



Distraction lengthening of the proximal phalanx in distal thumb amputations

Eren CANSÜ¹, Mehmet Bekir ÜNAL², Fatih PARMAKSIZOĞLU³, Serkan GÜRCAN⁴

¹Marmara University Faculty of Medicine, Department of Orthopaedics and Traumatology, İstanbul, Turkey

²Medipol University Faculty of Medicine, Department of Orthopaedics and Traumatology, İstanbul, Turkey

³Yeni Yüzyıl University Faculty of Medicine, Department of Orthopaedics and Traumatology, İstanbul, Turkey

⁴Medistate Hospital Kavacık, Department of Orthopaedics and Traumatology, İstanbul, Turkey

Objective: Thumb amputation is a major cause of hand dysfunction, and the treatment for distal thumb amputations remains controversial. Although finger reconstruction methods using distraction lengthening are known to restore finger length and function, we found no reports in the literature regarding phalangeal lengthening in thumb amputations. We aimed to evaluate proximal phalangeal lengthening in thumb amputations at or near the interphalangeal (IP) joint.

Methods: We retrospectively evaluated patients who had undergone distraction lengthening of the proximal phalanx of the thumb. All patients underwent osteotomy, either during the initial procedure or as a second-stage procedure. Distraction began 10 days after osteotomy with the use of an external fixator that remained in place until ossification of the gap occurred without bone grafting. Patients were evaluated using the QuickDASH score.

Results: Fourteen patients with a mean age of 27 years and a mean follow-up period of 7 years were enrolled. The mean phalangeal lengthening achieved was 20 mm. Ossification occurred at all distraction sites, and the fixators were maintained for a mean of 85 days. The mean healing index was 42.5 days/cm. All 14 patients achieved the desired amount of phalangeal lengthening without major complications such as nonunion, premature union, or gross infection.

Conclusion: For reconstruction in cases of distal thumb amputations, distraction lengthening of the proximal phalanx can be used to improve absolute length, web space, and grip distance. The technique is safe and effective, improves functionality/cosmesis, and offers a low complication risk.

Keywords: Distraction lengthening; phalangeal lengthening; thumb amputation; thumb lengthening; thumb reconstruction.

Thumb amputations create significant hand dysfunction, and morbidity is higher with when the amputation level is more proximal. From simple local procedures to complex microsurgical operations, many reconstructive

procedures and techniques have been reported for every amputation level.

Treatment of thumb amputations at or near the interphalangeal (IP) joint remains controversial. Primary

Correspondence: Eren Cansü, MD. Marmara Üniversitesi Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, İstanbul, Turkey.

Tel: +90 532 – 274 25 56 e-mail: erencansu@hotmail.com

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closure, advancement or island flaps, and deepening of the first web are some of the reconstructive procedures that are now being used.

Although the first metacarpal is a more common lengthening site for thumb reconstruction, lengthening of the proximal phalanx of the thumb has not been widely mentioned in the literature. It was first presented by Matev as a single case report.^[1] However, to our knowledge, there has been no specific research on phalangeal lengthening in thumb amputations. For this level of thumb amputation, we prefer to lengthen the proximal phalanx if the amputated part is not suitable for replantation, or if the replantation attempt fails. Accordingly, to assess procedure outcomes, we analyzed the data for consecutive patients with thumb amputations who underwent distraction lengthening of the proximal phalanx.

Patients and methods

Between December 2001 and June 2012, we treated 14 patients (13 men, 1 woman; mean age; 27 years, range: 18–43 years) who had sustained thumb amputations at or near the IP joint level with distraction lengthening of the proximal phalanx (Table 1). All were manual laborers who had sustained their injuries during industrial accidents. The amputation level varied from the base of the distal phalanx to the middle of the proximal phalanx (Figure 1). Osteotomies were performed during the initial procedure in 8 patients (Figure 2) and as a second-stage procedure in 6 patients.

Before surgery, all patients were provided with a

complete explanation of the risks, benefits, limitations, and potential complications of amputation, osteotomy, distraction lengthening, and alternative procedures, as well as the expected outcomes of the procedures. All provided written acknowledgment of the explanation and of their consent to undergo the procedures.

Osteotomies were performed through a longitudinal mini-incision lateral to the extensor tendon, through a periosteal window, without cutting the periosteum. Before the osteotomy, mini-Schanz pins were inserted percutaneously under fluoroscopy. We cut the bone with an osteotome after drilling multiple times with a Kirschner wire or an oscillating saw. After verifying that the osteotomy was complete, we constructed the distraction device. We used a unilateral miniature distraction device (TST®-Turkey) with 2 mini-Schanz pins for each fragment. A shorter bone stump could be osteotomized by inserting 1 of the proximal mini-Schanz pins into the base of the proximal phalanx and the other into the first metacarpal head.

