Partially ossified iliac crest graft for the reconstruction of the pediatric thumb proximal phalanx

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Introduction

We present a case of osteomyelitic destruction of the thumb proximal phalanx and interphalangeal (IP) joint in a 3-year-old girl. Such defects are seldom reported, and reconstruction proves to be challenging to obtain potential for digit growth and maintenance of joint function. The phalanx was successfully reconstructed with a free autogenous partially ossified anterior iliac osteochondral crest graft resulting in a functional thumb at 2.5 years post-surgery. We also explore other reports of pediatric phalanx reconstruction with iliac crest grafts and discuss the reconstructive outcomes.

Case Report

A 3-year-old girl sustained an intra-articular compound fracture of proximal portion of the right thumb distal phalanx with dislocation and fracture through the neck of the proximal phalanx when a door closed on it (Fig. 1). The thumb defect was irrigated, reduced, and splinted, and cephalexin was prescribed. Two weeks following the injury, she

developed cellulitis and an abscess of the thumb pulp extending into the thenar eminence and was only then seen by the plastic surgery team. The abscess was incised and drained (I & D) and then splinted, and oral cloxacillin and clindamycin were prescribed empirically. Intraoperative abscess cultures were sterile (likely due to prior antibiotic use). Two weeks after I & D, the thumb phalanges would not remain aligned, and the patient underwent placement of two Kirschner wires (K-wires), via open reduction, as there were no signs of infection.

Due to the slow healing, the K-wires remained in place for 2 months. Unfortunately, gradual resorption of the distal segment of the thumb proximal phalanx occurred, leaving the growth plate intact (Fig. 2). Despite multiple investigations, a treatable etiology for the resorption could not be found. This loss of the distal half of the proximal phalanx led to a grossly unstable thumb IP joint at 13 months post-K-wire removal (16 months post-trauma), and reconstructive surgery was required.

A partially ossified iliac crest graft was harvested and transferred to the right thumb proximal phalanx. The base of right proximal phalanx was freshened, leaving the physis intact, and a template of the defect was made with the thumb under traction to appropriate length. An incision was made over the left anterior iliac crest, and an oscillating saw was used to harvest the iliac graft of corticocancellous bone with a cartilage cap. The graft was trimmed, and inset into the subcutaneous pocket and two 0.028 K-wires secured the graft in place (Fig. 3).

The K-wires were left in for 8 weeks with the patient in a thumb spica cast. Following K-wire removal, the thumb spica cast was continued for another 2 weeks and then replaced with a hand-based thumb spica splint for an additional 2 weeks. At 12 weeks post-grafting, active movement of the thumb was permitted with 3 weeks of splinting for ball play. Eighteen weeks

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Fig. 1 Intra-articular compound fracture of proximal portion of the right thumb distal phalanx with dorsal dislocation and crush injury to the head of the proximal phalanx with fracture to remaining neck (*white arrow*)

post-grafting, she achieved a stable joint with a maximal IP joint range of motion of 15° of hyperextension, active flexion to neutral, and powerful thumb opposition, and pinch capabilities.

Radiographically, ossification of the graft was observed with remodelling of the cartilaginous articular surface from

12 weeks to 21 months post-grafting with phalangealization of the graft (Fig. 4). There was continued digit growth from both intact proximal and distal phalanx physis, 16.8–20.2 and 7.7–8.1 mm, respectively, from 12 to 21 months post-grafting, with no gross asymmetry compared to the contralateral thumb (Fig. 5).

Fig. 2 Two months post-surgery showing dorsal subluxation of the thumb IP joint with digit shortening and distal resorption of the proximal phalanx (*left*). Six months post-surgery showing complete

destruction of the head of the thumb proximal phalanx (*middle*). Ten months post-surgery with severe digit shortening, complete distal proximal thumb phalanx destruction but intact physis (*right*)

Fig. 3 Partially ossified iliac crest graft, with template seen above graft, prior to placement into the thumb (*left*). Iliac crest graft secured to physis stump with K-wires (*right*). The distal phalanx was purposefully excluded to prevent potential joint fusion

Unfortunately, 2.5 years after grafting, a soccer ball hit her neo-proximal phalanx, resulting in an undisplaced

transverse fracture through the graft (Fig. 6). The fracture was treated conservatively with a thumb spica cast for

Fig. 4 Iliac crest graft ossification with cartilage articular surface remodelling, phalangealization, and graft fusion to the physis post-surgery at 12 weeks (*left*) and 21 months (*right*)

Fig. 5 Measured growth of the thumb proximal phalanx from innate physis with lengths of 16.8 mm at 12 months post-surgery (*left*) and 20.2 mm at 21 months post-surgery (*right*). There was also growth of the distal phalanx from 7.7 to 8.1 mm (not shown)

6 weeks and then 3 weeks of splinting for activities. By 5 weeks post-fracturing, callous formation and healing of the fracture were observed (Fig. 6).

