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ORIGINAL RESEARCH ARTICLE

Wedging osteotomy to correct metacarpal adduction for the treatment of Wassel types V and VI duplicated thumb: surgical strategy, outcomes, and anatomical findings

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ABSTRACT

This study presents a wedge osteotomy technique for correcting metacarpal adduction in the treatment of Wassel types V and VI thumb polydactyly, evaluating its clinical efficacy and reporting intraoperative anatomical abnormalities. A retrospective analysis of 37 thumbs treated between January 2016 and June 2023 was performed. Preoperatively, the median inter-metacarpal angle (IMA) was 0°, and the median radial deviation angle of the metacarpophalangeal (MCP) joint of the ulnar thumb was 30°. All cases underwent excision of the hypoplastic radial thumb, thenar muscle relocation, and a radial closing wedge osteotomy at the base of the ulnar thumb metacarpal to achieve a corrected IMA exceeding 40°. The ulnar capsule and collateral ligament were reinforced, and one or two Z-plasties were performed to enlarge the first web space in most cases. Mean follow-up was 51.4 months (range, 12–120). Postoperative IMA and MCP joint angle improved significantly to a median of 40° (IQR: 35–42°) and 0° (IQR: 0–10°),respectively. Mean range of motion at the MCP and interphalangeal joints was 40° (IQR: 30–45°) and 60° (IQR: 45–75°). According to the modified Tada score, 31 thumbs were rated good, 5 fair, and 1 poor. In conclusion, wedge osteotomy to correct metacarpal adduction deformity in type V/VI thumb duplication yields encouraging results, with good functional outcomes and a low reoperation rate.

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Background

Thumb duplication is a common congenital hand deformity. Based on the skeletal level of duplication from distal to proximal, thumb duplication is divided into I–VI types [1]. In type V and VI, the duplicated level starts from the first metacarpal bone, and the deformity is often combined with thenar muscle/extrinsic tendon abnormalities, the first web narrowing, and metarcarpophalangeal joint (MCP) instability [2]. The conventional surgical strategy is to resect the poorly developed radial thumb, preserve the ulnar thumb and reconstruct its alignment, soft tissue balance and function [3, 4].

Several studies have described the anatomical abnormalities of type V and VI thumb duplication. Through intraoperative observation, Aurora M. Kareh found that the articular surface of trapezium was tilted due to the correspondence to two metacarpals, which resulted in the adduction of the ulnar thumb [5]. Meimei Du also confirmed the above findings through MRI studies [6]. The surgical treatment of type V and VI include removal of the radial thumb, adjusting tendon alignment, opening the first web and stabilizing the MCP joint [7, 8]. However, the long-term outcome is not satisfied due to the recurrence of the first web narrowing, the residual metacarpal adduction deformity and the MCP joint instability. Secondary surgery is required to correct the deformity and improve the thumb function for cases with severe residual deformity [9].

To avoid thumb adduction deformity, recurrent narrowing of the first web and compensatory ulnar instability of the MCP joint caused by metacarpal adduction, we conducted the radial closing wedge osteotomy at the ulnar metacarpal to increase the 1, 2-metacarpal angle. In this article, we retrospectively analyzed the data of patients treated with the above techniques, reported the midterm follow-up results, and described and analyzed the anatomic abnormalities found during the operation.

Materials and methods

Patient characteristics

This study was approved by the Medical Ethics Committee of the Children's Hospital Affiliated to Chongqing Medical University. A retrospective analysis was performed on patients with Wassel type V and VI duplicated thumb treated by surgery from January 2016 to June 2023, excluding atypical type VI cases with metacarpal dysplasia of the ulnar thumb. A total of 47 cases were identified and 13 patients with less than 1 year of follow-up were excluded. A total of 34 cases with a total of 37 thumbs were included. The mean age was 12 months (4–27 months). According to the appearance and preoperative radiographic findings, 7 thumbs were type V and 30 thumbs were type VI.

On the posterior-anterior view of the thumb, the median angle between the metacarpal of ulnar thumb and the second metacarpal (inter-metacarpal angle, IMA) was 0° (interquatile range [IQR]: 0°~12°). The median radial deviation angle of the MCP joint (MCPA)

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of the ulnar thumb was 30° (IQR: 15°~ 40°). The stability of the MCP joint of ulnar thumb was examined under anesthesia. If the MCPA exceeded 20° or 15° higher than the contralateral side under radial stress, the MCP joint was considered unstable (22 thumbs). A total of 25 thumbs were accompanied with varying degrees of first web narrowing. Five thumbs had contractures on the palmar side, characterizing by MCP joint flexion and increase of tension of the palmar skin when MCP joint was passively extended. Radial deviation of the interphalangeal joint (IP) was noticed in eight ulnar thumbs.

