

Donor site reconstruction by adjacent half-width metatarsal after full-width metatarsal transfer for metacarpal reconstruction in severe thumb hypoplasia

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The treatment of Manske type IIIB and IV thumb hypoplasia remains controversial, and parents increasingly expect to maintain the hypoplastic thumb in preference to a five-digit hand.^[1,2] There has been a recent increased number of reports regarding the reconstruction of severe thumb hypoplasia with the use of free metatarsal transfers (MTs). Tsujino *et al*^[3] reconstructed a thumb with a non-vascularized 4th metatarsal, and filled the bone defect with an iliac graft. Chow *et al*^[4] reported on thumb reconstruction with hemi-width MT, which reduced not only the sacrifice of the donor foot but also the strength of the reconstructed metacarpal.

Since 2015, we have performed more than 200 cases of non-vascularized full-width 4th metatarsal transfer^[2] (NF4MT) or vascularized full-width 2nd metatarsal flap transfer^[5] (VF2MFT) with good outcomes and minor donor site morbidity; the donor site was filled with a hemi-width graft of the 3rd metatarsal. The full-width MT reconstructs a stronger first metacarpal and a carpometacarpal joint with intact epiphysis in comparison with the hemi-width MT; and the reconstructed hemi-width metatarsal retains the blood supply from the periosteum, which ensures its rapid recovery. Despite the reported success of various techniques in thumb function, the donor site morbidity has not been studied in detail. Thus, this study aimed to evaluate the donor site outcome after donor bone defect repair using adjacent half-width metatarsal in patients with Manske type IIIB and IV thumb hypoplasia who underwent full-width MT to reconstruct the first metacarpal.

The study was conducted in accordance with the *Declaration of Helsinki* and was approved by the Institutional Review Board of Beijing Jishuitan Hospital (No. 202007-28). All parents were informed about the

advantages and disadvantages of pollicization and MTs. The final choice was made by the parents. Written informed consent was obtained from all parents before their children's enrollment in the study.

We retrospectively evaluated 20 feet of 20 pediatric patients following NF4MT or VF2MFT for Manske IIIB and IV thumbs from 2020 to 2021, with a follow-up >12 months. In each patient, bilateral feet were normal pre-operatively and only one foot underwent MT.

Surgical details had previously been described in the literature.^[2,5] The graft harvest and reconstruction of donor foot is further elaborated here. The hypoplastic thumb was pulled after surgical preparation to measure the length of the bone defect at the recipient site. In NF4MT, a longitudinal incision was made between the 3rd and 4th metatarsals over the dorsum of the foot, and an osteotomy was performed to harvest the full-width graft of the distal 4th metatarsal, with the length of the graft based on the bone defect at the recipient site. In VF2MFT, an oval-shaped flap was designed over the dorsum of the 2nd metatarsal. The incision was continued proximally to prepare the vessels, and an osteocutaneous flap was harvested in a manner similar to NF4MT. In our practice, osteotomies were always performed proximal to the midpoint of the longitudinal axis of the donor metatarsals. A row of holes was drilled using a Kirschner wire (K-wire) (0.8 mm) along the middle line of the 3rd metatarsal, and then an extra-periosteal osteotomy was performed with a scalpel, during which the periosteum, vessels, and the capsule were protected. Then the adjacent half-width graft of the 3rd metatarsal was rotated 180° about its middle line and horizontally transposed to the donor site, and two K-wires (0.8 mm) were used to stabilize the reconstructed m-

Access this article online	
Quick Response Code: 	Website: www.cmj.org
	DOI: 10.1097/CM9.0000000000002552

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Chinese Medical Journal 2023;136(17)

Received: 30-11-2022; Online: 19-06-2023 Edited by: Jing Ni

etatarsal. The new reconstructed metatarsophalangeal joint was stabilized by K-wires and trans-capsule-cartilage suture [Supplementary Figure 1, <http://links.lww.com/CM9/B398>]. After the radiologic healing of reconstructed metatarsal was achieved about 4 weeks post-operatively, the K-wires were removed and weight-bearing was allowed.

For evaluation, the donor foot was compared with the normal contralateral foot. Each patient was examined by three investigators, and the results were recorded under their agreement. Following items were measured in the objective assessment. Appearances of the 2nd/4th and 3rd toes were reported as normal or nearly normal, lengthening, shortening, deformity (described in detail), and other anomalies. The definitions of “lengthening” and “shortening” of toes were described in the legend of [Supplementary Figure 3, <http://links.lww.com/CM9/B398>].

