PRS
GLOBAL OPEN

Osteoplastic Thumb Reconstruction in the Immediate Setting: A Case Series

Yusha Liu, MD, PhD*
Erin A. Miller, MD, MS*
Corinne E. Wee, MD†
Adnan Prsic, MD‡
Danielle J. Eble, MD*
Dennis S. Kao, MD†

Background: Traumatic thumb amputation can have devastating effects on residual hand function. When replantation is not possible, thumb reconstruction is often performed in a delayed manner and may require multiple stages. Furthermore, reconstruction techniques often require microsurgical skills and equipment, which are not readily available at all institutions. This case series illustrates our technique for immediate osteoplastic thumb reconstruction following traumatic amputation.

Methods: This is a case series involving all patients who sustained unreplantable thumb amputations and underwent immediate osteoplastic thumb reconstruction with bone autograft and pedicled groin flap by the senior author from September 2016 through August 2018.

Results: Five patients underwent immediate osteoplastic thumb reconstruction during the study period. Total operative time for the initial osteoplastic reconstruction averaged 158 minutes (range 96–290 minutes). In addition to flap division surgery, patients underwent an average of 1.2 revision procedures (range 0–2), primarily for debulking and hardware removal. Patients achieved an average gain in length of 3.3 cm compared with the maximum anticipated length with revision amputation at the time of injury, and had stable clinical outcomes for a minimum of 12 months.

Conclusions: Osteoplastic thumb reconstruction is a useful technique for thumb reconstruction for select patients following traumatic thumb amputation. Advantages of this approach include shorter overall operative times and hospital length of stay, minimal donor site morbidity, and a straightforward, reproducible technique. *(Plast Reconstr Surg Glob Open 2022;10:e4385; doi: 10.1097/GOX.0000000000004385; Published online 14 June 2022.)*

INTRODUCTION

Traumatic thumb amputations can result in a devastating loss of hand function, particularly with fine motor movements such as precision handling and grip.[1] Replantation remains the gold standard but may not be possible due to various reasons, such as a severe crush/avulsion injury, a lack of a microsurgical team or specialized equipment, patient instability, underlying medical comorbidities, or immediate failure of a replantation attempt.[2] In these cases, many options for delayed thumb reconstruction exist, including metacarpal lengthening, webspace deepening, osteoplastic reconstruction, pollicization, and toe transfer.[2–10]

Osteoplastic reconstruction is an excellent option to increase thumb length without the need for microsurgical skills or equipment. Historically performed in a delayed manner, this technique combines a large piece of autologous cortical bone graft, typically harvested from the iliac crest, with soft tissue coverage by a pedicled groin flap or distally based radial forearm flap.[3,11] Here, we present our experience with osteoplastic thumb reconstruction at the time of injury, utilizing the remaining bone from unsalvageable portions of the injured hand coupled with an immediate pedicled groin flap for soft tissue coverage to restore functional length.

With this technique, we take advantage of the "spare parts" available at the time of injury.[12–15] The bone from the amputated thumb, or from adjacent fingers in cases of

DOI: 10.1097/GOX.0000000000004385

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

multidigit injuries, is readily available to serve as autograft. When osteoplastic thumb reconstruction is performed in a delayed manner, this valuable bone would have been discarded at the time of injury with a revision amputation, thus requiring autologous bone graft harvest from an additional donor site at the time of reconstruction.[11]

Our straightforward approach to reconstruction offers a number of key benefits. First, osteoplastic thumb reconstruction is possible at most hospitals because the technical aspects of the operation are well within a trained hand surgeon's skill set and do not require an institution to have microsurgical capabilities. Second, when undertaken in the immediate setting, the total operative time and hospital length of stay is significantly shorter in comparison with replantation or toe transfer. Subsequent procedures such as flap division and revision surgery, primarily for debulking, are outpatient procedures. When compared with other options such as metacarpal lengthening, this technique obviates the need for frequent outpatient visits and long-term distractor use.[16] Because the first stage of definitive reconstruction is performed at the time of injury, this technique may help patients achieve an accelerated timeline for regaining function and returning to work or hobbies.

METHODS

This is a case series involving all patients who sustained unreplantable thumb amputations and underwent immediate osteoplastic thumb reconstruction with bone autograft by the senior author from September 2016 through August 2018. After receiving institutional review board approval, data was collected and included patient demographics and comorbidities, intraoperative details and clinical outcomes.