Ten days after the osteotomy, we began the distraction at an interval of 1 mm/day (2×0.5 mm), stopping when the desired length was achieved (Figure 3a). The middle of the contralateral distal phalanx was the goal for the maximum lengthening level (Figure 3b); in addition, we decided on a maximum elongation gap of 100% of the remaining bone. When the elongated callus matured, the distraction device was extracted without the need for anesthesia. The patients' functional statuses were evaluated using the QuickDASH score.^[2,3]

Table 1. Patient data.

No.	Sex	Age	Side	Level	PP length (mm)	Elongation (mm)	EFT (day/cm)	Healing index	Operation	F-Up
1	Male	28	Right	IP	33	18	81	45	Secondary	12
2	Male	34	Right	DP	32	20	89	45	Secondary	11
3	Male	23	Left	DP	30	19	84	44	Secondary	11
4	Male	18	Right	DP	31	17	73	43	Secondary	10
5	Male	35	Left	IP	29	18	79	44	Primary	9
6	Male	21	Left	IP	27	20	82	41	Primary	8
7	Male	29	Right	IP	30	20	87	44	Primary	8
8	Male	24	Left	DP	32	18	75	42	Secondary	7
9	Male	20	Right	PP	20	24	113	47	Primary	6
10	Male	43	Left	PP	25	26	104	40	Secondary	5
11	Female	23	Right	IP	29	20	82	41	Primary	4
12	Male	31	Right	DP	30	19	76	40	Primary	3
13	Male	21	Left	PP	27	22	89	41	Primary	3
14	Male	27	Right	DP	31	20	78	39	Primary	1

PP length, length of the proximal phalanx; EFT: External fixator time; Op.: Operation; F-Up: Follow-up (years); IP: Interphalangeal joint; DP: Distal phalanx; PP: Proximal phalanx.

Results

The mean follow-up period was 7 years (range: 1–12 years). In 6 patients, the stumps were reconstructed with local flaps (using a neurovascular island flap from the ulnar side of the middle finger in 2 patients) or closed during the primary procedure. When there was not enough healthy soft tissue to close the wound during the primary procedure, we used local flaps to avoid excessive bone shortening. After the soft tissues healed in those 6 patients, we performed the osteotomy and lengthening as a second-stage procedure. For the remaining 8 patients, the lengthening procedure was performed as part of a single-stage procedure in which the soft tissues were treated at the same time (Figure 2). The mean amount of lengthening of the phalanges was 20 mm (range: 17–26 mm).

In all patients, we maintained the external fixator in place until ossification occurred, and we did not perform any bone-grafting procedures. All distraction sites ossified. The mean time from osteotomy to the extraction of the distraction device was 85 days (range: 72–113 days).

There were no instances of nonunion, malunion, premature union, fracture of the elongated callus, or gross infection necessitating the early removal of the pins. There was 1 instance of pin-tract infection, which was treated with local care and oral antibiotics. We observed thinning of the proximal phalanx in 2 patients and protruding proximal phalanx condyles in 1 patient. There was no soft-tissue breakage at the tip of the phalanx

during or after the lengthening procedure in any patient. All patients had good results from the lengthening procedure in terms of the pain level and discomfort, and all patients were compliant. There were no requests for distraction discontinuation before the desired amount of lengthening was achieved. A study limitation may be that we did not evaluate pinch strength or metacarpophalangeal joint movements in these patients. The average QuickDASH score was 1.62 (range: 0–6.8).

Discussion

The thumb accounts for nearly 40% of hand functions, and amputation below the IP joint level results in marked limitations in function. Opposition is the distinctive movement of the thumb. Proper thumb length along with thumb stability, strength, and mobility are major requirements for thumb opposition.^[4] The carpo-metacarpal joint plays a major role in thumb movements, and adequate function can be preserved despite a lack of mobility in the metacarpophalangeal and IP joints. However, sensation is another issue that must be addressed to allow thumb functionality.

Although there may be different procedure options for thumb reconstructions, replantation is always the first choice because it results in the best functionality with an almost-normal appearance, as reported by many authors.^[4–6] However, when replantation is not appropriate or if replantation attempts fail, many alternative procedures can be considered depending on the ampu-



Fig. 1. Loss of the distal phalanx.



