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Supermicrosurgical Replantation for Motorcycle Chain-Induced Fingertip Amputations: A Case Series

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ABSTRACT

Objective: Fingertip amputations from motorcycle chain injuries involve severe crushing and contamination, traditionally necessitating revision amputation. We evaluated the feasibility of a modified primary replantation protocol tailored to this high-energy trauma.

Methods: We conducted a retrospective analysis of six patients who underwent fingertip replantation for motorcycle chain-related amputations classified as Tamai Zone I or II at a tertiary care center between 2021 and 2025. The surgical protocol emphasized aggressive debridement and strategic bone shortening to facilitate tension-free primary anastomosis, thereby minimizing the need for interpositional vein grafts. A simplified single-vessel supermicrosurgical anastomosis was performed with 11-0 nylon sutures. Additional technical priorities included volar vein identification and management of the extensive zones of injury characteristic of these mechanisms. The primary outcome was digit survival. Secondary outcomes included perioperative complications (venous congestion and infection), radiographic bone union, nail aesthetics, and functional recovery.

Results: Of 12 patients presenting with motorcycle chain amputations, six met the criteria for replantation and were included. Among these six completed replantations, survival was achieved in five (83%). One failure resulted from delayed venous congestion on postoperative day five. Despite the heavy contamination inherent to these injuries, no infection-related complications were observed. All surviving digits regained gross sensation sufficient for protection and demonstrated satisfactory functional and aesthetic recovery. All five surviving patients returned to pre-injury occupations within three months, as assessed by self-reported functionality. The simplified single artery and single vein configuration proved reliable even without complex multivessel repairs.

Conclusion: Primary replantation is feasible for motorcycle chain injuries with identifiable vessels. A protocol of radical debridement, skeletal shortening, and single-vessel anastomosis successfully preserved digits traditionally managed via revision amputation, suggesting that exclusion criteria for reconstructable targets merit re-evaluation.

INTRODUCTION

Fingertip amputations resulting from motorcycle chain injuries constitute a distinct high-energy trauma pattern [1,2]. Disproportionately affecting young adults [1,3], these injuries are characterized by severe crushing, avulsion, and gross contamination [4,5]. In contrast to sharp amputations, the resulting multilevel intimal damage severely compromises microvascular integrity, often rendering standard replantation techniques ineffective [2,3]. Indeed, a recent epidemiological study by Jaiswal et al. reported that all attempted replantations for motorcycle chain injuries failed due to the extent of crush and contamination [3].

While the principles of digital replantation are well established [6,7], literature specifically addressing the unique constraints of motorcycle chain injuries remains sparse. Given this knowledge gap and the high failure rates associated with conventional management [3], there is a critical need for operative strategies that adapt conventional principles to the constraints of severe soft-tissue compromise. This article outlines a reproducible protocol tailored to these hostile conditions. We describe a systematic approach prioritizing aggressive soft tissue management, strategic bone shortening, and simplified single-vessel anastomosis, aiming to establish primary replantation as a viable alternative to revision amputation for contaminated crush injuries.

MATERIALS AND METHODS

Study Design and Data Collection

We conducted a retrospective analysis of patients who underwent fingertip replantation after crush injuries caused by motorcycle chains at a tertiary care center. The study period extended from November 2021 through May 2025. We extracted data on patient demographics, specific injury characteristics, surgical techniques employed, and postoperative clinical outcomes. The focus on motorcycle chain-related trauma allowed for consistent comparison within a single high-energy crush mechanism.

Inclusion Criteria and Surgical Exploration

The study included patients with fingertip amputations classified as Tamai Zone I or Zone II that resulted specifically from motorcycle chain mechanisms (Figures 1–5). All amputation stumps were explored under an operating microscope, followed by meticulous debridement and lavage. All stumps were systematically inspected to identify suitable dorsal or volar arteries and veins. Replantation proceeded only after confirmation of healthy, viable vessels following adequate debridement.