Surgical techniques

Excision of the poorly developed radial thumb and relocation of the thenar muscle were conducted on all cases. After removal of the metacarpal bone of the radial thumb, the distal radial articular surface of the trapezium was exposed and trimmed. A radial closing wedge osteotomy was performed at the base or the center of the angulation of the ulnar metacarpal bone, ensuring the corrected IMA was more than 40° (Figure 1). In cases with MCP joint instability or MCPA > 20° of the ulnar thumb, a radial opening wedge osteotomy was conducted simultaneously at the neck of metacarpal bone to reorient the metacarpal head, using the wedge-shaped fragment removed from the base as supporting graft. The osteotomy was fixed by longitudinal K-wires and the ulnar capsule and collateral ligament of MCP joint was reinforced with sutures. In addition, the transverse head of the adductor pollicis (AddP) was sutured to the dorsal side of the base of the proximal phalanx of the ulnar thumb as a reinforcement of the MCP joint. One or two Z-plasty was performed to enlarge the first web for adequate thumb abduction (Figure 2). A transverse incision and deep structures releasing was made at the palmar side of MCP joint in cases with flexion contracture, and the skin defect was covered by grafts from the excised radial thumb.

Follow-up

The mean follow-up was 51.4 months (12–120 months). We evaluated the appearance, thumb opposition ability, the alignment and stability of MCP and IP joint. The metacarpal and phalangeal bones were palpated and marked at the maximum palmar abduction to measure IMA and MCPA. The modified Tada score was adopted to evaluate thumb function after surgery [10, 11].

Results

All postoperative wounds healed by primary intention, with normal healing at the osteotomy sites. The median postoperative IMA and MCPA was 40° (IQR: 35–42°) and 0° (IQR: 0–10°), both showing significant improvement compared to preoperative values ($p < 0.001$). The median range of motion at the MCP joint was 40° (IQR: 30–45°), and at the IP joint was 60° (IQR: 45–75°). According to the modified Tada score, 26 cases were rated as good, 5 as fair, and 1 as poor (Figure 3). Figure 3 shows the 7-year follow-up of a case, with the thumb demonstrating favorable alignment, satisfactory appearance, and good flexion, extension and opposition functions. One case received revision surgery due to unstable MCP joint and poor opposition movement.

Anatomical abnormalities

Radial Digit: Two radial digits were rudimentary (nubbin-type) with no muscular or tendinous attachments. The other 35 thumbs had varying degrees of thenar muscle attachment to the radial digit, ranging from minimal abductor pollicis brevis (APB) fibers to the entire APB and flexor pollicis brevis (FPB). No AddP attachment was observed on any radial digit. Extensor tendon attachments similarly varied: absent in rudimentary digits, thin and underdeveloped in some, and equivalent in caliber to the ulnar digit's extensor tendon in others.

