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Case series

Hyperbaric oxygen therapy in managing fingertip injury after the thenar and V—Y flap procedure: A case series

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ABSTRACT

Introduction: Injuries to fingertips are common due to their critical role in tactile sensation and hand function. Management options depend on injury severity and include conservative care, skin grafts, or flaps. The Ishikawa classification system helps guide treatment by categorizing injuries from soft tissue damage (Type I) to more severe bone and tissue loss (Type IV). Hyperbaric oxygen therapy (HBOT) has emerged as a valuable adjunct in enhancing wound healing and graft survival.

Case presentation: This report discusses five patients with fingertip injuries (FTI) of varying degrees, ranging from mechanical traumas to accidents involving parasailing and firecrackers. Their injuries were classified as Type II ($n = 1$), III ($n = 2$), and Type IV ($n = 2$) according to the Ishikawa system. Surgical interventions included thenar flaps for radial digit injuries in two patients and V—Y advancement flaps with full-thickness skin grafts in the other three. The grafts were harvested from the plantar foot. Following surgery, each patient underwent five HBOT sessions to support healing.

Clinical discussion: The study observed that all five patients who underwent HBOT after surgical procedures experienced optimal graft healing. There were no signs of dehiscence, indicating that the grafts were well-integrated and functioning effectively. This outcome is attributed to the positive effects of HBOT on wound healing.

Conclusion: HBOT accelerates wound healing, improves graft survival, and helps preserve function and aesthetics, making it an effective addition to surgical treatment. This case series supports further exploring HBOT in treating complex FTI to optimize patient outcomes.

1. Introduction

The fingertip is located at the distal end of each finger and plays a crucial role in tactile and sensory perception, which is then transmitted to the brain. It is one of the most frequently used parts of the human body, making fingertip injuries (FTIs) among the most common upper extremity injuries, which typically occur at the distal insertion of the flexor and extensor tendons [1].

Hyperbaric oxygen therapy (HBOT) is widely recognized for its benefits in wound healing. Animal studies have demonstrated its effectiveness in improving the condition of ischemia-reperfusion injuries and stimulating angiogenesis [2]. For compromised flaps and grafts, HBOT, typically administered at 2.0–2.5 ATA for 90–120 min twice daily, can enhance survival rates, especially when applied before and after surgical

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procedures [3].

This study highlights HBOT's dual role in promoting wound healing and improving graft viability in surgical repairs. Its application is particularly beneficial when traditional methods yield suboptimal outcomes, offering a novel approach to patient care. The integration of HBOT with flaps and grafts represents a promising advancement in fingertip injury treatment, significantly enhancing healing and graft survival.

This study aimed to assess the potential benefits of HBOT in fingertip injury management by evaluating its efficacy as an adjunctive treatment to improve both functional and cosmetic outcomes. This case series is reported in accordance with the 2023 PROCESS guidelines [4].

2. Case presentation

This study involves a retrospective analysis of five patients who underwent surgical interventions for FTIs between 2019 and 2023. The patients were admitted to the emergency department and subsequently scheduled for fingertip injury reconstruction (Table 1), followed by HBOT as supplementary therapy. The cohort included three females and two males. Before treatment, all patients were fully informed about potential side effects and risks and provided informed consent.

The patients' mean age was 23.6 years with a range of 12 to 36 years old. The causes of injury varied but were predominantly mechanical. Specifically, injuries were caused by a motorcycle chain, an ice-crushing machine, a parasailing rope, a cupboard accident, and a firecracker malfunction. According to the Ishikawa classification, two patients sustained Type IV injuries, two sustained Type III injuries, and one sustained a Type II injury. These classifications reflect varying degrees of tissue and bone exposure, with Type IV being the most severe.

The study inclusion criteria were (a) fingertip injury with bone and tissue exposure and (b) willingness to participate by signing the informed consent form. The study exclusion criteria were (a) pregnancy, (b) peripheral vascular disease, and (c) absolute and relative contraindications to HBOT: untreated pneumothorax, perforated eardrum, uncontrolled hypertension, severe diabetes (glucose concentration of >300 or < 100 mg/dL), congestive heart failure (ejection fraction of <35 %), and claustrophobia.

