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# Bilateral Metacarpal Hands: Reconstruction With 6 Toe Transfers

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## Abstract

**Background:** Bilateral metacarpal hand injuries are extremely rare, but probably represent the most difficult reconstructive challenge in hand surgery. **Methods:** We discuss the various options for metacarpal hand reconstruction, including the Krukenberg procedure, bionic prostheses, multiple toe-to-hand transfers, and possibly hand transplantation, and present the long-term functional outcomes, gait analysis, and psychological evaluation after a 4-stage reconstruction of bilateral metacarpal hands in a child using 6 toe-to-hand transfers—bilateral great toe transfers to reconstruct both thumbs and bilateral combined second-third monobloc transfers to reconstruct 2 fingers in each hand. **Results:** Reconstruction of bilateral metacarpal hands with 6 toe transfers yielded excellent functional results and patient satisfaction. **Conclusions:** Bilateral metacarpal hand injuries result in a devastating functional deficit and a major psychological impact. Multiple toe transfers (4, 5, or 6) provide an excellent reconstructive outcome with acceptable donor site morbidity.

**Keywords:** multiple toe transfers, metacarpal hand, bilateral

## Introduction

Michon and Dolich<sup>1</sup> first described the metacarpal hand in 1970 as “lacking any possibility of prehension except as a hook and serving mostly as an assistant hand.” Wei et al<sup>2</sup> classified metacarpal hands into type I—amputation of all 4 fingers proximal to the mid-proximal phalanges, with either a normal thumb (IA) or a thumb amputated distal to the interphalangeal joint (IB)—and type II—amputation of all 4 fingers proximal to the proximal phalanges with a thumb amputation proximal to the interphalangeal joint. Del Piñal et al<sup>3</sup> also classified metacarpal hands into type I—all 4 fingers missing, type II—radial 4 digits missing with only a single small finger remaining, and type III—all 5 digits missing. Kotkansalo et al<sup>4</sup> proposed classifying a “no-finger hand” into level A, in which at least 2 functioning digital metacarpophalangeal joints (MCPs) were retained and the thumb amputation was at the MCP joint or distal metacarpal level, or level B, which described a true metacarpal hand with only a thumb metacarpal stump remaining. Extrapolating from a classification system for congenital absent digits, Jones and Kaplan<sup>5</sup> classified a metacarpal hand as amputation of all 5 digits between the carpometacarpal joints and the base of the proximal phalanges (R5(m)) or distal to the bases of the proximal phalanges (R5(p)), hence maintaining MCP joint motion.

Severe injuries producing bilateral metacarpal hands result in a devastating functional impairment, but fortunately are relatively rare in adults and extremely rare in

children. The goals of reconstruction of metacarpal hands are to provide 2 or more opposable, stable, and sensate digits that are able to pinch and grasp and allow the patient to perform the activities of daily living.

Options for reconstruction of bilateral metacarpal hands include bilateral Krukenberg procedures, bilateral prostheses, multiple toe-to-hand transfers, and possibly bilateral hand transplantation. Despite significant advances in upper limb prosthetics with myoelectric prostheses and targeted muscle reinnervation, the main limitations are lack of sensibility and reliance on visual input.<sup>6</sup> The Krukenberg procedure separates the radius and ulna in the forearm amputation stump into 2 potentially sensate stumps that can abduct and adduct, but the obvious cosmetic appearance and limited fine motor function preclude its selection other than in the Third World. While bilateral hand transplantation might provide excellent functional results, it requires lifelong immunosuppression to prevent rejection, which may result in significant side effects and is contraindicated in children. Consequently, the best option for reconstruction of a meta-

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**Figure 1.** Left and right metacarpal hands.

carpal hand is either to transfer 2 toes to reconstruct the thumb and 1 opposable digit or to transfer 3 toes to reconstruct a thumb and 2 digits to provide tripod pinch.

## Methods

Institutional review board approval and patient consent for publication were obtained.

An 8-year-old boy sustained full-thickness burns and required amputation of all 5 digits in both his hands. In his right hand, there was amputation of all 4 fingers at the level of the MCPs and amputation of the thumb at the level of the distal third of the metacarpal (Figures 1 and 2). In his left hand, there was amputation of the long and ring fingers at the MCPs, amputation of the index and small fingers just proximal to the MCPs, and amputation of the thumb at the mid-metacarpal (Figures 1 and 2). His metacarpal hands would be classified as type IIC,<sup>2</sup> type III,<sup>3</sup> level B,<sup>4</sup> or R5(m).<sup>5</sup> There were healed skin grafts over both the palmar and dorsal surfaces of both hands, wrists, and forearms with significant contractures of the first web spaces.