Radiographic findings on anteroposterior (AP) and oblique radiographs of the 2nd/4th and 3rd metatarsals were reported as normal or nearly normal, non-union, synostosis between 2nd/4th and 3rd metatarsals, deformity (described in detail), lengthening, shortening, widening, narrowing and other anomalies. The definitions of “lengthening” and “shortening” of metatarsals were described in the legend of [Supplementary Figure 2, <http://links.lww.com/CM9/B398>].

The lengths and widths of bilateral 2nd/4th and 3rd metatarsals at follow-up and the lengths of previous metatarsals immediately post-operation were measured. The width of metatarsals immediately post-operation was not measured because one border of metatarsals was vague after longitudinal osteotomy. Patients without radiograph of the contralateral foot were excluded from the measurement of metatarsals. The measurement strategy is shown in Supplementary Figure 2, <http://links.lww.com/CM9/B398>. The measurement was independently performed by three investigators, and means were calculated based on the three sets of data. Comparisons were conducted between length and width of metatarsals at follow-up and length of metatarsals immediately post-operation for donor and contralateral sides.

Parental satisfaction was assessed using two questions: (1) overall satisfaction with the appearance of the donor foot and (2) overall satisfaction with the function of the donor foot. Each question had five choices: very satisfied, somewhat satisfied, fair, somewhat dissatisfied, and very dissatisfied, with corresponding scores from 5 to 1, respectively.

For items that fit the normal distribution, their means and standard deviations were calculated and were analyzed using Student's *t* test; otherwise, medians (interquartiles) were calculated, and were analyzed using Wilcoxon signed-rank test. The analysis was realized using SPSS Statistics v.22 (IBM, Armonk, NY, USA). Statistical significance was set at $P < 0.05$.

Twelve male and eight female pediatric patients were evaluated. The mean age at operation was 31 (range: 14–127) months, the mean age at follow-up was 50

(range: 26–140) months, and the mean follow-up period was 18 (range: 12–36) months. There were 11 Manske type IIIB and nine type IV thumbs. According to the modified classification (JST classification) we proposed, there were three, eight, four, and five thumbs classified as type IIIB, type IIIC, type IIID, and type IV, respectively.^[6] Fifteen NF4MT grafts (eight left and seven right) and five VF2MFT grafts (three left and two right) were harvested in the first metacarpal reconstruction procedures [Supplementary Table 1, <http://links.lww.com/CM9/B398>].

Abnormal toes were observed in four patients [Supplementary Table 1, <http://links.lww.com/CM9/B398> and Supplementary Figure 3, <http://links.lww.com/CM9/B398>]. Shortening was observed on the 3rd toe of two patients (Patient (P)13 and P15), lengthening was observed on the 4th toe of one patient (P10), and deformity on that of one patient (deviation, P7). Unexpectedly, we found the 2nd toe overriding the first (P10) or 3rd toe (P11) in two patients after NF4MT, with unknown reason. The parents of both patients planned to correct this anomaly.

Mild abnormal radiographic findings of metatarsals were observed in nine patients, without associated discomfort [Supplementary Table 1, <http://links.lww.com/CM9/B398> and Supplementary Figure 4, <http://links.lww.com/CM9/B398>]. Synostosis between the 2nd/4th and 3rd metatarsals was observed in five patients (P1, P7, P9, P15, and P17); widening, deformity, and non-union of the 2nd/4th metatarsal were observed in two (P13 and P18), one (angulation, P6), and one (P9) patient, respectively. Widening, lengthening, and deformity of the 3rd metatarsal were observed in two (P1 and P13), one (P3), and one patient (curving, P15), respectively.

Sixteen patients underwent AP radiography of the bilateral feet, including 12 patients who underwent NF4MT and four patients who underwent VF2MFT [Supplementary Table 2, <http://links.lww.com/CM9/B398>]. Four patients (P5, P6, P8, and P19) were excluded for lack of AP radiography of the contralateral foot. The widths of the 4th, 2nd, and 3rd metatarsals in the donor side were not significantly different from those in the contralateral side at follow-up ($P = 0.699$, 0.415 , and 0.369 , respectively). The lengths of the 4th and 3rd metatarsals in the donor side were not significantly different from those in the contralateral side at post-operation ($P = 0.638$ and 0.438 , respectively). The lengths of the 2nd metatarsals in the donor side were longer than those in the contralateral side at postoperation ($P = 0.046$). The lengths of the 4th and 3rd metatarsals in the donor side were significantly longer than that in the contralateral side at follow-up ($P = 0.023$ and 0.046 , respectively). The lengths of the 2nd metatarsals in the donor side were not significantly different from those in the contralateral side at follow-up ($P = 0.465$).