Exclusion Criteria and Intraoperative Abandonment

We excluded patients who declined replantation. We also excluded those with amputation levels proximal to Tamai Zone II and those

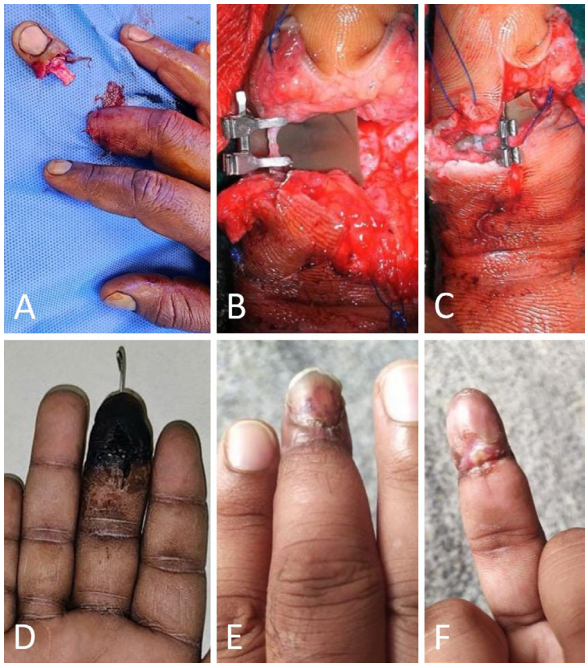

Figure 1. Replantation of a Tamai Zone II Crush-Avulsion Injury of the Right Middle Finger. (A) Preoperative clinical presentation showing a Tamai Zone II crush-avulsion amputation of the right middle finger. (B) Intraoperative view demonstrating the completed anastomosis of the ulnar digital artery. (C) Anastomosis of a volar digital vein; the ulnar skin-tagging suture has been released and the skin edge retracted to facilitate a tension-free venous repair. (D) Early postoperative appearance with diffuse epidermal discoloration but preserved tissue turgor, consistent with viable deep perfusion. (E, F) Late postoperative follow-up images in dorsal and volar views confirming complete survival of the replanted fingertip with satisfactory soft-tissue healing.

with injuries caused by mechanisms other than motorcycle chains. The analysis was restricted to patients who underwent completed replantation. Cases in which intraoperative exploration revealed non-reconstructable vascular damage (necessitating revision amputation) were excluded from this series to focus specifically on the outcomes of the described replantation protocol. The decision to abandon replantation was made if suitable recipient vessels were absent in the amputation stump or if arterial inflow could not be established despite appropriate microsurgical techniques. In these instances, the fingertip was reconstructed with techniques that did not involve microsurgery.

Surgical Technique

Anesthesia and antibiotic prophylaxis

Procedures were performed under supraclavicular brachial plexus block to induce sympathetic blockade and minimize intraoperative vasospasm. Patients received intravenous cefuroxime initiated preoperatively and continued through postoperative day three, followed by a one-week course of oral antibiotics. A uniform anesthetic and antibiotic protocol was maintained for all patients to minimize confounding variables.

Debridement and infection control

Prior to surgical exploration, the amputated stump was thoroughly irrigated with 4% chlorhexidine gluconate solution. Irrigation was then continued with 1–2 liters of normal saline. We performed meticulous debridement under operating microscope magnification and excised all residual grease and oil soaked tissues, including compromised skin, fat, tendon, bone, and vascular structures. Povidone-iodine was strictly avoided to prevent staining of neurovascular structures. This combination of aggressive irrigation and selective debridement was intended to minimize the bacterial burden while preserving viable tissue for replantation.

Distal vessel exploration

The nail plate of the amputated part was anchored to a plastic suture carrier with 4-0 polypropylene sutures to facilitate handling [8]. An assistant retracted the skin using microvascular toothed forceps. We then explored the vessels under an operating microscope. The digital artery was typically identified superficial to the periosteum and volar to the distal phalanx at the level of the lunula. The vessel was marked with a surgical pen or 10-0 nylon suture. In cases where multiple arterial branches were present, we ligated one branch to mobilize additional length for anastomosis. Adjacent adipose tissue was carefully debulked to provide adequate space for placement of vascular clamps. These steps allowed precise identification and preparation of the smallest possible arterial segment suitable for reliable anastomosis.

