Pollicization of Biphangeal Index Finger for Type IV Thumb Hypoplasia: A Case Report Describing Preoperative Planning, Intraoperative Decision-Making, and Technical Modifications

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Abstract

Background: Index finger (IF) pollicization is the standard treatment for severe congenital thumb hypoplasia. The procedure requires a supple and anatomically normal IF. No guidelines exist for IF pollicization in patients who have concomitantly underdeveloped IF, specifically when the digit has only 2 phalanges and 1 interphalangeal joint. **Methods:** We present a case of a 20-month-old boy with congenital type IV thumb hypoplasia who also had biphangeal IF. We proposed an IF pollicization operation that required significant modifications to the traditional procedure. **Results:** Preoperative planning and intraoperative execution are described. The modifications to the traditional procedure included: (1) removal of proximal third of IF metacarpal; (2) creation of a de novo thumb carpometacarpal (CMC) joint by fibrous union whereby the IF CMC joint cartilaginous components are maintained and the remaining distal IF metacarpal is translocated down and secured to this cartilage (in contrast to the traditional use of IF metacarpophalangeal joint as a de novo thumb CMC joint); (3) preservation of IF joints at their “natural” position and function; (4) maintenance of intrinsic muscles at their original distal insertion sites; and (5) important adjustments to skin incision. **Conclusions:** Pollicization of biphangeal IF can be executed in a safe and efficient manner. Early recovery has shown promising signs. Long-term results, including the de novo thumb CMC joint function, remain to be evaluated.

Keywords: pollicization, biphangeal index finger, congenital thumb hypoplasia, CMC suture fusion, metacarpal shortening

Introduction

Congenital thumb hypoplasia occurs in 1:100 000 births and can be a debilitating problem.¹ For severe forms of thumb hypoplasia, pollicization is the mainstay of treatment, in which the neighboring index finger (IF) is translocated and shortened to reconstruct a functioning ne thumb. Since its original description and several modifications, the pollicization procedure as detailed by Kozin is considered by many to be the standard approach.⁵ While highly successful and reproducible, the approach only applies to patients who have a relatively normal and functional IF. We present a case of a 20-month-old boy who had type IV thumb hypoplasia and a shortened, biphangeal IF. An IF pollicization approach was undertaken for this patient, but significant modifications had to be made to the traditional technique due to the abnormal anatomy of the IF. This report discusses preoperative planning, intraoperative decision-making, and technical execution of the case. The lessons learned are highly relevant for planning pollicization in the setting of abnormal, shortened IF.

Case Description

Patient History

A 20-month-old boy with an unknown genetic syndrome and multiple congenital anomalies was evaluated for thumb hypoplasia. He had previously undergone mandibular distraction for micrognathia, posterior cranial vault expansion for multisuture craniosynostosis, and cleft pal-

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Figure 1. Preoperative photographs of the patient's clinical presentation, demonstrating floating thumbs and biphthalangeal small and index fingers, bilaterally. Palmar views of the left (a) and right (b) hands are shown, as well as radial (c) and dorsoradial views (d) of the left hand. The left hand is the hand that underwent the operation described in the text.

ate repair. On examination, he had bilateral type IV thumb hypoplasia, with the “floating” thumbs attached to the proximal phalanges of the IF via a small skin bridge (Figure 1). The IFs also appeared reduced in size. Radiographs taken at 9 months of age demonstrated biphthalangeal IFs, compared with the normal triphthalangeal configuration of the long and ring fingers (Figure 2). Notably, the small fingers were also biphthalangeal.

Preoperative Planning and Considerations

In the conventional pollicization technique, the IF is not only translocated but also shortened to create a new thumb.⁵ Two osteotomies are typically performed: at the physis of IF metacarpal and at the base. The metacarpal shaft is then removed and the proximal and distal osteotomized segments are joined together, with the metacarpophalangeal (MCP) joint becoming a de novo thumb carpometacarpal (CMC) joint. To account for IF shortening, the first dorsal and palmar interossei muscles are disinserted from their

distal attachments and reinserted more distally into the IF proximal interphalangeal (PIP) joint, which becomes the de novo thumb MCP joint.