The primary indication for this procedure was thumb amputation with significant crush or avulsion component that is unsuitable for replantation. These previously mentioned reasons include severe crush/avulsion injury, a lack of a microsurgical team or specialized equipment, patient instability, underlying medical comorbidities, or immediate intraoperative failure of replantation. When the bone from the injured thumb is unavailable due to comminution or multilevel injuries, this technique may still be used for thumb reconstruction in the setting of multidigit injuries if a revision amputation is indicated for one of the other digits—autologous bone graft is harvested from the spare parts. A relative indication for this technique is amputation of the thumb at or proximal to the IP joint level with significant soft tissue loss, requiring locoregional flap coverage. This procedure was reserved for patients with amputations proximal to this level as distal third thumb defects do not generally need additional bony length for functional purposes, although specific patient factors should be taken into account.[17]

Contraindications include insufficient autologous bone graft and patients unable to tolerate either multiple or prolonged procedures, altered mental status, developmental delay, or significant psychiatric comorbidites, as these patients may not be able to tolerate the

Takeaways

Question: In which clinical situations is osteoplastic thumb reconstruction an appropriate reconstructive option, and what are the expected outcomes?

Findings: Osteoplastic thumb reconstruction provides a solution for thumb reconstruction in patients who are not good candidates for replantation due to their comorbidities or pattern of injury, or in institutions without microsurgical capabilities. This method can result in a considerable stable increase in thumb length when compared with revision amputation.

Meaning: Osteoplastic techniques provide a safe and effective method of thumb reconstruction in settings where replantation is not appropriate.

postoperative immobilization required until flap division. Relative contraindications include a BMI more than 35, as this will create an unacceptable aesthetic result due to excess soft tissue and significant contamination, requiring multiple debridements. In all patients undergoing attempted thumb replantation, consent for a possible immediate groin flap reconstruction was obtained.

DESCRIPTION OF TECHNIQUE

The groin flap receives its blood supply from the superficial circumflex iliac artery (SCIA), a branch of the superficial femoral artery (Fig. 1). This vascular pedicle is located two fingerbreadths inferior to and runs parallel to the inguinal ligament. Importantly, as the artery travels laterally, the SCIA penetrates the deep fascia and transitions from a subfascial plane to a suprafascial plane near the lateral border of the sartorius muscle. The portion of the flap that is medial to the lateral border of the sartorius muscle must be raised in a subfascial plane to ensure that this pedicle is elevated with the flap. The lateral femoral cutaneous nerve may be encountered around the anterior superior iliac spine, and should be identified and preserved if possible.

An indwelling peripheral nerve catheter (PNC) is placed preoperatively, targeting the brachial plexus of the affected extremity, and all cases are performed under general anesthesia. The patient is positioned supine with the upper extremity on a hand table. The injured hand is thoroughly irrigated, and critical structures are identified. The amputated thumb is explored on the back table.

If the amputated thumb is deemed unsuitable for replantation, bone autograft is harvested from the injured tissue, and all overlying soft tissue, including periosteum, is removed to encourage revascularization of the bone graft by the groin flap. The distal tip of bone is positioned in slight flexion to simulate a pinch grip, and arthrodesis is performed with 24-gauge 90-90 interosseous wiring for fixation (Fig. 2). The bone autograft may be taken from the amputated portion of the thumb or, in cases of multidigit injuries, an adjacent unsalvageable digit.