2.1. Surgical technique

The reconstructive and aesthetic plastic surgeon performed surgical interventions were selected based on the type and severity of the injury. Two patients underwent thenar flaps for guillotine injuries (Ishikawa Type III and IV), while the other three received V—Y flaps combined with full-thickness skin grafts (FTSGs) for crush injuries (Ishikawa Type III). For the FTSG procedure, the donor graft was harvested from a non-weight-bearing area of the plantar surface of the right foot. This site was chosen to minimize postoperative discomfort and reduce the risk of complications associated with graft harvesting. The choice of flap or graft was determined based on the injury's extent and location and the patient's specific needs.

2.2. Postoperative care

The patients were discharged the day after surgery with prescriptions for oral analgesics and prophylactic antibiotics for five days. A compressive moist gauze with an antibiotic dressing (framycetin sulfate) was applied to the recipient site to aid healing and prevent infection. The donor site was dressed with a foam dressing, which was changed every three days. The wounds were inspected weekly to monitor the healing process, and dressing changes were performed every other day. Depending on the wound's condition, stitch removal was scheduled for 7–10 days post-surgery at the recipient site and 5–7 days at the donor site.

2.3. HBOT administration

Once the surgical repair was completed, all patients were scheduled for HBOT sessions. Each patient began receiving 90-min 100 % oxygen therapy sessions at a 2.4 ATA pressure in a mono-chamber one day after surgery, administered for five consecutive days. This protocol was based on established guidelines for enhancing graft survival and tissue healing in compromised wounds [3].

2.4. Case one

A 20-year-old male mechanic presented to the emergency room with an open wound on his left hand after it was caught in a motorcycle gear 2 h prior. He had a clean-cut wound on his second finger without any fracture. On examination, the wound had a well-defined edge, and the distal phalanx was exposed (Fig. 1A and B). After debridement, the injured site was covered with a thenar flap (Fig. 1C). The wound was inspected weekly, and the dressing was changed every other day. One day postoperatively, the patient began a series of five HBOT sessions to aid healing.

At the six-week follow-up, the patient's graft showed complete survival, with minimal finger contracture. Both the functional and aesthetic outcomes were excellent, with the patient reporting satisfaction with the result and noting a significant improvement in hand function.

2.5. Case two

A 12-year-old female presented to the emergency room six hours after sustaining an injury to her third finger while using an ice-breaking machine. She had an open wound with an irregular edge but no fracture.

Table 1
Patients' characteristics.

No	Age/ Sex	Cause	Time to Surgery	Surgical Method	HBOT sessions	Complication on HBOT	Follow-up duration	Notes
1	20/M	Ground by a motorcycle chain 1 day before admission.	6 Hours	Thenar flap	5	Transient right ear pain	6 months	Digit II left hand, guillotine injury. Ishikawa IV Sensory loss in distal finger. No motor function problem.
2	12/F	Ground by an ice-crushing machine 6 h before admission.	6 Hours	Thenar flap	5	None	6 months	Digit III left hand, crush injury. Ishikawa III. Sensory lost in distal finger. Motor function normal.
3	22/F	Strangled by a parasailing rope 5 h before admission.	4 Hours	V-Y flap & FTSG	5	None	6 months	Digit V right hand, guillotine injury. Ishikawa III. No Sensory and motor function problem.
4	36/F	Caught in a cupboard while moving items.	10 h	V-Y flap & FTSG	5	None	6 months	Digit II left hand, crush injury. Ishikawa II. No Sensory and motor function problem
5	28/M	Firecracker malfunction.	22 Hours	V-Y flap & FTSG	5	None	1 year	Digit IV left hand, crush injury. Ishikawa III. Sensory loss in distal finger. Weakened motor function in DIP joint.

Notes: FTSG, full-thickness skin graft; F, female; M, male; DIP, distal interphalangeal.