Fig. 2. During primary closure of the wound, an external fixator was applied after the osteotomy of the proximal phalanx. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

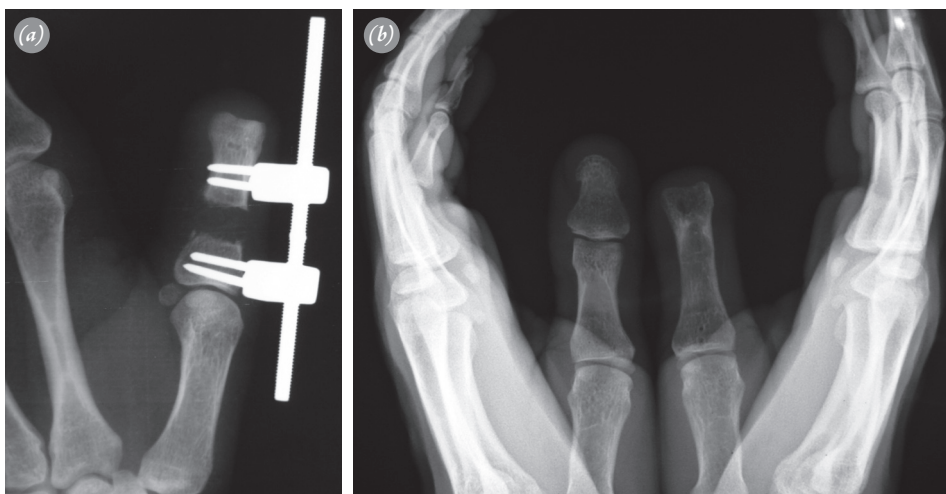


Fig. 3. (a) Lengthening of the distal phalanx was initiated 10 days after the osteotomy; it was continued until the tip of the proximal phalanx reached the middle of the opposite distal phalanx. (b) The acquired osseous length after full consolidation of the gap, as seen in this radiograph at the final follow-up evaluation.

tation level. These procedures include revision amputations, the use of simple local flaps, and other complex and demanding microvascular operations such as free toe transfers;^[7] each of these procedures has its own advantages and disadvantages.

After a distal thumb amputation, the decision about the reconstruction method and even the need for reconstruction remain controversial.^[4,7,8] Some surgeons choose primary wound closure, whereas others prefer to use various types of local flaps, especially when there is extensive tactile surface loss. Some may suggest that no lengthening is needed when the distal phalanx of the thumb is lost. However, there has been a report of a 6-mm lengthening of the distal phalangeal stump of an amputated thumb,^[9] and others prefer to use even more complex techniques such as toe or partial-toe transfers for this amputation level.^[10] We believe that patients should be given information about the various options available for restoring thumb length.

Because length is of prime importance for opposability of the thumb, restoring length ameliorates difficulties with both function and cosmesis by absolute deepening and widening of the first web space (Figure 4). Lengthening the bones of the hand via distraction is a widely-used method for both traumatic and congenital defects. After its first presentation by Matev in 1967,^[11] this method has been safely used by many hand surgeons for a variety of indications such as lengthening the stumps of distal phalanges or even replanted fingers.^[9,12-16] We find that this technique has many advantages:

i. It is easy to perform and has a short learning curve.

- ii.* It is inexpensive because it does not require microsurgery, expertise, or even special training; it also does not require special equipment such as microscopes or other micro-instruments.
- iii.* Unlike some other procedures, the duration of surgery for this procedure is short, and it can be done with local or regional anesthesia.
- iv.* In cases with multiple injuries, the technique can be applied to multiple fingers at the same time.
- v.* Although patients must wear a fixator for up to 3 months, they are still able to freely use their hands in daily life during the treatment.
- vi.* There is no donor-site morbidity because only local sources (bone and soft tissues of the individual finger) are used; this is a main advantage of this technique. These local sources have qualities similar to the lost tissues. The skin also provides original sensation and thus does not require cortical adaptation, as with use of an island flap, or microsurgical neurotomy, as with free tissue transfers.
- vii.* There is also no risk of losing the lengthened finger, as there is with toe transplantation.

The first metacarpal is historically the first site for distraction lengthening of the thumb.^[11] A common problem with first metacarpal lengthening is the elevation of the first web space base, which diminishes the effect of the procedure.^[17] This occurs because the intrinsic tendons of the thumb insert into the base of the proximal phalanx, a point which is distal to the osteotomy site.^[18] Therefore, additional surgery (deepening of the first web space and/