At a preliminary first-stage operation, he underwent radical release of the bilateral first web space contractures with dorsal transposition flaps and full-thickness skin grafts, resection of both index finger metacarpals, and temporary pinning of the remnant of the thumb metacarpals to the long finger metacarpals to hold the thumbs out into full abduction.

At a second-stage operation, the right great toe (Figure 3), based on its dorsal circulation, was transferred to reconstruct the right thumb, with end-to-end anastomosis of the first dorsal metatarsal artery to the dorsal branch of the radial artery.

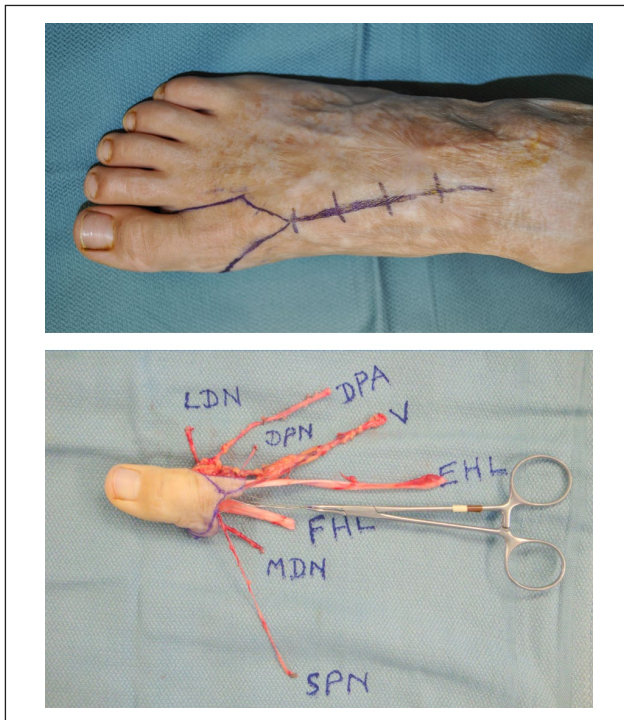
At a third-stage operation, the left great toe, also isolated on the first dorsal metatarsal artery, was transferred to reconstruct the left thumb. After the bilateral great toe-to-thumb transfers, the patient regained excellent flexion and extension at the interphalangeal joints of both new thumbs. Abduction and adduction at the carpometacarpal joints allowed him to begin pinch and grasp functions between the great toe transfers and the amputation stumps of the long, ring, and small finger metacarpals as sensory reinnervation progressed (Figure 4).

At a fourth-stage operation, the left second and third toes, isolated on the plantar circulation of the foot—the second plantar metatarsal artery—were transferred as a combined monobloc (Figure 5) to reconstruct the right ring and small fingers and positioned to allow opposition with the great toe-to-thumb transfer. The long finger metacarpal was resected. The second plantar metatarsal artery was elongated with a reversed greater saphenous vein graft and anastomosed end-to-end to the distal ulnar artery.

At a fifth-stage operation, the right second and third toes, also harvested on the second plantar metatarsal artery, were transferred as a combined monobloc to reconstruct the left ring and small fingers. The long finger metacarpal was resected. The second plantar metatarsal artery was anastomosed end-to-end to the distal ulnar artery.



**Figure 2.** Radiographs of left and right metacarpal hands.



**Figure 3.** Right great toe transfer for reconstruction of the right thumb.

Note. LDN = lateral digital nerve; DPA = dorsalis pedis artery; DPN = deep peroneal nerve; V = vein; EHL = extensor hallucis longus; FHL = flexor hallucis longus; MDN = medial digital nerve; SPN = superficial peroneal nerve.

No postoperative reexplorations of the microsurgical anastomoses were required in any of the 4 toe transfer stages. Fortunately, recipient veins were found for all 4 transfers, despite the entire dorsal surface of both wrists and forearms being covered with split-thickness skin grafts. The patient did not consent to undergo a mid-metatarsal amputation of both feet and wanted to keep the fourth and fifth toes on both feet.

## Results

Four years following his last toe transfers (Figure 6), the patient is able to perform all activities of daily living and on direct questioning does not feel that he has any limitations in either hand. Functional testing 4 years postoperatively revealed Box and Blocks test scores of 30 (right hand) and 40 (left hand). The Nine-Hole Peg test score was 78/100 (right hand) and 80/100 (left hand). The Southampton Hand Assessment Protocol (SHAP) score was 76/100 (right hand) and 81/100 (left hand). Two-point discrimination was 5 to 7 mm in all 6 toe transfers. His Disabilities of the Arm, Shoulder and Hand (DASH) score was 27 (with 0 being no subjective impression of disability). Gait and foot pressure analysis 4 years following the last toe transfer procedure was reported as essentially normal (Figure 7).