Eleven, six, two, and one parent respectively answered very satisfied, somewhat satisfied, fair, and somewhat dissatisfied to the appearance of donor foot, for a mean score of 4.35 ± 0.88 . Thirteen, five, and two parents respectively answered very satisfied, somewhat satisfied, and fair to the function of donor foot; the mean score was

4.55 ± 0.69 [Supplementary Table 1, <http://links.lww.com/CM9/B398>].

MT for reconstruction of the severely hypoplastic thumb is an increasingly popular option.^[6] A minimal donor site may provide a stronger impetus for parents to choose metatarsal reconstruction over a pollicization. However, few studies have specifically examined the outcome and parental satisfaction of the donor foot. In this study, we proposed an evaluation strategy, consisting of objective and subjective assessments, which is appropriate for very young patients. The outcomes for most patients were satisfactory.

In objective assessments, mild anomalies of toes and metatarsals were observed in some patients, without associated discomfort; therefore, we believe that slight morbidity is acceptable in the short term. The widths of the 4th, 2nd, and 3rd metatarsals were not significantly different between two sides, indicating a rapid width recovery of donor metatarsals, which also demonstrated their reliable strength. The lengths of the 4th metatarsals were not statistically significantly different between two sides at post-operation, indicating that the parallel transposition did not significantly change the length of donor metatarsals. The statistically longer length of the 4th metatarsals in donor side at follow-up implies the overgrowth of metatarsals after surgery, but the difference was too small (<1 mm) to be clinically important. The length change of the 2nd metatarsals was opposite to that of the 4th and 3rd metatarsals, which we attribute to the small sample (four patients). In the subjective assessment, most parents were satisfied with the appearance and function, implying the generally good outcomes of donor feet.

We think that following MT for severe thumb hypoplasia, transposition of the adjacent half-width metatarsal for

donor reconstruction results in minor donor deficit. However, a long-term assessment with a larger sample is needed.

Acknowledgements

We would like to thank Jie Shen for her assistance in this research.

Conflicts of interest

None.

References

1. Zhu AF, Light TR. Overcoming barriers to hand surgical care in low-resource settings. *Hand Clin* 2019;35:397–402. doi: 10.1016/j.hcl.2019.07.001.
2. Liu B, Chen S, Chow ECS, Li P, Liu K, Yang C. Type IIIB and IV hypoplastic thumb reconstruction with non-vascularized fourth metatarsal. *J Hand Surg Eur Vol* 2020;45:722–728. doi: 10.1177/1753193420937547.
3. Tsujino A, Itoh Y, Hayashi K. Reconstruction of floating thumb by transplanting the fourth metatarsal. *J Bone Joint Surg Br* 1994;76:551–554. doi: 10.1302/0301-620X.76B4.8027138.
4. Chow CS, Ho PC, Tse WL, Hung LK. Reconstruction of hypoplastic thumb using hemi-longitudinal metatarsal transfer. *J Hand Surg Eur Vol* 2012;37:738–744. doi: 10.1177/1753193411432677.
5. Tong DD, Wu LH, Li PC, Rong YB, Liu B, Lee W, *et al.* Reversed vascularized second metatarsal flap for reconstruction of Manske type IIIB and IV thumb hypoplasia with reduced donor site morbidity. *Chin Med J* 2019;132:2565–2571. doi: 10.1097/CM9.0000000000000477.
6. Liu B, Bai F, Chen S. Revisiting the management of Manske type 3B and 4 thumb hypoplasia. *J Hand Surg Eur Vol* 2021;46:21–29. doi: 10.1177/1753193420967240.

How to cite this article: Bai F, Liu L, Wei Q, Li Q, Xue Y, Yang C, Chen S. Donor site reconstruction by adjacent half-width metatarsal after full-width metatarsal transfer for metacarpal reconstruction in severe thumb hypoplasia. *Chin Med J* 2023;136:2104–2106. doi: 10.1097/CM9.0000000000002552