If the level of the amputation is close to a joint, even if the cartilage surfaces on both sides of the joint are preserved,
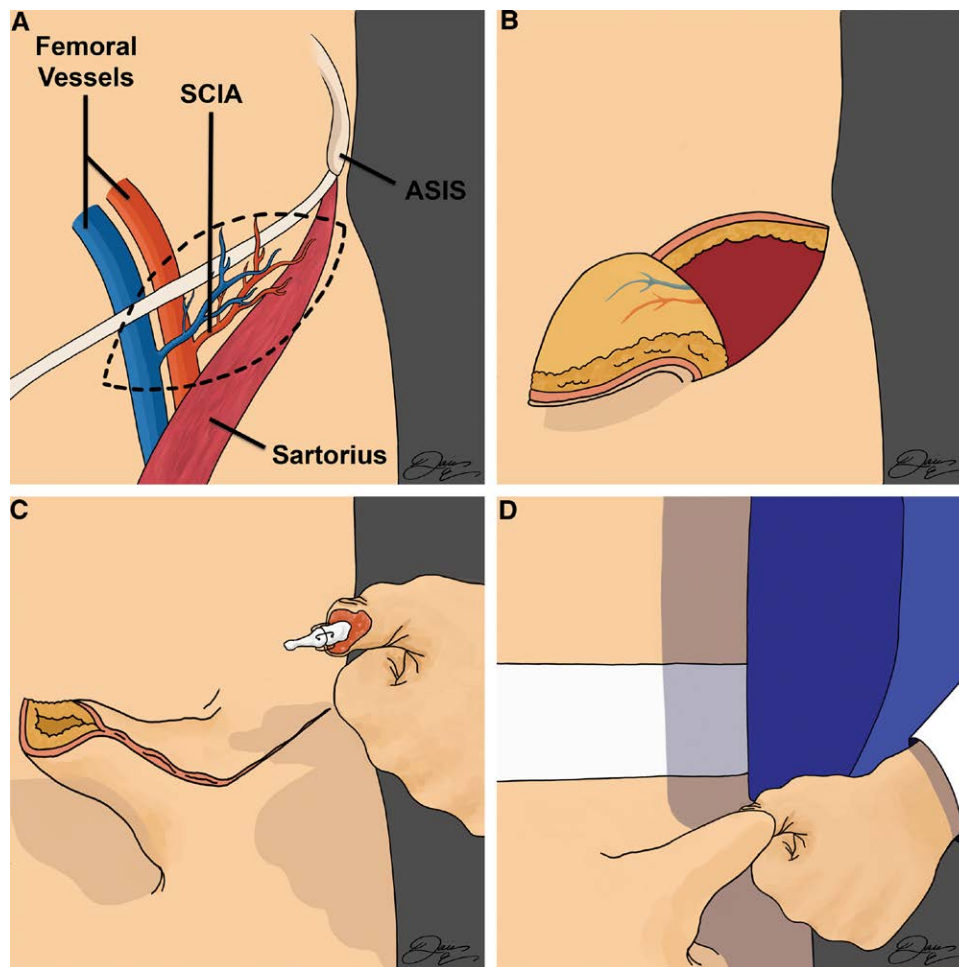
Fig. 1. Operative technique. A, The groin flap is supplied by the superficial circumflex iliac artery, which arises from the femoral artery. A Doppler is used to identify the pedicle, located below the inguinal ligament and medial to the sartorius muscle. B, The flap is raised in a lateral-to-medial fashion to ensure inclusion of the vascular pedicle. C, Bony fixation of the thumb is achieved with 90-90 interosseous wiring, and the exposed bony construct is inset into the tubularized flap. D, A custom splint is worn at all times to protect the flap and immobilize the extremity in slight shoulder abduction until flap division.

we remove the intact cartilage surfaces in preparation for a joint fusion. Our previous experience with osteoarticular grafts involving the entire joint has not been favorable, often resulting in early development of joint space narrowing and painful arthritis, leading to subsequent joint fusion for pain relief. Consequently, we now proceed directly to joint fusion. Furthermore, if two pieces of autologous bone graft are used in series to achieve greater thumb length, an additional Kirshner wire is placed in addition to the interosseous wires to provide more structural rigidity (Fig. 3).

Soft tissue coverage over this bony construct is provided by a pedicled groin flap. A Doppler is used to identify and mark out the course of the ipsilateral SCIA vascular pedicle inferior to the inguinal ligament. The skin is pinched to determine the maximal width of flap that can be harvested while achieving primary closure of the donor site, and an obliquely oriented, elliptical skin paddle is marked centered over the axis of the SCIA vascular pedicle. Flap harvest begins at the superomedial portion, as the deep fascia is much easier to identify at this location. Incision