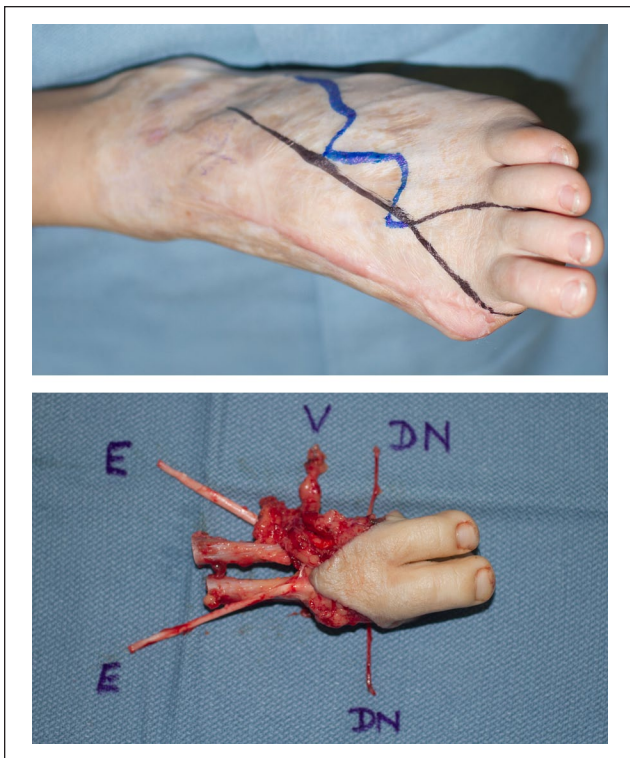
## Discussion

While there is consensus that microsurgical toe transfers are the criterion standard for reconstruction of metacarpal





**Figure 4.** Postoperative photograph of right great toe-to-right thumb and left great toe-to-left thumb transfers.



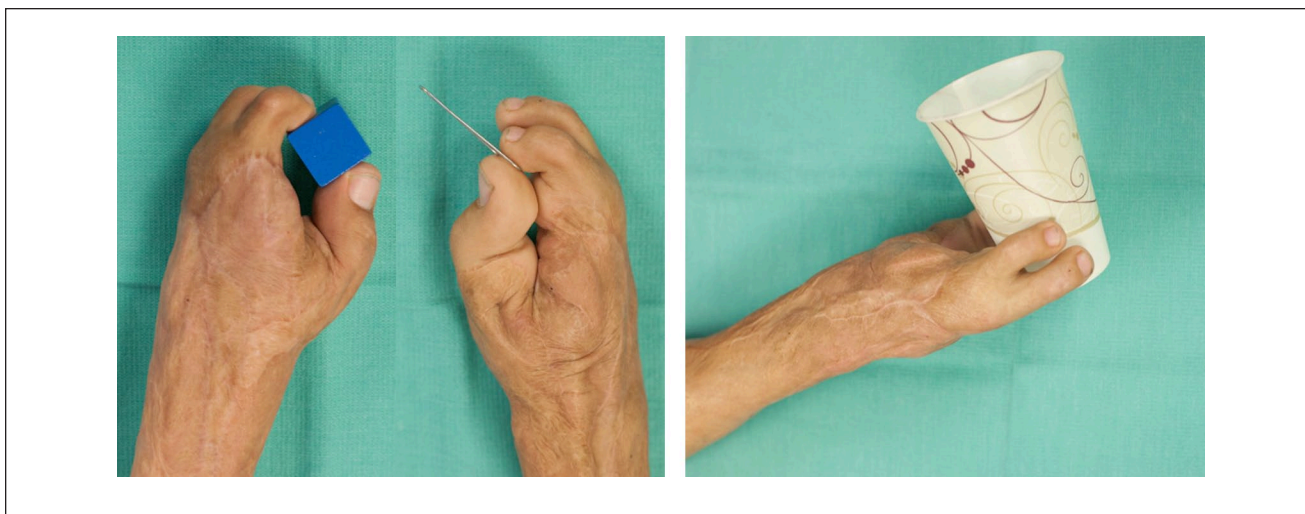
**Figure 5.** Combined left second-third toe monobloc transfer after previous transfer of the left great toe.

Note. E = extensor tendon; V = vein; DN = digital nerve.

hands, the decision whether to transfer 2 or 3 toes, which toes to harvest (the great toe, the second toe, or combined second and third toes), where to position the toe transfers, and the specific sequence of transfers remain controversial. Furthermore, the great majority of reported cases only describe unilateral metacarpal hand reconstructions. Soft tissue replacement with a pedicle groin flap has been advocated prior to considering multiple toe transfers,<sup>7</sup> but we elected to perform all 6 toe transfers without utilizing a preliminary groin flap because even a thin groin flap adds extra bulkiness to the reconstructed hand.