Volar vein identification

Because dorsal veins were often unavailable due to the avulsion component of motorcycle chain injuries, we prioritized identification of volar veins. We located these vessels by applying gentle pressure to the digital pulp. After we created a plane between the vein and the overlying skin with microscissors, we designed an oblique incision to facilitate skin closure without tension over the anastomosis [6]. When the identified volar vein was positioned away from the midline, we used a central longitudinal incision and selectively released skin tagging sutures to achieve a tension-free venous repair (Figure 1C). This venous strategy emphasized preservation of any suitable outflow channel to reduce the risk of postoperative congestion.

Proximal preparation and bone shortening

We explored the proximal stump in a similar manner. The skin edges were retracted and sutured proximally to optimize exposure. We selected the longest available digital artery and ligated proximal branches to gain additional length. Corresponding volar or dorsal veins were dissected. Before osteosynthesis, we approximated the bone ends to

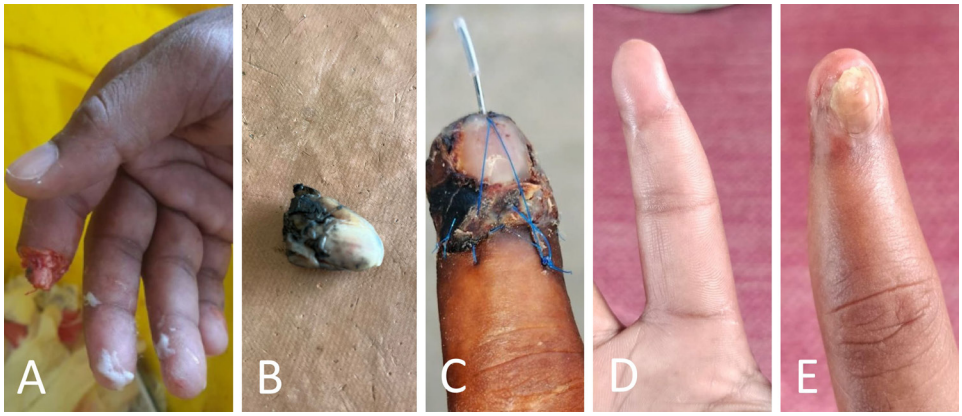

Figure 2. Replantation after Tamai Zone I Crush-Avulsion Fingertip Amputation. (A) Clinical presentation of a Tamai Zone I crush-avulsion amputation of the right index finger caused by entrapment in a motorcycle chain. (B) The amputated distal segment showing severe soft-tissue compromise and grease contamination typical of this injury mechanism. (C) Intraoperative view following replantation, demonstrating a figure-of-eight suture used to splint the nail bed repair and secure the nail plate. (D, E) Postoperative follow-up images showing a viable, well-perfused fingertip with successful soft-tissue healing, despite the presence of nail dystrophy.

assess vessel reach and skin coverage. The proximal bone stump was shortened sufficiently to permit closure without tension. Strategic skeletal shortening was performed to facilitate tension-free repair, thereby obviating the need for interpositional vein grafts. Preference for primary anastomosis without interposition grafts was considered particularly important in this contaminated crush setting.

Osteosynthesis and nail bed repair

To reduce the risk of iatrogenic injury to the critical volar neurovascular bundle, we used an approach from dorsal to volar for fixation. We achieved rigid osteosynthesis using a single 1 mm axial Kirschner wire. This caliber provided adequate longitudinal stability while preserving the delicate architecture of the distal phalanx. This construct created a stable platform for soft tissue reconstruction and protected the subsequent microvascular anastomosis from shear forces.