is made at the superomedial part of the flap marking, followed by dissection using electrocautery down until the deep fascia is visualized. Once the deep fascia has been identified, the superomedial skin incision is extended laterally to the lateral tip of the flap marking. Staying in the suprafascial plane, dissection is carried along the entire superior border, from medial to the lateral extent of the flap marking; this elevates the lateral (distal) portion of the flap near the flank area. As dissection proceeds laterally toward the flank area (distal part of the flap), the deep fascia may become indistinct and difficult to see. In that scenario, one should dissect and maintain the same flap thickness as that of the superomedial part of the flap. Once the distal part of the flap has been elevated, the direction for dissection reverses, and proceeds from lateral to medial along the inferior marked border of the flap. As dissection proceeds from lateral to medial, one continues to stay in the same suprafascial plane until the lateral border of the sartorius muscle is encountered at the level of the anterior superior iliac spine.
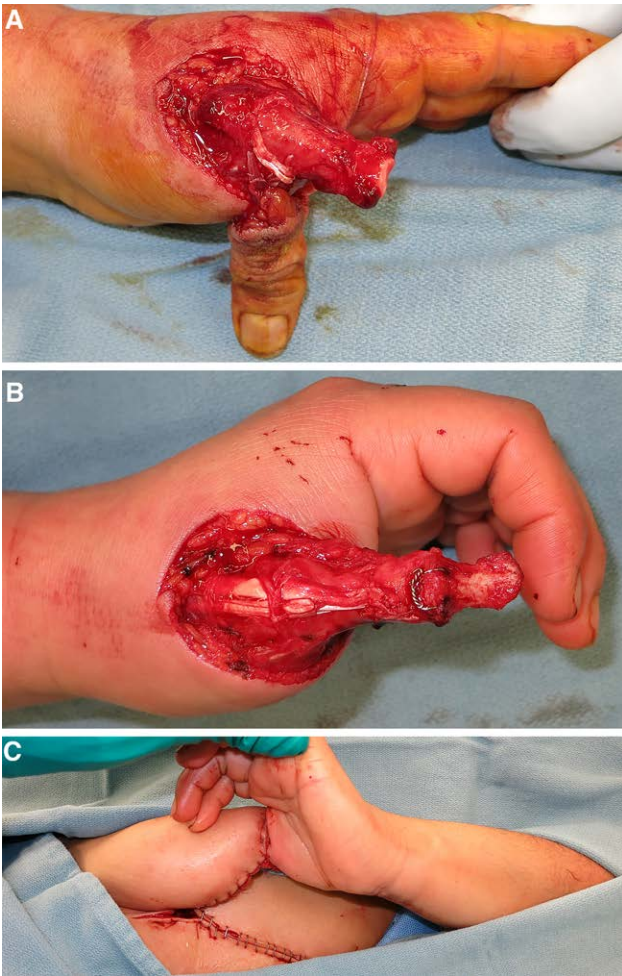
Fig. 2. Intraoperative photographs during immediate osteoplastic reconstruction. A, Patient (case 2) presented with a dysvascular left thumb secondary to avulsion, notable for significant soft tissue loss from the proximal phalanx. B, The distal phalanx served as bone autograft for reconstruction, and fixation was performed with interosseous wiring. C, The bony construct was inset into a tubularized, pedicled groin flap with primary closure of the groin donor site.

At this point, one should determine if the elevated portion of the groin flap is adequate to provide complete soft tissue coverage for the osteoplastic thumb. If the flap is sufficient, no additional flap dissection is necessary. However, if the elevated portion of the flap is unable to cover the entire osteoplastic thumb construct, then flap dissection must be continued medially. Upon identifying the lateral edge of the sartorius, the deep fascia covering the sartorius muscle is incised at this lateral border, and the dissection continues medially in a subfascial plane to ensure inclusion of the pedicle with the flap. The flap dissection is continued until sufficient length is attained.

Once adequate length of flap has been elevated, the donor site is then closed first. The groin flap donor site is closed in multiple layers. Closure near the proximal, medial portion, at the base of the flap near the vascular pedicle, is done loosely, and often left with a small, open area to prevent compression of the vascular pedicle. This open area also allows fluid from the groin flap donor site to drain out spontaneously, and therefore no drain is routinely placed in the donor site.

Once the groin flap donor site has been closed, the flap is then tubularized along its long axis, and the osteoplastic thumb construct is buried within the tubularized flap. The tubularized flap is inset to the hand using horizontal mattress, 4-0 braided, absorbable sutures. We prefer braided sutures here because they are softer and less irritating for patients, as the exposed suture ends lie in the sensitive groin area. Additionally, absorbable sutures are easier to remove after 4 weeks at the time of flap division because many sutures may become buried and difficult to visualize by that time, and incomplete removal of absorbable sutures will be inconsequential.