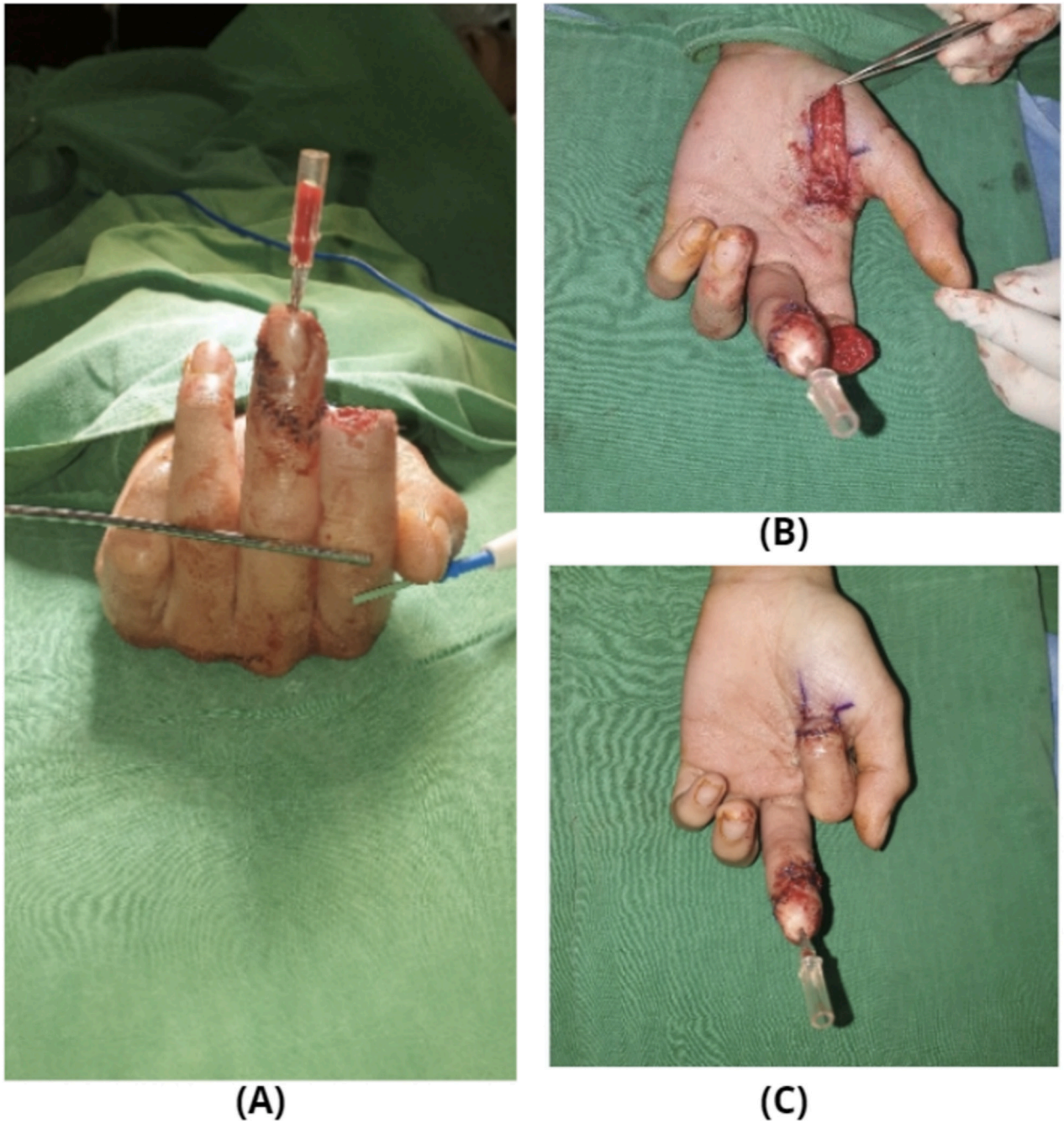

Fig. 1. A patient with an amputated second finger treated with a thenar flap. (A, B) Perioperative appearance of the injury and (C) postoperative appearance after the thenar flap was performed.

Upon examination, the distal phalanx was exposed (Fig. 2A and B). After debridement, the defect was covered with a thenar flap (Fig. 2C and D). Postoperative care included weekly wound inspections and dressing changes every other day (Fig. 2E and F). The patient began HBOT one day after surgery, with five sessions prescribed to enhance healing.

At her six-week follow-up, the graft had completely survived with no major complications. The patient had minimal contracture, and finger function and appearance were well maintained. She expressed satisfaction with the recovery, noting that her finger had regained both strength and flexibility.

2.6. Case three

A 22-year-old female presented at the emergency room after injuring her right hand during a parasailing event five hours prior. Her fifth finger has been caught in the sail, resulting in a clean-cut wound (Fig. 3A and B). The examination revealed a well-defined wound edge with distal phalanx exposure. After debridement, a V—Y flap and FTSG were performed, with the graft harvested from a donor site on the plantar foot (Fig. 3C and D). HBOT was initiated the day after surgery, with five consecutive sessions prescribed.