Unfortunately, this standard approach to pollicization could not be employed for our patient due to the shortened, biphthalangeal anatomy of the IF. If a standard pollicization were performed, the new thumb would lack an interphalangeal joint and would also be shorter than desired for optimal functional use. Alternatively, if the IF were not shortened at all, it would be too long as a thumb. In adduction, the tip of the normal thumb is 70% as long as P1 of the adjacent IF.⁴ In our patient, the tip of the IF extended almost up to the distal interphalangeal joint of the long finger. As such, our first challenge was to plan a pollicization procedure that achieved appropriate degree of IF shortening without loss of functional joints.

After reviewing the radiographs, we decided that the most logical way to shorten the pollicized digit was to remove the proximal third of the IF metacarpal. The MCP and interphalangeal (IP) joints of the IF would thus

Figure 2. Preoperative radiographs of the left hand taken at 9 months of age, showing hypoplastic thumb with no bony connection, absent first metacarpal, and biphalangal index finger and small finger anatomy.

become the MCP and IP joints of the neothumb, respectively. With regard to the CMC joint, the cartilaginous cap of the IF metacarpal base would be preserved, and the remaining distal two-thirds of the metacarpal would be approximated and fixated to this cartilaginous cap, essentially relying on fibrous union between these two components for healing.

Other factors were also considered. As the operative plan maintained the joints of the pollicized digit at their “natural” level (i.e., MCP IF to MCP thumb), the necessity of disinserting and reinserting the interossei muscles more distally was debated. We anticipated not having to disinsert them during the procedure but were prepared for both options. Because we typically do not shorten flexor or extensor tendons in a conventional pollicization, these were planned to be left alone as well. Finally, whether or not to release the A1 pulley to prevent buckling of flexor tendons was left for intraoperative decision-making.

Operation

Skin Incision and Flap Designs

Per parents’ preference, the left side was to be operated on first. Compared with the Kozin approach, we prefer a “racket”-type incision that tapers proximally into a dorsoradial v-shaped flap on the IF.⁵ Usually, another incision is then made at the apex of the dorsoradial v-shaped flap and extended proximally. After IF abduction and pronation, the corner of the dorsoradial v-flap fits into the most proximal end-point of this incision. In the case presented herein, we decided to adjust our skin incision slightly. There was no incision extending proximally from the apex of the dorsoradial v-flap; instead, another incision was made extending distally, creating a zigzag pattern and 2 v-shaped flaps (Figure 3). This was felt to better fit the current patient’s presentation

and the position of the future thumb, as the IF was being proximated into its new location. We envisioned that the proximally based v-flap would be utilized in closure of the webspace. The circular part of the “racket” curved around the IF base just proximal to the MCP flexion crease volarly, then into the index-middle finger webspace, and finally dorsally to connect with the dorsoradial v-flap of the IF. The floating thumb was planned to be excised via an ellipse incision.

Neurovascular and Interossei Dissection

After raising skin flaps, the ulnar proper digital nerve and artery to the IF were identified and dissected proximally to the common digital neurovascular bundle. The radial digital artery to the long finger was ligated, leaving the common digital artery attached to the ulnar digital artery of the IF. The transverse metacarpal ligament was divided. The first volar interosseous muscle was dissected off the shaft of the IF metacarpal and was left attached to the extensor mechanism.

Attention was then turned to the dorsal side of the hand. In this area, we were expecting to identify a single muscle belly of the first dorsal interosseous muscle. Instead, 2 muscle bellies were identified, possibly representing the thenar muscle remnants. These muscles were dissected off the metacarpal shaft to prepare for osteotomy and IF translocation. Based on intraoperative manipulation of structures, it was not felt necessary to divide the A1 pulley for prevention of flexor tendon buckling.

Index Metacarpal Osteotomy and Repositioning

The IF metacarpal was shortened as follows. Because the IF and ring finger (RF) are usually of similar length, we measured the distance from the RF tip down to the physis of the RF metacarpal neck (labeled distance *x*; Figure 4) as

Figure 3. Intraoperative markings.

Figure 4. Schematic representation of the operative planning for shortening the index finger (IF). Distance x is the distance from the tip of the ring finger to the physis of the fourth metacarpal neck. Distance y is the distance from the tip of the IF to the base of the second metacarpal. Distance $z = y - x$ is the amount of IF shortening that we performed, taking bone from the proximal part of the metacarpal.