At the end of the case, an abdominal binder is placed around the patient's trunk and affected extremity to keep the arm adducted during emergence from general anesthesia. It is the senior surgeon's preference to leave the indwelling PNC in place as well to provide regional analgesia and decrease opioid requirements and their side effects.[18] It also has the secondary effect of weakening/ paralyzing the affected arm to prevent avulsion of the osteoplastic thumb inset from the groin flap in the immediate postoperative period.

The flap is divided after 4 weeks. At the time of the flap division, an attempt is made to divide the groin flap as proximal to the groin as possible while allowing primary closure of the groin donor site. This ensures that the portion of the flap covering the osteoplastic thumb has adequate laxity to achieve primary closure as well without tension. It is important to ensure that the closure over the osteoplastic thumb heals without wound dehiscence or wound complications, as wound breakdown can potentially lead to infection of hardware or bone graft. The technique described is further illustrated in Video 1. (**See Video 1 [online],** which displays spare parts principle for length augmentation in cases of multidigit injuries. Final outcome of patient (case 3) using his reconstructed thumb is shown.)

POSTOPERATIVE MANAGEMENT

Occupational therapy is consulted to fashion a custom splint to immobilize the arm at the patient's side, positioned in slight abduction to prevent kinking of the flap pedicle. Patients work with occupational therapy to learn how to remove the splint and put it back on. Patients also work with physical therapy on transfers and mobility until they become accustomed to the new arm position. The indwelling PNC is maintained throughout the hospitalization until they have cleared both physical therapy and occupational therapy, at which time the PNC is removed and they are discharged on oral medications.

Because these injuries are typically seen in contaminated, traumatic scenarios, patients begin taking oral antibiotics immediately after surgery to minimize the risk of osteomyelitis. Current antibiotic guidelines in lower extremity open fractures support the use of antibiotics until 24 hours after soft tissue coverage in grade I and II injuries.[19] For these open upper extremity injuries, the

Fig. 3. Stable fixation for long bone grafts. A, B, Patient (case 1) presented with bilateral hand crush injuries, including left thumb amputation at the metacarpal level. C, Two pieces of bone were harvested from unsalvageable digits of the contralateral hand to reconstruct the left thumb. An additional 0.054-inch Kirshner wire was placed to enhance structural support for the long construct. D, Fusion of the bony construct was stable after removal of all hardware.

senior author's preference is doxycycline, 100 mg twice daily, continued until after flap division and healing. Doxycycline was chosen for its ability to penetrate the bone and to cover community-acquired methicillin-resistant *Staphylococcus aureus.*

After the planned groin flap division surgery at 4 weeks, the osteoplastic thumb is protected with a thermoplast thumb spica splint. The remaining fingers are allowed to range as tolerated, and patients may carry up to five pounds of weight with their unaffected fingers, as well as weight bear as tolerated through the forearm while wearing the thumb spica splint. Radiographs are taken every 2 or 3 months until bone fusion is visualized, at which point the splint is discontinued. Any subsequent flap debulking is delayed for at least 3 months after flap division to ensure

viable soft tissue coverage, and to more accurately assess the extent of debulking required.

RESULTS

Five patients underwent immediate osteoplastic thumb reconstruction during the time period and were included in this case series. Patient characteristics can be found in Table 1.

Total operative time for the initial osteoplastic reconstruction averaged 158 minutes (range 96–290 minutes); operative time for patients with isolated thumb injuries was shorter compared with that of patients who sustained multidigit injuries (average 116 versus 222 minutes, respectively).

5

Table 1. Patient Characteristics and Reconstructive Outcomes

			Patient Characteristics				Reconstructive Outcomes		
	Age	Gender	Mechanism of Injury	Additional Hand Injuries	Dominant Thumb?	Medical Comorbidities	Residual Thumb Length after Injury (cm)	Reconstructed Thumb Length (cm)	Gain in Thumb Length (cm)
1	26	Masculine	Crush from industrial press	Ipsilateral small finger amputation; contralateral thumb, ring, and small finger amputations	No	Tobacco use	3.0	10.7	7.7
2	29	Feminine	Avulsion from crab cleaning machine	None	No	None	5.8	7.6	1.8
3	64	Masculine	Avulsion from apple conveyor belt	Ipsilateral index, middle, and ring finger amputations	No	Hypertension; tobacco use	0.8	4.3	3.5
4	55	Masculine	Saw	None	Yes	Hypertension	7.1	8.0	0.9
5	79	Masculine	Avulsion due to roping injury	None	Yes	Hyperlipidemia, benign prostatic hyperplasia	6.6	9.4	2.8