After skeletal fixation, we prioritized precise anatomical reduction of the nail complex to minimize the risk of secondary onychodystrophy. The sterile and germinal matrices were repaired with 5-0 rapidly absorbing polyglactin (Vicryl) sutures. The native nail plate was repositioned to act as a physiologic splint and to maintain the integrity of the eponychial fold, thereby reducing the risk of synechiae formation. A figure-of-eight suture was then placed to secure the construct and to provide additional external splintage without compromising distal perfusion (Figure 2C).

Microvascular anastomosis

We examined vessel walls under the microscope to identify intimal damage or contusions. Damaged segments were excised, and repair was performed primarily with 11-0 nylon sutures, with 10-0 nylon sutures used when indicated. We confirmed pulsatile arterial flow before anastomosis. Using supermicrosurgical instruments, we performed end-to-end anastomoses of arteries and veins (Figure 1B). To minimize vessel manipulation within the confined soft-tissue envelope, we employed the posterior-wall-first anastomotic technique (Video 1, available at https://doi.org/10.24983/scitemed.imj.2025.00201). We consistently preferred 11-0 nylon sutures because of the thin vessel walls in the fingertip region. Intravascular stenting was used in one case [9]. A single artery and a single vein were repaired in all patients. The goal was to achieve a simple but reliable vascular configuration that could withstand the hostile conditions of crush and contamination.

Nerve coaptation and wound closure

We adopted a zone-specific approach to nerve management. For Tamai Zone II amputations, primary coaptation was attempted whenever proximal and distal nerve stumps were identifiable. In contrast, for Tamai Zone I injuries, formal neurorrhaphy was not performed due to the limited caliber of distal branches; in these cases, sensory recovery relied on spontaneous neurotization. After completion of the neurovascular repair, skin flaps were approximated with 6-0 polypropylene sutures. To prevent iatrogenic compression of the repaired vessels, we took care not to place any sutures directly over the sites of microvascular anastomosis.

Postoperative Management and Rehabilitation

We applied chlorhexidine impregnated gauze dressings with antibiotic ointment and loose padding. The limb was splinted above the elbow to facilitate appropriate positioning. The splint was modified to a below elbow configuration before discharge. Low molecular weight heparin was administered for thromboprophylaxis for five days. Patients were typically discharged on postoperative day five. Chemical leeching was used in one patient to manage venous congestion. Supervised mobilization of the proximal interphalangeal joint was started during the second postoperative week. Kirschner wires were removed at six weeks. This postoperative regimen was designed to protect the replant, limit thrombotic complications, and promote early joint motion once vascular stability had been established.

Outcome Assessment

The primary outcome was the survival of the replanted digit, defined as the maintenance of tissue viability with complete epithelialization and no requirement for revision amputation. Secondary outcomes included the incidence of perioperative complications, specifically infection and venous congestion. We also evaluated the achievement of radiographic bone union and aesthetic outcomes, with particular focus on the presence of nail plate regrowth and the incidence of onychodystrophy. Functional recovery was assessed clinically based on the restoration of protective sensation, the ability to perform a pinch grip, and the timeline for returning to pre-injury occupational tasks.

RESULTS

Patient Demographics and Injury Characteristics

A total of 12 patients presented with fingertip amputations related to

Table 1. Characteristics of Patients With Fingertip Amputations Caused by Motorcycle Chains

No.	Age (yr)	Sex	Tamai Zone[1]	No. of Arterial Anastomoses	No. of Venous Anastomoses	Digital nerve coaptation[2]	Postoperative complications	Outcome[3]
1	24	M	I	1	1	No	Nail dystrophy	Survived
2	30	M	II	1	1	No	None	Survived
3	26	M	II	1	1	Yes	None	Survived
4	23	M	I	1	1	No	Nail dystrophy	Survived
5	24	M	I	1	1	No	Mild pulp atrophy	Survived
6	24	M	II	1	1	Yes	Venous congestion	Failed[4]