Six-week after surgery, the patient's graft was intact, with minimal contracture. The finger maintained both functionality and a pleasing aesthetic appearance. The patient was satisfied with the outcome, reporting improved function in her hand and a restored appearance.

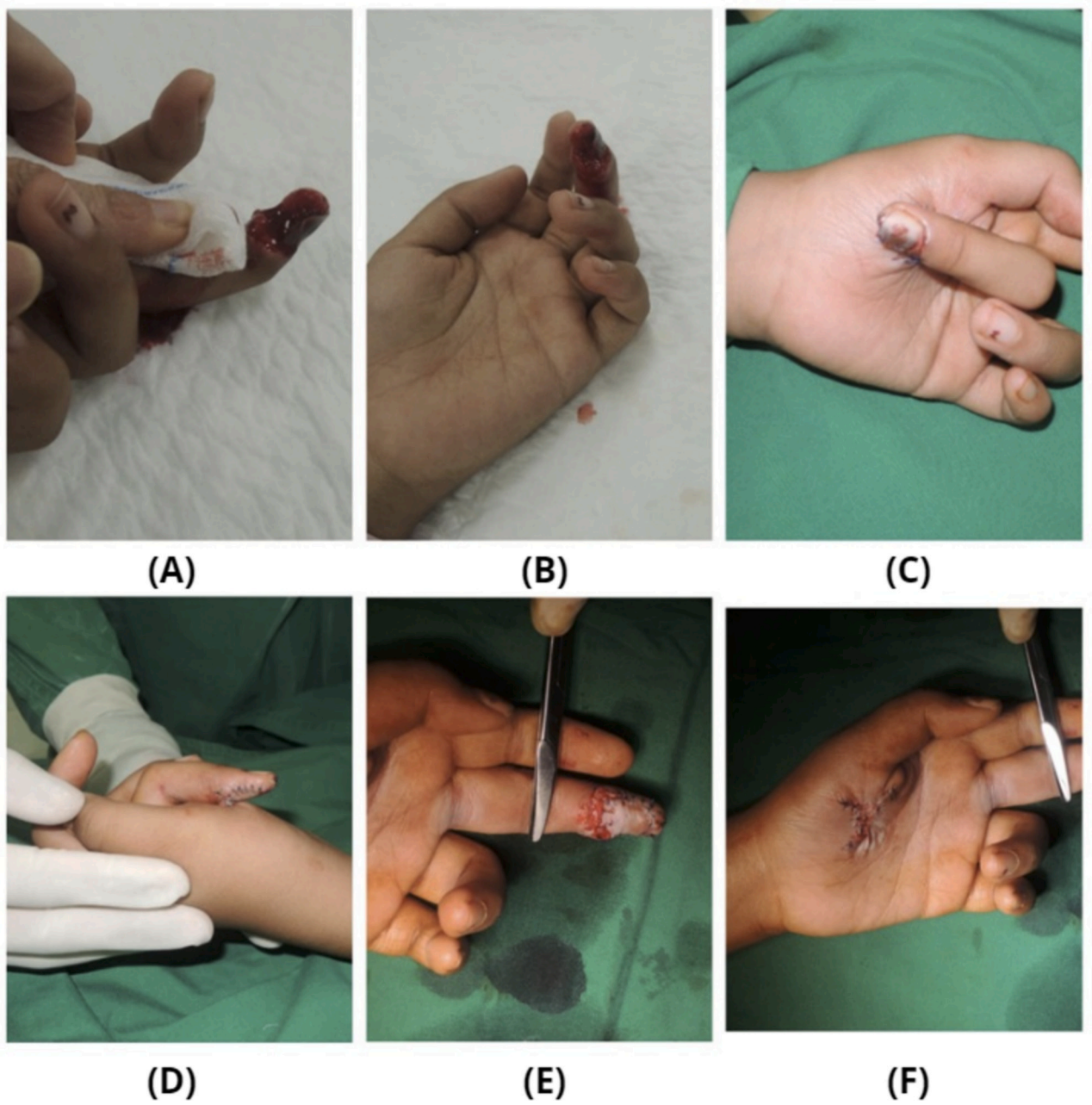

Fig. 2. A patient with a crush injury treated with a thenar flap. (A, B) Preoperative appearance of the injury. (C, D) Postoperative appearance after a thenar flap was performed. (E, F) Postoperative appearance after flap release 3 weeks post-injury.