At 43 months post-surgery, there is persistent dorsal subluxation, but active flexion has increased to 15°, and passive range of motion is from 15° of flexion to 70° of hyperextension. She has no functional limitations, being able to play the piano and write, but she does prefer certain mannerisms to compensate for the subluxed distal phalanx (Fig. 7). The donor site is well healed, pain free with a normal pelvic configuration.

Discussion

Pediatric joint reconstructive goals include the maintenance of joint function and a potential for digit growth. Pediatric phalangeal diaphysis and IP joint destruction are rarely reported in the literature, and proposed joint reconstruction methods have used bone grafts as common adult joint reconstructive options are of limited use [3–5]. Arthrodesis is typically seen as a salvage procedure which results in no joint mobility and can limit digit growth in a child. Arthroplasty hardware would also affect the physis' potential for growth and has a limited life-span. In congenital phalangeal abnormalities and post-oncologic phalanx resections, the use of free toe phalangeal transfers have been described [2, 6, 7].

The method has the potential to transfer both the physis and epiphysis of the toe. This surgical option has been criticized as the toe phalanx is of poor length match to a finger phalanx [5, 7], and the donor site morbidity of shortened and potentially floppy toes is often unacceptable to the child's parents, necessitating an iliac crest graft to reconstruct the toe [1]. The iliac crest graft is a good choice for finger phalanx, and IP joint reconstruction as the donor site morbidity is minimal with no functional deficit. The digit receiving an iliac crest graft can have a good functional outcome [3, 5].

The postoperative course of the iliac graft in our patient is consistent with the literature. Graft survival with minimal resorption appears to be achieved when a good vascular bed is present to receive the graft. This occurred by leaving the phalangeal periosteal sleeve intact, as in the case of phalanx resection [3] or leaving the surrounding anatomy undisturbed [5]. Transferred bone graft surface remodelling is typical as the new articular surface will shape to meet the demands of the new biomechanical forces applied to it. This was seen in our iliac crest graft and reported by other authors [3, 5].

While both our digit reconstruction and that of others have resulted in a functional digit, the range of IP motion obtained is quite variable. In our case, the patient at 43 months post-surgery obtained a pain-free active thumb IP range of motion of 15° of flexion to

Fig. 6 Transverse fracture through the iliac crest graft 2.5 years after surgery (*left*). Fracture site callous formation and healing after 5 weeks (*right*)

70° of hyperextension, with good pinch and thumb opposition capabilities. Gadegone and Salphale [3] resected the proximal phalanx of a ring finger in a 15-year-old girl for treatment of a giant cell tumor. At 13 years follow-up, the iliac fibro-osseous graft articular surface was remodelled, but range of motion for the metacarpophalangeal joint and proximal interphalangeal (PIP) joint was minimal at 0–15° and 0–10°, respectively. Salon et al. [5] resected the middle phalanx of the middle finger of a 13-year-old boy for treatment of an aneurysmal bone cyst. They used a free chondral graft from the non-ossified iliac crest for reconstruction. At 3 months post-operation, 80 % of the PIP and distal interphalangeal joint normal range of motion was obtained. The wide variety of reported final ranges of IP joint movement is likely multifactorial. Contributing factors may include the mechanism

of phalanx defect (trauma, pathological, and surgical), amount of graft resorption, type of graft articular surface (cartilage versus bone), degree of remodelling of both ends of the neo-interphalangeal joint, and physiologic tension imparted by tendons surrounding the reconstructed joint [5].

With respect to digit growth, we were unable to find any reports stating growth of the iliac graft. Our patient had continued growth of her phalanx, presumably from her original epiphysis. The thumb presently appears grossly symmetric to the contralateral thumb.

The use of a free partially ossified anterior iliac osteochondral crest graft to reconstruct a functional thumb proximal phalanx and IP joint in a skeletally immature patient proved to be successful. The patient returned to her normal activities, but with atypical joint range of motion requiring some adaptations to perform tasks. The graft underwent

Fig. 7 No functional limitation of thumb is present at 43 months post-surgery (*top*). While normal pencil holding is possible, she prefers this position likely to compensate for the subluxed distal phalanx (*bottom*), an acceptable thumb appearance (*bottom*)

remodelling, incorporated into the tissue bed, and there was minimal donor site morbidity.

Conflict of Interest None.

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