particularly in patients with increased subcutaneous tissue. All SCIP donor sites were primarily closed, and five of the seven patients returned to their preinjury occupations. Three patients received neurotized flaps and achieved protective sensation. Three patients required secondary revision procedures involving flap liposuction, while one also underwent additional flap advancement. The authors concluded that the SCIP flap provided reliable coverage with favorable functional and aesthetic outcomes in severe hand injuries (14).

Tan et al. (15) described two male patients who sustained crush injuries involving digits 1 through 5 of the left hand, resulting in extensive volar soft-tissue defects after debridement. Both patients underwent reconstruction using a single-pedicle, five-lobed SCIP free flap, designed according to the distribution of the superficial circumflex iliac artery perforators and the individual geometry of the defects. The arterial pedicle was anastomosed using an end-to-side technique to either the superficial palmar arch or a digital artery, while venous anastomoses were performed in an end-to-end fashion. Both flaps survived successfully, and during follow-up, the reconstructed fingers demonstrated color and skin texture similar to the surrounding normal tissue. The donor sites healed with only linear scars, and neither patient reported significant donor-site discomfort. Both patients expressed satisfaction with the appearance and functional recovery of the reconstructed fingers (15).

The three published reports share important similarities with the present case, particularly regarding the complexity of hand reconstruction, the need for individualized treatment, and the use of complementary procedures to optimize functional and aesthetic outcomes. Similar to our patient, the cases reported by Jain et al. and Tan et al. involved severe traumatic injuries with extensive soft-tissue damage requiring microsurgical reconstruction (14,15). The need for secondary flap liposuction reported by Jain et al. is particularly relevant to our case, in which the SCIP flap subsequently underwent debulking and additional autologous fat grafting to improve contour and symmetry (14). Likewise, the successful reconstruction of multiple digital defects using a multilobed SCIP flap described by Tan et al. demonstrates the versatility of this technique in managing extensive hand injuries (15). Furthermore, the report by Al-Hayder et al. provides a relevant parallel to the management of post-traumatic scar contractures through adjunctive lipofilling, although the mechanism and extent of injury differed substantially (13).

Despite these similarities, relevant differences distinguish the present case from the published reports. Our patient sustained a particularly complex occupational crush injury involving multiple fractures, carpal and carpometacarpal dislocations, extensive soft-tissue destruction, neurovascular injury, and subsequent severe hypertrophic and retractile scarring with functional impairment. In contrast, Jain et al. focused on blast-related hand injuries treated with SCIP flaps, while Tan et al. described crush injuries characterized primarily by extensive volar soft-tissue defects involving all five digits and reconstructed using a multilobed SCIP flap (14,15). The case reported by Al-Hayder et al. differed in both etiology and severity, involving a pediatric patient with a burn-related palmar contracture treated with Z-plasty and lipofilling) (13). The present case is distinguished by the sequence and breadth of reconstructive interventions, including initial skeletal stabilization, secondary wound revision, serial autologous fat grafting, extensive scar release, adhesiolysis, neurolysis, microsurgical SCIP flap reconstruction, prolonged rehabilitation, and subsequent flap refinement.

The prolonged staged approach adopted in our patient reflects the evolving nature of severe crush injuries, in which definitive reconstruction cannot necessarily be established during the initial surgical intervention. During the acute phase, treatment priorities included removal of devitalized tissue, wound management, restoration of skeletal alignment, and preservation of viable anatomical structures. Following stabilization and wound healing, the principal challenges shifted toward hypertrophic scarring, adhesions, joint stiffness, pain, and impaired finger extension. At this stage, autologous fat grafting was employed as an adjunctive procedure before definitive scar release and flap reconstruction, consistent with its application in pathological hand scars described by Al-Hayder et al (13). Subsequent SCIP free-flap reconstruction provided vascularized soft-tissue coverage for the extensive palmar defect, in accordance with previously reported applications of this technique in severe hand trauma (14,15).

Importantly, the reconstructive process did not end with successful flap survival. As demonstrated by Jain et al.(14), secondary contour procedures may be necessary following SCIP reconstruction, particularly when residual flap bulk compromises the desired anatomical contour (14). In the present case, secondary debulking and additional fat grafting were performed as part of the continuing reconstructive process rather than as evidence of failure of the primary reconstruction. Although progressive improvement in range of motion and functional status was documented, the absence of standardized functional measurements limits objective assessment of the magnitude of recovery. Taken together, the clinical course highlights the importance of considering severe hand reconstruction as a dynamic and individualized process in which therapeutic objectives evolve according to tissue viability, wound healing, scar maturation, functional recovery, and residual anatomical limitations. The integration of microsurgical reconstruction, adjunctive fat grafting, secondary refinement, and rehabilitation may contribute to progressive functional improvement following devastating hand trauma. However, as this report describes a single patient, the findings should be interpreted as an illustration of a feasible reconstructive strategy rather than evidence of comparative effectiveness.

## Conclusion

This case demonstrates that the reconstruction of a severely crushed hand may require a prolonged, individualized, and sequential approach rather than a single definitive procedure. Initial skeletal stabilization and debridement allowed preservation of the injured hand, while subsequent management of scar contractures with autologous fat grafting, extensive scar release, and SCIP free-flap reconstruction provided progressive improvement in soft-tissue quality and function. Secondary flap debulking and additional fat grafting further addressed residual contour abnormalities during the rehabilitation process. Overall, this experience highlights the potential value of integrating microsurgical reconstruction, adjunctive fat grafting, secondary refinement, and rehabilitation according to the evolving functional and anatomical needs of the patient.

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