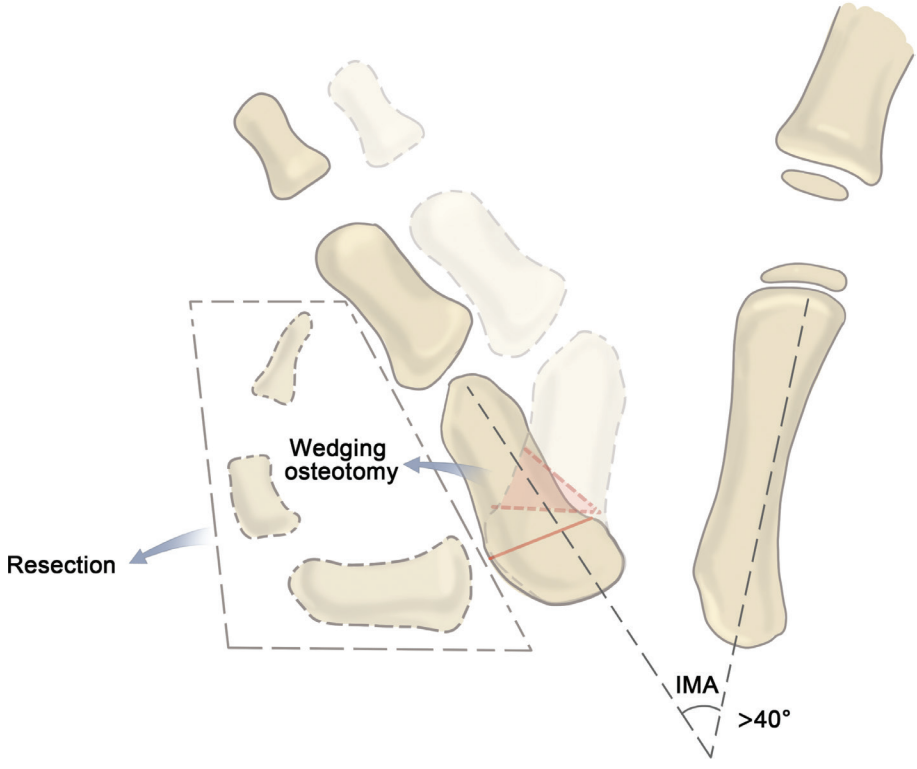

Figure 1. Illustration of wedging osteotomy and reorientation of the ulnar first metacarpal to increase the inter-metacarpal angle.

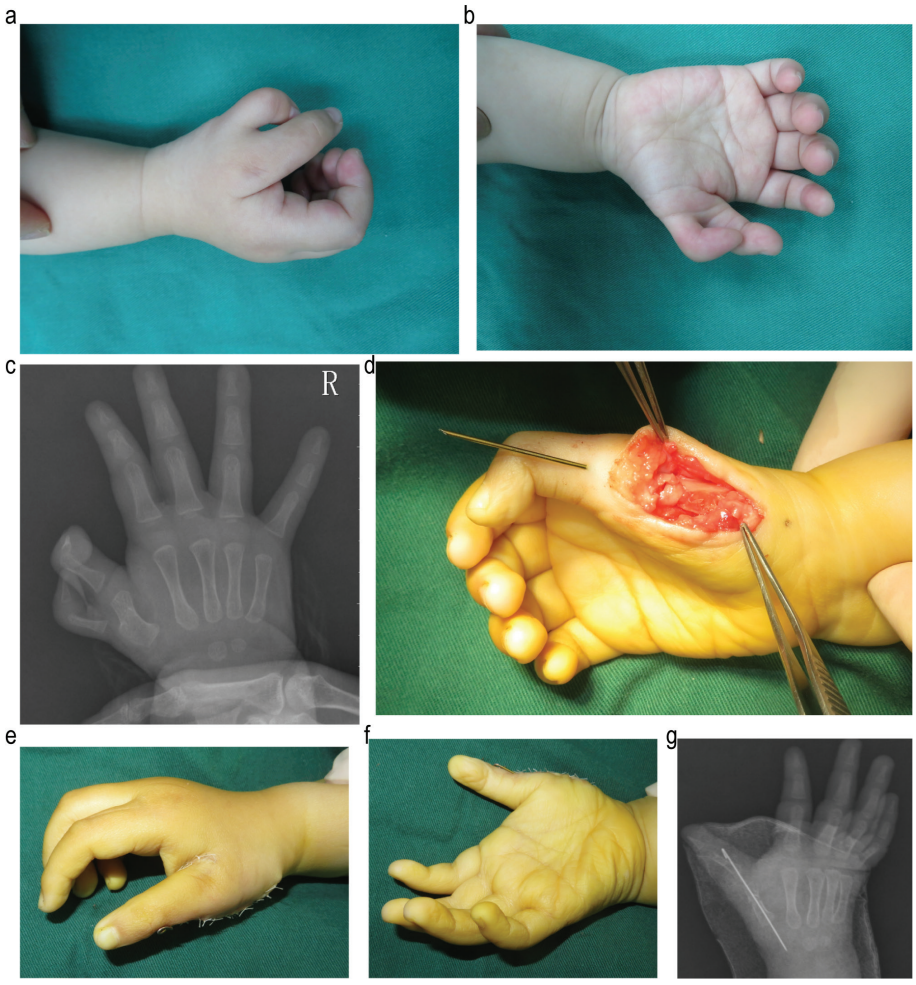

Figure 2. a, b and c show the preoperative appearance of the duplicated thumb and the adduction deformity of the ulnar first metacarpal; d demonstrates the wedging osteotomy and trimming of the remaining metacarpal; e, f and g reveal the postoperative appearance and the increased IMA on x-ray film.