[1]Tamai Zone I denotes amputation distal to the nail base; Tamai Zone II denotes amputation proximal to the nail base and distal to the distal interphalangeal joint.
[2]Digital nerve coaptation performed only when distal stump was identifiable; formal neurorrhaphy not undertaken for Tamai Zone I injuries.
[3]Outcome defined as complete survival of the replanted digit.
[4]Failure in Patient 6 resulted from irreversible venous congestion on postoperative day five despite conservative management.
All injuries involved the dominant hand.
Abbreviation: M, male.

motorcycle chain injuries during the study period. Of these, six male patients met the inclusion criteria, underwent replantation, and were included in the final evaluation. The dominant hand was involved in all cases. Detailed demographic and clinical characteristics are summarized in Table 1. The mean age of the cohort was 25.2 years. Injuries were classified according to the Tamai system as Zone I (n = 3) and Zone II (n = 3). All patients presented with extensive soft tissue compromise, characterized by severe crush and avulsion mechanisms and significant gross contamination (Figures 1A, 2A–B, 3A, 4A, 5A–B). These injury features indicate a consistently high-energy trauma pattern with limited scope for primary tissue preservation.

Replantation Survival and Complications

The overall survival rate was 83%, with successful replantation achieved in five of six patients; typical early postoperative viability is shown in Figure 1D. One replantation failed because of venous congestion that developed on postoperative day five. Despite rescue attempts with chemical leeching, the digit could not be salvaged. Surgical re-exploration was not attempted in this case. No patient experienced infection-related loss of the replant.

Functional and Aesthetic Outcomes

Radiographic union at the osteosynthesis sites was achieved in all patients (Figure 3D). Nail regrowth occurred in all surviving digits, although two patients exhibited nail dystrophy (Figures 2D–E). Figure 4 illustrates the favorable aesthetic outcome of a Tamai Zone I thumb replant, characterized by a stable soft-tissue envelope and successful nail plate preservation.

Regarding functional recovery, all patients with successful replants returned to their pre-injury occupations within three months. Protective sensation was restored in all surviving digits, although mild pulp atrophy was noted in one patient. Patients reported functional grip strength and minimal stiffness of the distal interphalangeal joints, sufficient for daily living activities. This functional utility is substantiated in Figure 5C, which demonstrates a stable, sensate fingertip capable of performing a precise pinch grip. Final follow-up examinations confirmed that surviving digits demonstrated satisfactory functional and aesthetic recovery (Figures 1E–F, 3B–C, 4B–C, 5C). Although formal psychophysical or patient-reported measures were not utilized, all surviving digits clinically regained protective sensation (deep pressure and pain perception). Functional recovery was further confirmed by the patients' return to pre-injury occupational tasks.