2.7. Case four

A 36-year-old female presented to the emergency room with pain and an open wound on her left hand after an accident at home four hours prior. She had injured her third finger while moving furniture during local flooding. The wound had an irregular edge and exposed distal phalanx (Fig. 4A and B). After debridement, a V—Y flap and FTSG were performed, with the graft taken from a donor site on the plantar foot (Fig. 4C and D). HBOT was initiated the day after surgery, with five sessions prescribed.

At the six-week follow-up, the graft was fully viable with minimal contracture. The patient's finger regained normal functionality, and the aesthetic result was satisfactory. She expressed relief and satisfaction with the recovery, reporting noticeable improvement in hand function and appearance.

2.8. Case five

A 28-year-old male presented to the emergency room with an open wound on his fourth finger after a firecracker malfunction one hour prior. The examination revealed an irregular-edged wound on his left hand with an exposed distal phalanx (Fig. 5A and B). After debridement, a V—Y flap and FTSG were performed using a graft from a donor site on the plantar foot. The patient began five sessions of HBOT one day after surgery to support tissue healing.

At the 1-year follow-up, the graft was fully healed with no significant contracture (Fig. 5C and D). The patient's finger retained both functional and aesthetic integrity. He reported a sensory loss in the distal finger and weakened motor function in the distal interphalangeal joint.