The estimated blood loss was minimal in all cases, and no patients required a blood transfusion as a result of surgery. After reconstruction, patients remained hospitalized for an average of 3.2 days (range 1.7–5.1 days) before being discharged. In addition to flap division surgery, patients underwent an average of 1.2 revision procedures (range 0–2), primarily for debulking and hardware removal.

All patients had a minimum of 12 months of follow-up (average 19.7 months, range 12.1–33.5 months). When measuring from the metacarpal base, the average bony length of the residual thumb was 4.7 cm on initial postinjury radiographs. The total length of the reconstructed thumb averaged 8.0 cm, representing an average gain in length of 3.3 cm compared with the maximum anticipated length with revision amputation at the time of injury. Clinical outcomes following osteoplastic reconstruction were stable over at least 1 year of follow-up despite radiographic evidence of mild bone resorption, primarily tapering (Fig. 4), with acceptable aesthetic appearance and function with the final length achieved (Fig. 5). In terms of functional status, one patient remained retired postoperatively; one patient's work status is unknown, and one patient suffered posttraumatic stress disorder related to the injury and was unable to return to work despite being physically optimized. The other two patients reached maximal medical improvement under the senior surgeon's care and sought an independent medical examination.

Despite being limited in the quantity of bone available from spare parts, particularly in isolated thumb injuries, we have been successful in achieving modest gains in length in all cases. Although some of our patients have had revisions, none have undergone additional reconstruction. In the case that our patients desire or request additional reconstruction at a later date, all standard reconstructive options remain viable possibilities.

There were no major complications within our series. One patient had malunion and required a corrective osteotomy to bring the thumb tip into flexion. One had surgical site cellulitis, which was resolved with oral antibiotics, and one patient required revision fixation due to hardware failure.