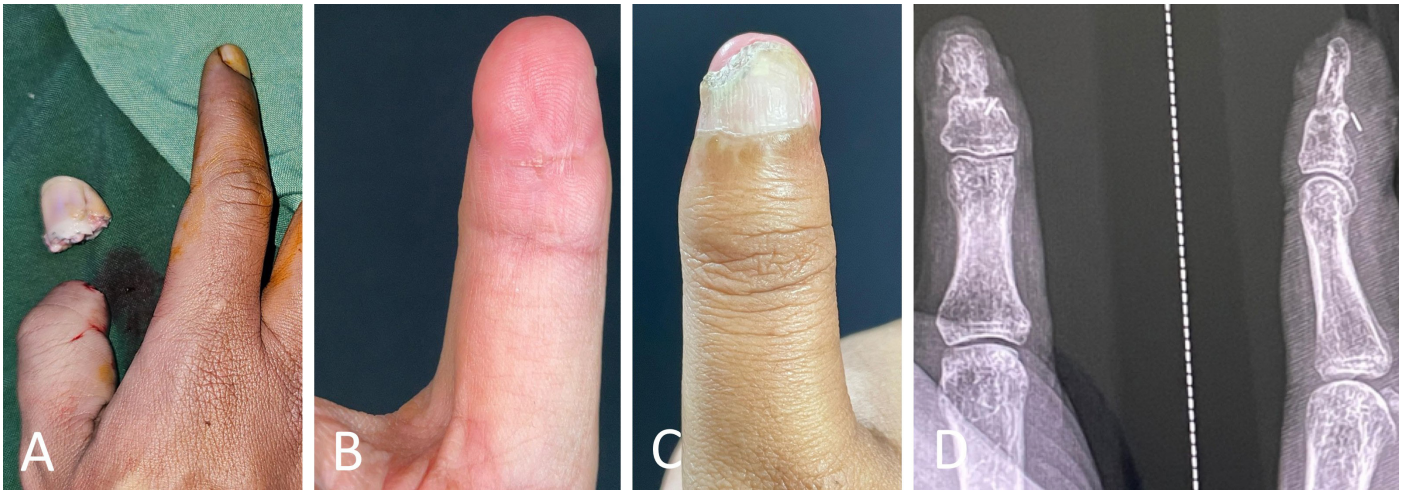

Figure 3. Replantation of a Tamai Zone I Crush-Avulsion Thumb Tip Amputation. (A) Preoperative clinical presentation showing a Tamai Zone I crush-avulsion amputation of the right thumb. (B, C) Postoperative follow-up images demonstrating a well-settled, viable thumb tip with the repositioned nail plate remaining in situ before separation. (D) Postoperative radiograph confirming solid osseous union at the site of osteosynthesis.

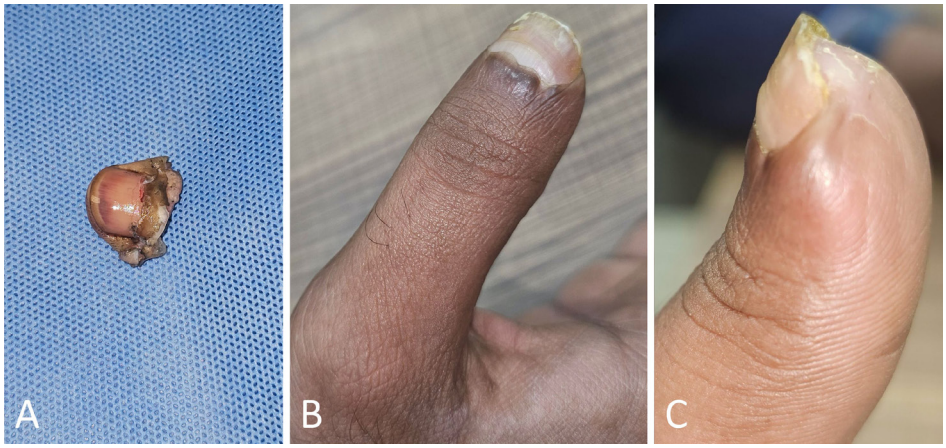

Figure 4. Replantation of a Tamai Zone I Crush Amputation of the Right Thumb. (A) Clinical photograph of the amputated distal segment following a Tamai Zone I crush injury of the right thumb. (B, C) Postoperative follow-up images demonstrating a well-healed, viable thumb tip with satisfactory soft-tissue contour and nail regrowth.

DISCUSSION

This study evaluates the outcomes of primary replantation in a specific subset of motorcycle chain injuries where distal vascular targets were preserved. In this selected cohort, strictly adhering to a protocol of radical debridement, strategic bone shortening, and simplified single-vessel repair yielded an 83% survival rate without infectious complications. These results suggest that contaminated crush trauma is not an absolute contraindication to replantation, offering a viable alternative to traditional revision amputation. Furthermore, our findings indicate that functional restoration is achievable through refined technique, reducing the operative burden of multivessel repairs and supporting attempted replantation in complex trauma when anatomical conditions permit.