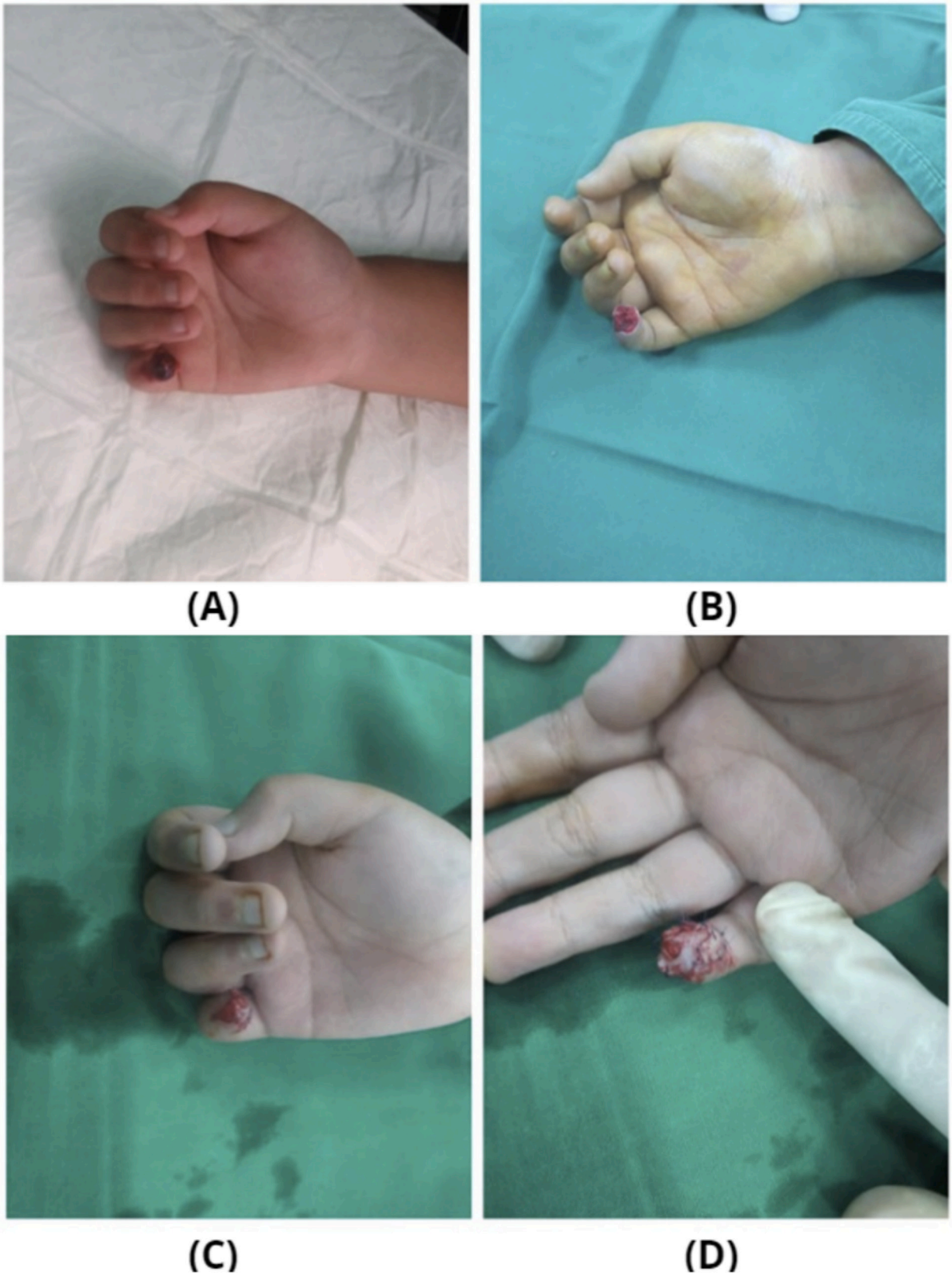

Fig. 3. A patient with a guillotine injury treated with a V—Y flap and FTSG. (A, B) Preoperative and (C, D) postoperative images.

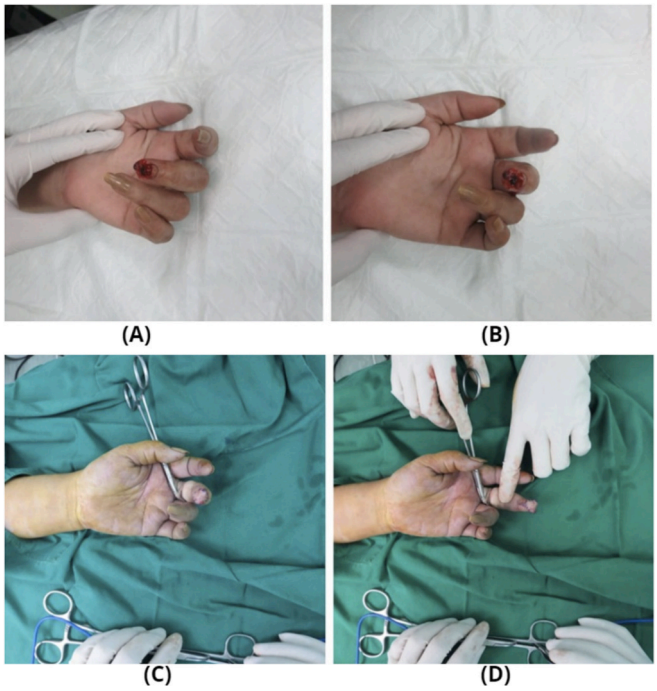

Fig. 4. A patient with a crush injury treated with a V—Y flap and FTSG. (A, B) Preoperative and (C, D) postoperative images.

3. Discussion

FTIs are among the most common injuries of the upper extremities, and the primary treatment goal is maximizing preserved function. The management approach varies depending on the injury's type and severity and the patient's overall condition [5].

In the first and second cases, we utilized the thenar flap procedure. The thenar flap is particularly effective for covering volar tissue loss in the radial digits, as these fingers have sufficient mobility to reach the thenar eminence for proper coverage. However, this technique is unsuitable for the ulnar digits, which lack the necessary excursion. For cases 3–5, we utilized V—Y advancement flaps, which offer the advantages of preserving finger sensation, maintaining length, and providing excellent soft tissue coverage [6].

After their respective surgical procedures, all patients were scheduled for five HBOT sessions. According to Lee et al., HBOT significantly benefits FTIs by inducing hyperoxygenation and vasoconstriction, promoting early revascularization, and supporting healthy skin grafting. We observed faster graft healing in cases 1 and 2, who had clean-cut injuries, than in cases 3–5, who had crush injuries, as evidenced by the early appearance of pinkish coloration around the graft sutures, indicating revascularization. In all five cases, the grafts healed optimally, with no signs of dehiscence, an outcome likely influenced by the positive effects of HBOT on wound healing, fibroblast activity, collagen synthesis, and angiogenesis [6].