an approximation of the length of the de novo thumb. The distance from the tip of the patient's IF to the metacarpal base was also measured (labeled distance y ; Figure 4). The difference $z = y - x$ then became the planned amount of IF that needed to be removed to shorten the IF for de novo thumb. It measured approximately 6 mm. Accordingly, an osteotomy was made 6 mm distal to the base of the metacarpal with the aid of intraoperative fluoroscopy and this 6-mm proximal segment was removed (Figure 5). A drill hole was made in the remaining IF metacarpal just through the dorsal cortex and angled into the osteotomy site. A 4-0 prolene suture was passed through the hole and used to tie down the IF metacarpal to the cartilaginous cap previously articulating with the metacarpal base. Prior to securing the metacarpal to the cartilaginous cap, the IF was pronated 90°, so that its palmar pad faced the long finger (Figure 5, Supplemental Figure 1). Alignment was confirmed using intraoperative fluoroscopy. In contrast to the Kozin approach, we routinely rely on sutures and casting rather than a Kirschner wire to maintain the new thumb in its position.⁵

Closure and Follow-up

Once the IF was stabilized in its new position, the tourniquet was deflated and hemostasis obtained. The distally based dorsoradial v-flap was sutured to the proximal end

Figure 5. (a) Exposure of the second metacarpal in preparation for osteotomy; (b, c) intraoperative fluoroscopy imaging following osteotomies and removal of proximal third of the second metacarpal; (d, e) positioning of the neothumb.

of the palmar incision (Figure 6). The proximally based v-flap was used for webspace closure. A triangular flap was inserted into the midpoint of the dorsal incision to break up the linear closure (Figure 6). The floating thumb was then excised via ellipse. The patient was placed in a long-arm thumb spica cast with the thumb tip exposed for vascular checks. The patient remained hospitalized overnight and was discharged the next day. At a 2-week follow-up visit, the patient was referred to hand therapy for a custom thumb spica splint and range of motion exercises. At 7 weeks after pollicization, the patient had gained

active flexion and extension of the new thumb with good demonstration of pinch use (Figure 7). The splint was discontinued.

Discussion

The thumb is a highly specialized digit that balances power grip and delicate prehension. Its absence impairs the functionality of the entire hand. Following the prudent principle to “replace tissue losses in kind,” pollicization of the IF is an elegant technique to replicate thumb function with like

Figure 6. Immediate postoperative photographs of pollicization and skin flap closure.

Figure 7. Postoperative results depicted by (a) radiographs taken 2 weeks postoperatively and (b) photographs at 7 weeks postoperatively.

tissue. Since its original report by Buck-Gramcko,² several modifications have been proposed with reported technical success and evolving designs arising. Kozin provide a step-by-step guide to what today is considered to be the standard approach to pollicization. The case presented herein is one in which the anatomical variation of the IF precluded the standard pollicization technique. A modified approach was designed for this patient with key adjustments being: (1) removal of the proximal third of the IF metacarpal by careful radiographic measurements and calculations (6 mm); (2) creation of a de novo thumb CMC joint by fibrous union whereby the remaining distal IF metacarpal was translocated proximally to fit into the CMC cartilage cap; (3) preservation of the joints at the “natural” position and function; (4) maintenance of the interossei muscles inserted into their original sites; and (5) modification of the skin incisions. A schematic detailing the key steps and comparisons to Kozin’s technique can be found in Supplemental Figure 2.

Long-term functional and aesthetic outcomes of pollicization for congenital thumb hypoplasia are extremely reassuring. Preoperative function of the pollicized digit has long been considered a primary predictor of thumb function.⁷ A healthy and supple IF is preferred, but can still result in suboptimal thumb function with an appreciable amount of stiffness and weakness.⁶ Range of motion in pollicized digits is reportedly 40% to 70% that of normal controls with strength studies showing some weakness compared with normal contralateral hands (44%-60% decrease) and normal controls (25%-38% decrease).³ Unfortunately, CMC joint movement specifically is not well-described in the literature. The approach undertaken in reconstructing the CMC joint in our patient is somewhat unconventional but was necessitated by the IF length and structure. Given the high adaptability of young children, we suspect the patient’s long-term function may not be significantly worse than in the standard pollicization approach. At the most recent postoperative visit (7 weeks), the patient’s mother already noted that the child was using the new thumb to pick up objects. Long-term follow-up will clarify how well he adapts to his new thumb.

Conclusions

In summary, we describe a unique presentation of a child with a type IV hypoplastic thumb and a biphalangeal IF that required technical modifications for this patient’s pollicization. Preoperative adjustments and intraoperative decision-making are described. Emphasis is placed on the importance of judicious planning and how the standard pollicization

procedure can be adjusted to fit an individual patient with unique anatomy.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study

Declaration of Conflicting Interests

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