Comparison with Alternative Reconstruction Techniques

Despite the prevalence of motorcycle chain-related fingertip amputations, literature guiding their microsurgical management remains sparse [3]. Several authors have reported favorable outcomes with graft repositioning over local flaps [2,10,11]. We reserved this non-microsurgical approach for cases in which suitable recipient vessels were unavailable. In our view, graft repositioning offers a practical method for wound closure but provides functional and cosmetic results that differ from true replantation. The nonglabrous skin of the flap affords inferior sensibility compared with native glabrous skin. The aesthetic restoration is also less anatomic than that achieved through successful replantation.

Advanced Microvascular Strategies

The technical challenges of fingertip replantation have been well documented [1,9,12,13]. Alternative strategies include the two artery method, interpositional vein grafting, and composite grafting without anastomosis [12–15]. We considered these principles as part of an escalation framework. A key adaptation in this series involved management of the volar veins. Because mobilizing and flipping volar veins with vascular clamps is technically demanding, proficiency in the posterior-wall-first anastomosis technique is essential to avoid unnecessary manipulation (Video 1, available at https://doi.org/10.24983/scitemed.imj.2025.00201). While strategic skeletal shortening typically obviates the need for grafting in this protocol, the threshold for using interpositional vein grafts should remain low whenever tension-free primary anastomosis is not feasible [12]. These advanced microvascular strategies are particularly relevant in motorcycle chain-related injuries, in which short vessel segments and contused vessel walls are common.

Vascular Configuration and Survival Rates

Hahn et al. have correlated higher numbers of vascular anastomoses with improved survival rates, noting an 82% success rate specifically for the one-artery and one-vein configuration [7]. Our series suggests that a simplified configuration of this type can yield comparable outcomes in this specific injury pattern. We achieved a survival rate of 83%, which is consistent with Hahn's findings and close to the 86% success rate reported by Sebastin et al. in a systematic review of distal digital replantations [4]. This finding indicates that in the setting of severe crush and avulsion, the quality of the anastomosis and the extent of radical debridement within the zone of injury may be more important determinants of survival than the absolute number of repaired vessels. Nail dystrophy occurred in a subset of patients, which is a recognized consequence of germinal matrix injury even in successful replants [4]. These sequelae underscore the need to counsel patients that nail deformity may persist despite complete survival of the replant.

Debridement and Infection Control

The importance of meticulous debridement cannot be overstated. Complete excision of devitalized tissue, foreign material, and grease contaminants is the single most critical determinant of infection control and replant survival. We observed no infection-related losses in this series, despite the gross contamination inherent to motorcycle chain mechanisms. This absence of infection supports the effectiveness of aggressive irrigation and debridement as the foundation of the reconstructive protocol.

Sensory Outcomes

Although the mechanism of injury often precludes primary nerve repair, nerve coaptation was performed whenever it was feasible in order to optimize sensory reinnervation. We observed protective sensation in all surviving digits. This finding supports the observation that some degree of sensory recovery is attainable even in the absence of direct nerve repair [4].

Pathophysiology of Replant Failure

We encountered one replantation failure involving a Tamai Zone II injury that developed irreversible venous congestion on postoperative day five. The single failure was characterized by late-onset venous congestion.