Recent studies on HBOT have shown promising effects on graft survival rates in composite grafting for FTIs [7,8]. HBOT enhances tissue oxygenation, which is crucial for healing, particularly in clean-cut injuries like guillotine amputations [9]. In such cases, HBOT has been associated with higher graft survival rates and significantly faster healing, reducing the recovery period by about a week compared to traditional treatments. However, HBOT's benefits appear less pronounced for crush injuries with more extensive vascular damage due to impaired blood flow, though some cases still show improvement with early intervention [6].

Studies suggest that HBOT can decrease inflammation by reducing levels of harmful cytokines and increasing antioxidant responses, both of which contribute to faster wound recovery and reduced infection rates [2,10]. Therefore, HBOT is often used as an adjunctive treatment in chronic wound management alongside standard care options like debridement and topical treatments [2].

All cases were evaluated after completing five HBOT sessions, each showing excellent results. The structural integrity and sensory function of their fingers were well-preserved. Most common postoperative complication observed was pain at the surgical site, which subsided within a few days with appropriate treatment. During follow-up, patients reported minimal sensory complaints, primarily in the distal areas of the injured finger. Sensory and motor outcomes were assessed clinically, with sensory deficits evaluated through patient-reported symptoms and, when necessary, two-point discrimination tests. The patient who experienced weakened motor function was referred to the medical rehabilitation department for further evaluation and rehabilitation therapy.

The Ishikawa classification system categorizes FTIs based on the degree of damage to soft tissue, bone, and nail. Type I involves only soft tissue injury without bone or nail matrix exposure. Type II involves nail bed damage without bone exposure. Type III involves bone exposure with some soft tissue remaining. Type IV, the most severe, involves complete bone exposure and significant soft tissue loss. This system guides treatment choices, from conservative care for minor injuries to surgical intervention for severe cases, ensuring optimal functional and cosmetic outcomes [11,12]. This case series also highlights the distribution of FTIs based on the Ishikawa classification. One patient presented with a Type IV injury, characterized by complete bone exposure and total loss of soft tissue. Three patients had Type III injuries, which involved bone exposure with partial soft tissue loss. One patient had a Type II injury, which involved damage to the nail bed but no bone exposure. This classification underscores the variable nature of FTIs and emphasizes the importance of tailoring treatment strategies according to injury severity.

A study demonstrated that patients receiving HBOT after composite grafting for fingertip amputations had significantly higher graft survival rates compared to those undergoing conventional treatments, particularly in guillotine-type injuries ($P = 0.0337$) [13]. The combination of HBOT with prostaglandin E1 has been shown to enhance outcomes in cases where revascularization is not feasible, indicating a synergistic effect on tissue repair [14]. Compared to standard treatments without HBOT, patients in this study experienced faster healing, fewer complications, and improved graft survival rates.

Future research should compare HBOT with other advanced wound care modalities, including negative pressure wound therapy and bioprinting techniques, to determine the optimal management approach for FTIs. While our case series showed promising results, it is essential to acknowledge its limitations. Firstly, the study had a short follow-up period and a relatively small sample size. Secondly, more objective evaluation methods could improve the reliability of the findings. Therefore, future studies with larger sample sizes and longer observation periods are needed to deepen our understanding and potentially enhance clinical practice in this area.

4. Conclusion

HBOT is a valuable adjunct in managing FTIs requiring graft procedures. It enhances wound healing and graft survival, making it a crucial addition to comprehensive fingertip injury treatment. Future studies should focus on randomized controlled trials with larger sample sizes and longer follow-up periods to establish standardized protocols for HBOT in fingertip injury management.

Patient consent

Written informed consent was obtained from the patient or the patient's parents/legal guardian for the publication of this case series and

Fig. 5. A patient with a crush injury treated with a V—Y flap and FTSG. (A, B) Preoperative and (C, D) 1-year postoperative images show adequate tissue growth.

accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal upon request.

Ethical approval

This case series is exempt from ethical approval from the ethical local board of the Faculty of Medicine, Sam Ratulangi University, Manado, Indonesia.

Guarantor

Mendy Hatibie Oley and Maximillian Christian Oley.

Provenance and peer review

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Author contribution

MHO and MCO: Conceptualization, Methodology, Software. MHO, MCO, ADN, and YS: Data curation, Writing-Original draft preparation. VS: Visualization, Investigation. MHO and MCO: Supervision.: VS and MF: Writing-Reviewing and Editing. All authors read and approved the final manuscript.

Declaration of competing interest

None.

Acknowledgment

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