DISCUSSION

Traditional osteoplastic reconstruction requires three steps: (1) two-stage pedicled groin flap to achieve stable soft tissue coverage, (2) bone grafting to restore bone length, and (3) neurosensory island flap to provide sensation at the thumb tip. By utilizing a pedicled groin flap to cover amputated bone that would otherwise be discarded, our technique achieves the first two steps of osteoplastic thumb reconstruction in a single stage, at the time of injury. The third step, involving sensory reconstruction for the pinching surface of the reconstructed thumb, is important for thumb dexterity and for prevention of extensive bone resorption. With an insensate thumb, patients may exert more excessive pressure during use, which may lead to gradual bone resorption near the distal end of the bone graft. Because our described technique is
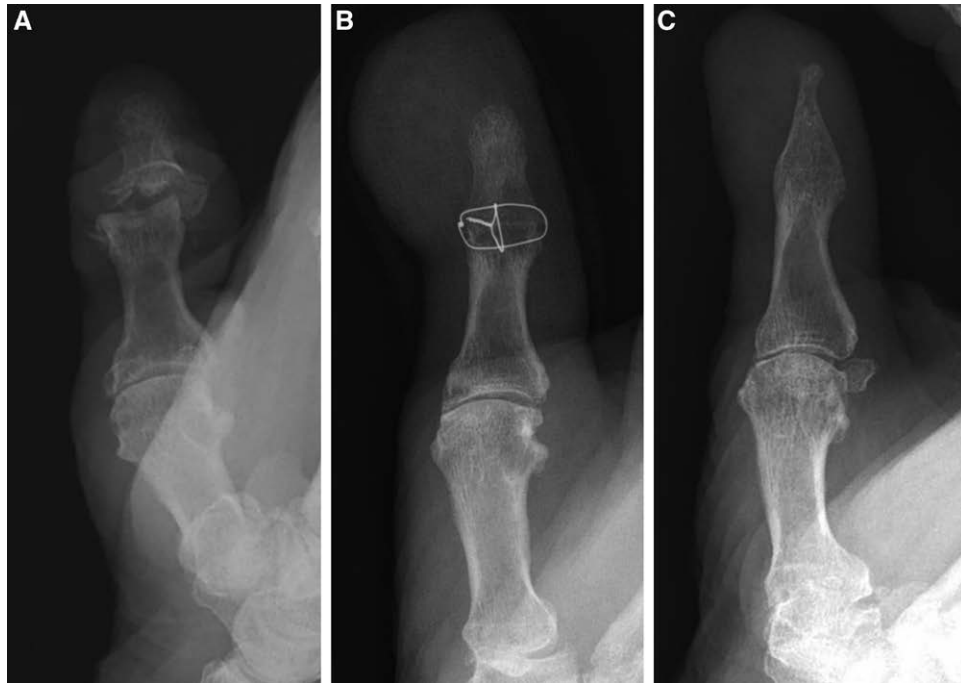
Fig. 4. Posteroanterior and lateral radiographs demonstrating stable results after injury and osteoplastic reconstruction. Images were taken preoperatively at the time of injury (A), at the first postoperative visit after flap division approximately 6–7 weeks after initial reconstruction (B), and at 1 year of follow-up (C).
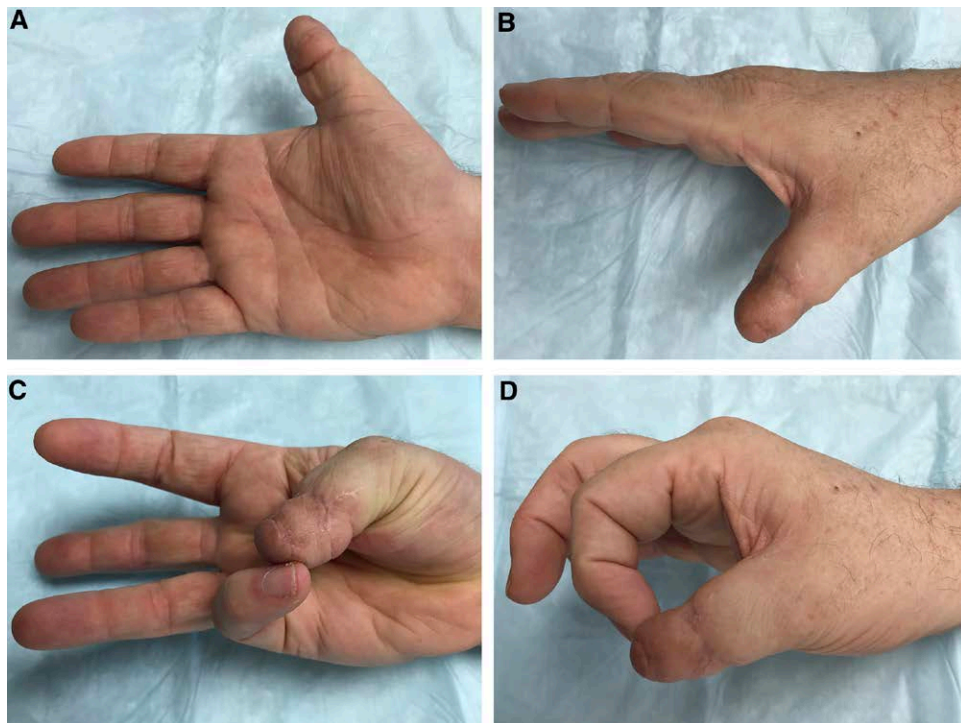

Fig. 5. Aesthetic and functional outcomes after immediate osteoplastic thumb reconstruction. A, Final aesthetic appearance of the reconstructed thumb was acceptable. Overall hand function with the thumb length resulting from immediate osteoplastic reconstruction was preserved for abduction with maintenance of the first webspace (B), opposition to the small finger (C), and pinch (D).

not a sensate thumb reconstruction, we expect the degree of long-term bone resorption in our patient population to be higher than published reports in which bone autograft is combined with sensate soft tissue coverage.[16,20] Although we have observed only mild bone resorption on radiographs at 1 year, our patients have not reported any notable changes in thumb function or appearance. As this is a retrospective series, we do not have bilateral hand X-rays or measurements, which would be useful in comparing the affected with the unaffected side. This would be a useful metric to obtain in further studies. Although we feel that sensory reconstruction using a pedicled neurosensory island flap or a great toe wraparound flap would provide the best functional thumb reconstruction, none of the patients in our series desired additional surgery when such reconstructive options were discussed and offered.

