Staged Orthoplastic Reconstruction of a Gustilo Anderson Grade IIIB Open Proximal Phalanx Fracture of the Thumb with Segmental Bone Loss

Atanu Mohanty[1], Anuraag Mohanty[2]

Abstract

Background: The thumb contributes approximately 40 to 50 percent of global hand function. Loss or shortening of the thumb markedly impairs pinch, grasp and fine manipulation, which makes preservation and reconstruction of severe thumb injuries a priority in hand trauma.

Case presentation: A 40 year old man sustained a Gustilo Anderson Grade IIIB open fracture of the proximal phalanx of the right thumb with segmental bone loss following a machinery crush injury. He was managed with staged orthoplastic reconstruction. The first stage consisted of meticulous debridement and provisional external fixation. The second stage used a dorsal metacarpal artery based sensate flap for soft tissue coverage. The third stage involved definitive skeletal reconstruction with tricortical iliac crest bone graft and K wire fixation.

Outcome: The flap survived, the graft united, and the patient regained a stable, pain free thumb with useful opposition and pinch.

Conclusion: A planned orthoplastic strategy that combines early debridement and temporary external fixation, reliable sensate flap cover and delayed structural bone grafting can successfully salvage high grade open injuries of the thumb with bone loss and restore functional length.

Keywords: Thumb fracture, open fracture, Orthoplastic reconstruction, Dorsal metacarpal artery flap, Iliac crest bone graft, External fixation

Introduction

The thumb is central to hand function. Biomechanical and clinical studies estimate that the thumb accounts for roughly 40 to 50 percent of overall hand function and a comparable proportion of global upper limb disability when lost [1–3]. Loss of thumb length or stability significantly impairs key pinch, opposition and power grip [1, 2]. Functional reconstruction of the thumb therefore receives priority in severe hand injuries, even when other digits are involved.

Open fractures with extensive soft tissue damage and contamination are commonly classified using the Gustilo Anderson system, which correlates increasing grade with risk of infection, non-union and amputation [4, 5]. Grade IIIB injuries are characterised by extensive soft tissue loss with periosteal stripping and often segmental bone loss. These injuries require coordinated management that addresses infection control, skeletal stability and soft tissue coverage in a staged manner [5–7].

In the hand, open fractures need prompt irrigation and debridement, early skeletal stabilisation and timely soft tissue reconstruction to provide a vascularised envelope before definitive bone reconstruction or internal fixation [6, 7]. External fixation is frequently used as an initial stabilisation method in severely contaminated or high energy injuries since it maintains length and alignment while allowing repeated debridement and flap surgery [5, 8].

For thumb reconstruction, the goals are restoration of functional length, stability, mobility (especially opposition), sensibility and acceptable appearance [9]. The dorsal metacarpal artery based first dorsal metacarpal artery (FDMA) flap provides a reliable sensate option for soft tissue coverage of moderate sized thumb defects [10–12]. Segmental bone loss is commonly reconstructed with iliac crest bone graft, which provides structural cortical support with a cancellous component for incorporation and is well described in both osteoplastic thumb reconstruction and complex hand injuries [9, 13–15].

We report a case of a Grade IIIB open proximal phalanx fracture of the thumb with segmental bone loss managed by staged orthoplastic reconstruction using provisional external fixation, a dorsal metacarpal artery based sensate flap and delayed tricortical iliac crest bone grafting.

Case Report

A 40 year old right handed male sustained a crush injury to his right thumb on 30 July 2024 when his hand was trapped in a machine. On presentation to Maharaja Jajati Kesari Medical College and Hospital, he had a contaminated, mangled injury of the thumb with bone exposure and soft tissue loss. Radiographs showed a comminuted fracture of the proximal phalanx of the thumb with segmental bone loss. The injury was classified as a Gustilo Anderson Grade IIIB open fracture. Distal perfusion was preserved and there was no obvious nerve

[1]Department of Orthopaedics, Maharaja Jajati Kesari Medical College and Hospital, Jajpur, Odisha, India
2Department of Orthopaedics, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India

Address of Correspondence
Dr. Anuraag Mohanty*
Postgraduate Resident, Department of Orthopaedics, Kalinga Institute of Medical Sciences, Bhubaneswar, Odisha, India
Email: anuraag98@gmail.com

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Figure 1: Post debridement status of the right thumb after crush injury showing exposed proximal phalanx defect and temporary external fixation construct maintaining length and alignment.

deficit.

Stage 1: Debridement and provisional stabilisation

The patient underwent emergency debridement on 31 July 2024. All non viable skin, subcutaneous tissue and devitalised bone were excised with copious irrigation. A temporary external fixation construct was applied using percutaneous pins and connecting rods to restore thumb length, alignment and rotation while leaving the wound accessible for inspection and dressings. This stage is shown in Figure 1, which demonstrates the post debridement status and external fixation.

Stage 2: Soft tissue reconstruction with dorsal metacarpal artery based sensate flap

Given the persistent bone and tendon exposure, local flap cover was required. On 5 August 2024 a dorsal metacarpal artery based sensate flap arising from the dorsal metacarpal arterial system was designed, elevated and transposed to the thumb defect. Care was taken to preserve the vascular pedicle and to include a sensory nerve branch so that the flap could provide protective sensibility. Donor site closure was achieved with appropriate mobilisation and, where needed,

Figure 3: Final fixation with tricortical iliac crest bone graft bridging the proximal phalanx defect and K wire stabilisation maintaining thumb length and alignment.

Figure 2: Intra operative photographs demonstrating elevation and inset of the dorsal metacarpal artery based sensate flap used to provide soft tissue coverage to the thumb defect.

grafting. The steps of flap elevation and inset are illustrated in Figure 2.