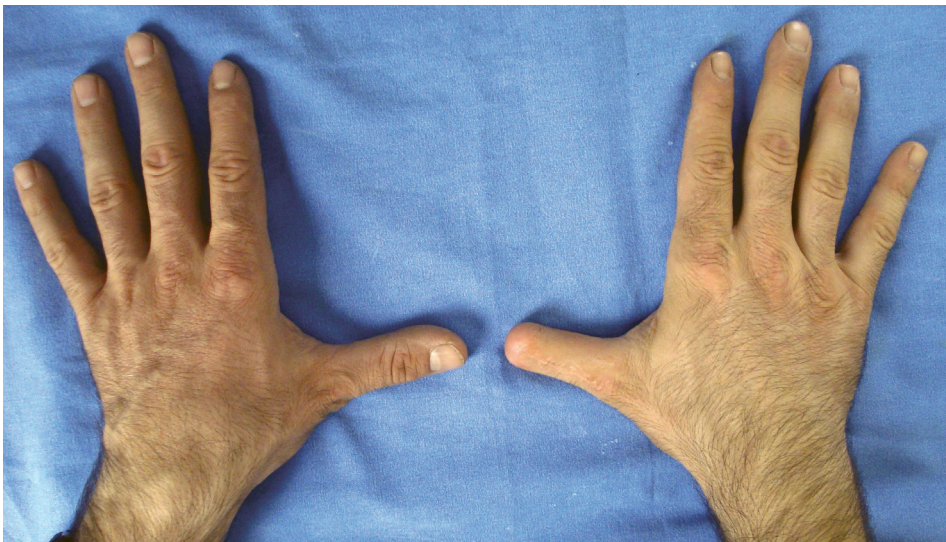


Fig. 4. Improved absolute deepening of the first web space, which was achieved by the distraction. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

or proximal transfer of the adductor pollicis brevis) may be required to alleviate this problem. Salom et al reported that they had performed deepening procedures for the first web in all cases and additional proximal transfers for the adductor pollicis brevis in 2 cases in their series of 6 patients who underwent first metacarpal lengthening.^[19] Finsen and Russwurm have treated 9 patients with first metacarpal lengthening after traumatic thumb amputations.^[20] In 6 of these patients, the proximal transfer of the adductor pollicis brevis and deepening of the first web were performed as an additional treatment.

With proximal phalangeal lengthening, however, there is no elevation of the base of the first web space, because the osteotomy site is distal to the insertions of the intrinsic tendons of the thumb.

Another drawback of first metacarpal lengthening in comparison with proximal phalangeal lengthening is that flexion contracture of the proximal phalangeal stump in the former.^[17, 20] To avoid this complication, the proximal phalangeal stump can be fixed to the first metacarpal or it can be integrated into the external fixator, as done by Finsen and Russwurm.^[20] We believe that lengthening the proximal phalanx may be more convenient if its length allows the mounting of an external fixator.

Another method involves osteoplastic reconstruction, in which a piece of bone from the iliac crest and surrounding skin are transferred to the amputation site. Resorption of the transferred bone is a well-known complication with this method, and the skin of the new thumb has no sensation.^[4]

The main disadvantages of distraction lengthening of the proximal phalanx are the overall procedure duration (nearly 3 months until solid bone consolidation is achieved) and the requirement that the patient wear a fixator during the entire process. If an osteotomy can be performed during the initial procedure, the total treatment time will be shortened, as it was for 8 of our 14 patients. Bone grafting of the gap is another option to decrease the treatment time. Although this allows the treatment to be completed several weeks earlier, it also carries the risks of another procedure: donor-site morbidity or graft-site nonunion. Similar to other surgeons, we prefer to leave the external fixator in place until the elongated callus matures.^[12,13,15,16] The absence of the thumb's nail may be an important cosmetic factor for some patients. These patients will also have some limitations in picking up thin objects.^[21]

Another issue associated with this method is the extent of lengthening required. According to Matev, although 100% lengthening is possible for the hand skeleton, the elongated thumb should be shorter than its normal counterpart to provide better function, because it lacks a joint.^[17] He has advised lengthening the injured thumb until it is equal in length to the middle of the uninjured thumb's distal phalanx. We have followed his suggestions for our lengthening procedures, setting a goal of allowing the most distal level of the injured thumb to reach the middle of the contralateral distal phalanx. For achieving the maximum elongation gap, we do not exceed 100% of the remaining bone so that we can avoid destroying its regeneration potential.

Finally, the possibilities and limitations of this method and of alternative procedures must be explained thoroughly to patients. Patients must be informed that there will be no joint or nail in the lengthened finger; these can be achieved only by replantation or with free toe transplantation. In a mentally healthy patient who is aware of these risks and benefits, this lengthening procedure may be done during the initial procedure. For other patients, making a decision may not be easy immediately after such an accident; therefore, it may be appropriate to give the patient some time, and to allow postponement of the procedure until the second procedure. Tolerating a fixator might be problematic for some patients at first. However, it has been our experience that most learn to function well with the fixator after education about its care and after they discover that they can function easily with it in daily life.

Conflicts of Interest: No conflicts declared.

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