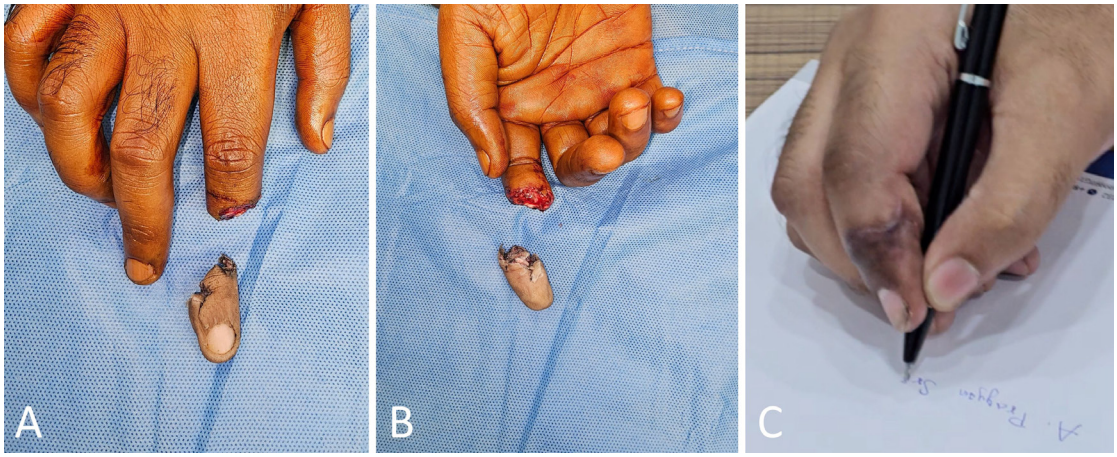

Figure 5. Replantation of a Tamai Zone II Crush-Avulsion Amputation of the Right Index Finger. (A) Dorsal view of the amputated right index finger following a Tamai Zone II crush-avulsion injury. (B) Volar view of the same injury, showing the exposed soft-tissue at the amputation level. (C) Postoperative functional assessment demonstrating a stable, sensate fingertip that permits effective pinch grip, as evidenced by the ability to hold a pen.

While retrospective analysis cannot confirm the precise etiology, this clinical course is consistent with progressive thrombosis secondary to occult endothelial injury within the zone of trauma, highlighting the vulnerability of a single-vein outflow tract. The gradual development of a hematoma or subclinical infection may also have compromised venous return through external compression. These mechanisms are difficult to confirm retrospectively but should prompt a low threshold for early re-exploration when warning signs of congestion appear.

Surgical Principles and Prevention

Our experience supports a protocol that emphasizes systematic exploration of all amputation stumps, liberal bone shortening to permit tension-free repair, and use of supermicrosurgical techniques with 11-0 nylon sutures. These strategies are consistent with and extend established principles for successful digital replantation. Ultimately, primary prevention remains the most effective strategy. Safety measures to prevent motorcycle chain-related fingertip injuries have been described in detail by Geevarughese et al. [5]. Integration of these preventive measures into public awareness campaigns and workplace safety regulations may reduce the incidence of these injuries [1,3,5].

Study Limitations

We acknowledge several limitations inherent to this study. First, the small sample size and retrospective design restrict the broader generalizability of our findings. Crucially, the exclusion of cases where intraoperative exploration revealed non-reconstructable vascular damage introduces a specific selection bias. Consequently, our reported survival metrics reflect the outcomes of completed primary replantations in a highly selected subpopulation, rather than the overall success rate for all patients presenting with this injury mechanism. Second, the absence of quantitative sensory mapping, such as static two-point discrimination, precludes objective benchmarking of functional outcomes against other cohorts. Functional recovery was assessed based on clinical examination of protective sensation and return to work, rather than standardized objective metrics. Despite these limitations, the strict uniformity of the injury mechanism allows for a detailed technical evaluation of the described protocol in a consistent high-energy trauma model. Future research utilizing prospective designs and validated sensory testing protocols is required to further define the functional potential of replantation in this setting.

CONCLUSION

Primary replantation is a feasible therapeutic option for fingertip amputations caused by motorcycle chains. A simplified protocol emphasizing radical debridement, strategic skeletal shortening, and single-vessel anastomosis achieved successful reattachment and functional restoration in 83% of patients. This approach reduces the technical burden of primary replantation, offering a practical solution to preserve the digit rather than resorting to revision amputation.

ARTICLE INFORMATION

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Ethics Approval and Consent to Participate: The study adheres to the ethical principles outlined in the 1964 Helsinki Declaration and its subsequent revisions, or other equivalent ethical standards that may be applicable. These ethical standards govern the use of human subjects in research and ensure that the study is conducted in an ethical and responsible manner. The researchers have taken extensive care to ensure that the study complies with all ethical standards and guidelines to protect the well-being and privacy of the participants.

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