CONCLUSIONS

This case series illustrates that osteoplastic thumb reconstruction in the immediate setting is a safe, reliable alternative for restoring length when replantation is not feasible. Advantages of this approach include short operative time and hospital length of stay, straightforward reproducible technique without the use of microsurgery, utilization of spare parts, minimal donor site morbidity, and an accelerated path to definitive reconstruction.

Dennis S. Kao, MD
9500 Euclid Ave
Cleveland, OH 44195
E-mail: dsjkao@gmail.com

REFERENCES

1. Emerson ET, Krizek TJ, Greenwald DP. Anatomy, physiology, and functional restoration of the thumb. *Ann Plast Surg*. 1996;36:180–191.
2. Pet MA, Ko JH, Vedder NB. Reconstruction of the traumatized thumb. *Plast Reconstr Surg*. 2014;134:1235–1245.
3. Adani R, Corain M, Tarallo L, et al. Alternative method for thumb reconstruction. Combination of 2 techniques: metacarpal lengthening and mini wraparound transfer. *J Hand Surg Am*. 2013;38:1006–1011.
4. Al-Qattan MM, Al-Qattan AM. Defining the indications of pedicled groin and abdominal flaps in hand reconstruction in the current microsurgery era. *J Hand Surg*. 2016;41:917–927.
5. Del Piñal F, Pennazzato D, Urrutia E. Primary thumb reconstruction in a mutilated hand. *Hand Clin*. 2016;32:519–531.
6. Graham DJ, Venkatramani H, Sabapathy SR. Current reconstruction options for traumatic thumb loss. *J Hand Surg Am*. 2016;41:1159–1169.
7. Heitmann C, Levin LS. Alternatives to thumb replantation. *Plast Reconstr Surg*. 2002;110:1492–503; quiz 1504.
8. Henry SL, Wei FC. Thumb reconstruction with toe transfer. *J Hand Microsurg*. 2010;2:72–78.
9. Parmaksizoglu F, Beyzadeoglu T. Composite osteocutaneous groin flap combined with neurovascular island flap for thumb reconstruction. *J Hand Surg Br*. 2003;28:399–404.
10. Song D, Xu J, Lv H, et al. Wraparound chimeric radial collateral artery perforator flap for reconstruction of thumb loss. *J Reconstr Microsurg*. 2015;31:95–101.
11. Segu SS, Athavale SN, Manjunath P. Osteoplastic reconstruction for post traumatic thumb amputations around metacarpophalangeal joint. *J Clin Diagn Res*. 2015;9:PC11–PC13.
12. Neumeister MW, Brown RE. Mutilating hand injuries: principles and management. *Hand Clin*. 2003;19:1–15, v.
13. Peng YP, Lahiri A. Spare-part surgery. *Semin Plast Surg*. 2013;27:190–197.
14. Salah MM, Khalid KN. Thumb reconstruction by grafting skeletonized amputated phalanges and soft tissue cover - a new technique: A case series. *Cases J*. 2008;1:22.
15. Küntscher MV, Erdmann D, Homann HH, et al. The concept of fillet flaps: classification, indications, and analysis of their clinical value. *Plast Reconstr Surg*. 2001;108:885–896.
16. Hahn SB, Park HJ, Kang HJ, et al. Finger reconstruction with a free neurovascular wrap-around flap from the big toe. *J Reconstr Microsurg*. 2001;17:319–323.
17. Muzaffar AR, Chao JJ, Friedrich JB, et al. Posttraumatic thumb reconstruction. *Plast Reconstr Surg*. 2005;116:103e–122e.
18. Richman JM, Liu SS, Courpas G, et al. Does continuous peripheral nerve block provide superior pain control to opioids? A meta-analysis. *Anesth Analg*. 2006;102:248–257.
19. Hoff WS, Bonadies JA, Cachecho R, et al. East practice management guidelines work group: update to practice management guidelines for prophylactic antibiotic use in open fractures. *J Trauma*. 2011;70:751–754.
20. Yang K, Zhao Z, Pan Y, et al. Resorption of iliac bone grafts following wrap-around flap for thumb reconstruction: a follow-up study. *J Hand Surg*. 2020;45:64.e1–64.e8.