Ulnar Digit: All ulnar digits had an extensor pollicis longus (EPL) tendon. In the two cases with rudimentary radial digits, concomitant thenar hypoplasia (characterized by a thin APB muscle bundle) was present in the ulnar digit. The EPL in the ulnar digit was essentially normal in all cases, but no extensor pollicis brevis (EPB) tendon was attached to it. The transverse head of the AddP inserted onto the proximal phalanx of the ulnar digit in all cases; however, in thumbs with severe radial deviation at the MCP joint, this insertion was displaced volarward. In cases with radial deviation at the IP joint, the flexor pollicis longus (FPL) tendon was observed inserting onto the radial side of the distal phalanx. Ulnar release of the MCP joint capsule in the ulnar digit revealed that the proximal attachments of the capsule and ulnar collateral ligament (UCL) were displaced distally, indicating that the articular surface was also radially deviated.

Discussion

Current reports on surgical management of type V/VI duplication remain limited. Reconstruction of the ulnar thumb primarily involves tendon/muscle transfer to restore thumb alignment and opposition function, along with first web space widening. However, we did not find reported cases of performing osteotomy during primary surgery to correct bony alignment in English literature.

The main challenge in treating type V/VI duplication is the high reoperation rate. Yuki Bessho et al. reported a 24% reoperation rate at 3-year follow-up in 29 cases [7], while Young Ho Shin documented a 19% rate at 1-year follow-up in 23 cases [9]. Studies suggest reoperation rates may rise to 60% with prolonged follow-up [12]. Key reasons for reoperation include recurrent web space narrowing, MCP joint instability, and poor opposition. Susumu Saito found that metacarpal adduction deformity underlies web space narrowing, leading to compensatory MCP radial deviation. Soft tissue balancing alone often fails to address metacarpal adduction [2].

In our cases, we performed primary metacarpal osteotomy in addition to soft tissue balancing and tendon transfer to increase the ulnar thumb's abduction angle. For severe MCP radial deviation, opening osteotomy at the metacarpal neck was added to prevent recurrence. Midterm follow-up demonstrated significant improvement in the intermetacarpal angle and MCP alignment. Our approach did not substantially increase surgical complexity or risk, and proper bony alignment may enhance long-term functional outcomes and decrease reoperation rate.

Consistent with reports by Susumu Saito, Bo He, and Aurora M. Kareh, intraoperative findings revealed prevalent hypoplasia of the thenar muscles [13]. Except for rudimentary 'nubbin-type' duplications, most cases exhibited varying degrees of thenar hypoplasia, with the APB and superficial head of the FPB often inserting into the radial digit. These muscles were detached and reattached to the ulnar thumb's proximal phalanx base. Abnormal extrinsic tendon insertions (e.g. EPL and FPL) were centralized to prevent progressive joint deviation. In cases with hypoplastic/absent

Figure 3. a and b: preoperative appearance; c: preoperative x-ray shows the adduction deformity of the ulnar metacarpal; d and e: immediate appearance after operation; f and g demonstrate good flexion and opposition function after surgery; h and i show the favorable alignment and appearance of the thumb.

EPB on the ulnar side, the radial digit's extensor tendon was transferred to the dorsal base of the ulnar proximal phalanx under appropriate tension, supplemented by skin grafting for volar defects.

We acknowledge several limitations in the present study. First, non-standard radiographic positioning in infants compromised the accuracy of metacarpal adduction angle measurements. Second, the relatively high rate of loss to follow-up may have led to an underestimation of the reoperation rate. Third, given the absence of a control group and comparative data from patients without osteotomy, we cannot objectively assess the superiority of this technique in reducing reoperation rates.

Conclusions

To address the unsatisfied outcomes and high reoperation rates in type V/VI thumb duplication, we incorporated primary osteotomy to optimize bony alignment. Midterm results are encouraging, manifested by good functional outcomes and low reoperation rate, though long-term results of our technique require further evaluation.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of the Children's Hospital Affiliated to Chongqing Medical University and obtained written informed consent from all the patients' guardians. I confirm that all methods were performed in accordance with the relevant guidelines. All procedures were performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Zhixin Wang and Guoqing Chen carried out the studies, participated in collecting data, and drafted the manuscript. Xiaofei Tian participated in acquisition, analysis, and interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

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