Postoperatively the flap remained viable with no marginal necrosis. The wound bed became stable, supple and ready for later skeletal reconstruction.

Stage 3: Definitive skeletal reconstruction

After maturation of the soft tissue cover, definitive bony reconstruction was performed in November 2024. A tricortical iliac crest bone graft was harvested and contoured to bridge the segmental defect in the proximal phalanx. The graft provided both cortical strength and cancellous bone to support incorporation. It was fixed with smooth K wires passed across the proximal phalanx and adjacent segment to maintain length and alignment. The construct and graft position are shown in Figure 3, which depicts the final fixation with tricortical iliac crest bone graft and K wire stabilisation.

The flap continued to survive, and serial radiographs demonstrated progressive graft incorporation and union.

Follow up and functional outcome

At follow up the patient had a stable thumb with preserved length, painless union and good soft tissue contour. He achieved useful opposition to the index and middle fingers, satisfactory key pinch and the ability to hold larger objects with power grip. Protective

Figure 4: Final functional outcome demonstrating preserved thumb length, opposition to the index and middle fingers and satisfactory pinch and grasp function.

sensibility over the reconstructed area was present. The final functional outcome is shown in Figure 4, demonstrating preserved thumb length, opposition and overall hand function.

Discussion

The presented case illustrates several important principles in the management of severe open injuries of the thumb with bone loss.

First, the functional importance of the thumb justifies considerable effort at salvage. Loss of thumb function can produce 40 to 50 percent loss of hand function and substantial whole upper limb impairment [1–3, 9]. Preservation of thumb length and opposition is crucial for key pinch and precision grip. In the setting of a Grade IIIB open fracture, the surgeon must balance infection control and soft tissue viability against the long term functional benefit of reconstruction [4, 5].

Second, adherence to open fracture principles remains foundational. Gustilo and Anderson demonstrated that higher grade open fractures have increasing risks of infection and complications, which underpins early irrigation, debridement and staged reconstruction [4]. Subsequent reviews of open fracture management have reinforced the need for meticulous debridement, early antibiotic therapy, provisional stabilisation and timely soft tissue cover [5–7]. External fixation is particularly useful as a provisional method since it preserves length and alignment while avoiding implants in a contaminated field and leaving the wound accessible for flap surgery [5, 8, 16]. In the upper limb, external fixation has been shown to provide effective temporary stabilisation for complex open fractures while definitive reconstruction is planned [16].

Third, the choice of soft tissue cover for the thumb should prioritise sensate, durable tissue. The first dorsal metacarpal artery based flap and its modifications have become standard options for small to moderate sized thumb defects. Series from different centres report high flap survival, acceptable two point discrimination and good functional outcomes when FDMA flaps are used for thumb pulp or dorsal defects [10–12, 17]. A systematic review and recent cohort data have confirmed that FDMA based flaps provide stable, sensate coverage with minimal donor site morbidity and good overall patient satisfaction [10, 11, 17, 18]. In our case, a dorsal metacarpal artery based sensate flap provided robust coverage over the proximal phalanx and created a healthy, vascular bed for later bone grafting.

Fourth, reconstruction of segmental bone loss of the thumb can be achieved with non vascularised iliac crest bone graft in selected cases. Iliac crest bone graft is a well established technique in osteoplastic thumb reconstruction, particularly for post traumatic defects and amputations around the metacarpophalangeal and proximal phalanx levels [9, 13–15, 19]. Case series and reports have shown that tricortical iliac crest grafts can restore functional length and alignment with satisfactory union and hand function, especially when combined with appropriate flap coverage [13–15, 19]. A recent case report and small series have reiterated that iliac crest bone graft, combined with regional flaps such as the groin or radial forearm flap, can salvage severely injured thumbs with restoration of grip strength and opposition [13–15]. In the present case, non vascularised tricortical iliac crest bone graft, placed into a well vascularised bed under a stable flap, consolidated without major resorption and allowed the patient to regain a functional thumb.

Finally, the staged orthoplastic approach used here aligns with modern concepts in complex extremity reconstruction. Early coordinated planning between orthopaedic and plastic surgery teams improves decisions about timing and sequencing of debridement, fixation and flap cover [7, 20]. Godina's landmark work on early microsurgical reconstruction emphasised the benefits of timely soft tissue coverage for complex extremity trauma, including higher flap survival and reduced infection [20]. Although our case did not require free tissue transfer, the principle of integrating skeletal and soft tissue reconstruction in a planned sequence remains central to successful salvage.

Overall, this case supports the view that even high grade open injuries of the thumb with bone loss can be salvaged with good functional outcome when managed by an orthoplastic strategy that respects open fracture principles, uses sensate local flaps for coverage and applies structural iliac crest grafts for segmental bone reconstruction.

Conclusion

Grade IIIB open fractures of the thumb with segmental bone loss represent a severe form of hand trauma with high risk of infection, non union and functional loss. This case demonstrates that:

1.Early debridement with provisional external fixation can maintain thumb length and alignment while allowing repeated wound care.

2.A dorsal metacarpal artery based sensate flap provides reliable, sensate soft tissue coverage over exposed bone and tendon.

3.Delayed tricortical iliac crest bone grafting in a stable, well vascularised bed can restore segmental bone loss and achieve union.

4.A staged orthoplastic approach can salvage the thumb and restore useful opposition and pinch in injuries that might otherwise have proceeded to amputation.

This strategy is reproducible in resource constrained settings with access to basic external fixation, regional flaps and autologous iliac crest grafting, and it offers a limb saving and function preserving option for similar injuries.

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Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

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