For the most simple type I unilateral metacarpal hand with an intact thumb, most surgeons would recommend a second toe transfer to the ulnar side of the hand to allow pinch and grasp movements.<sup>4,8-11</sup> Surgeons with extensive microsurgical expertise have advocated the transfer of 2 second toes, one from each foot, either performed simultaneously or staged sequentially, to provide improved tripod pinch, or even a combined second-third toe transfer toward the ulnar side of the hand.<sup>12-15</sup> Kay and Wiberg<sup>12</sup> considered the donor site of a combined second-third toe transfer in the foot to be unacceptable, but did not hesitate to transfer 2 second toes simultaneously, one from each donor foot, to minimize any donor site morbidity.

Wei et al<sup>14</sup> argued that a combined second-third toe transfer is a better choice when 2 adjacent digits need to be reconstructed in a type I metacarpal hand, if the amputation is proximal to the MCPs, whereas individual transfer of



**Figure 6.** Reconstruction of bilateral metacarpal hands with bilateral great toe transfers and bilateral combined second-third toe monobloc transfers 4 years postoperatively.



**Figure 7.** Photograph of both feet 4 years postoperatively showing retention of the fourth and fifth toes bilaterally.

bilateral second toes is a better option for reconstruction of 2 fingers, if the amputation level is distal to the MCPs. Wei et al<sup>2,16</sup> also described a unique reconstruction of all 4 fingers of a unilateral type IB metacarpal hand with an intact thumb using a combined second-third toe transfer to reconstruct the index and long fingers and subsequently reconstructed the ring and small fingers by transfer of the contralateral combined second-third toes.

For unilateral type II metacarpal hands, there are 4 options for reconstruction. Most surgeons would recommend bilateral second toe transfers into the thumb and small finger positions, either transferred sequentially or simultaneously.<sup>8</sup> Alternatively, the second toe can be transferred to reconstruct the thumb and the third toe from the contralateral foot transferred to reconstruct one finger,<sup>17</sup> or the great toe from one foot can be transferred to reconstruct the thumb and the second toe

from the contralateral foot can be transferred to reconstruct the small finger.<sup>11,18</sup> A third option is to transfer the second toe from one foot to reconstruct the thumb and to transfer a combined second-third toe monobloc from the contralateral foot to reconstruct 2 fingers.<sup>3,4,14,19</sup> The final option which we employed in this child is to consider transferring the great toe from one foot to reconstruct the thumb and transferring a combined second-third toe monobloc from the contralateral foot to reconstruct 2 fingers toward the ulnar side of the hand. Transferring 3 toes instead of 2 toes provides tripod pinch, greater contact surface area for pulp to pulp pinch, and increased grip strength. When transferring 2 or more toes for a unilateral metacarpal hand, there is no consensus as to the particular order of the transfers, but most surgeons prefer to transfer a toe into the thumb position first and then perform a second transfer into the optimum position for pinch.

Gordon et al<sup>8</sup> described 8 unilateral metacarpal hands out of 16 patients who underwent multiple toe transfers and recommended either a great toe or a second toe for thumb reconstruction and either a contralateral second toe or a combined second-third toe transfer for finger reconstruction. Two of these 8 unilateral metacarpal hands were in children. Yu and Huang<sup>20</sup> recommended the great toe or second toe from one foot to reconstruct the thumb and the second toe from the contralateral foot to reconstruct one finger, or alternatively, a great toe skin-nail flap wrapped around an iliac crest bone graft to reconstruct the thumb and a combined second-third toe transfer from the same foot to reconstruct 2 fingers. Wei et al<sup>21,22</sup> and Tan et al<sup>23</sup> reported successful reconstruction of a unilateral metacarpal hand by transfer of combined second-third toes to reconstruct the index and long fingers and secondarily a contralateral second toe to reconstruct the thumb. Wei et al<sup>16,22</sup> reported 2 unilateral metacarpal hand reconstructions from a series of 26 combined second-third toe transfers. Two patients underwent a trimmed great toe trans-



fer for thumb reconstruction and a combined second-third toe transfer for reconstruction of either the index and long fingers or the long and ring fingers. Kotkansalo et al<sup>4</sup> described 12 unilateral “no-finger hands,” but only 2 were reconstructed, one with 2 second toe transfers to reconstruct the thumb and small finger and one by a second toe transfer to reconstruct the thumb and combined second-third toes to reconstruct the long and ring fingers. Del Piñal et al<sup>3</sup> reported reconstruction of 3 unilateral type III metacarpal hands in which the great toe or a modification was transferred to the thumb at the first stage, followed by a combined transfer of the second and third toes into the index and long finger positions in 1 patient and into the ring and small finger positions in 2 patients. Yu and Huang<sup>20</sup> advocated using only a single donor foot for reconstruction of 64 fingerless hands in what was described as “one-foot donation reconstruction.” Either the distal half of the distal phalanx of the great toe was included in a wrap around flap and combined with the adjacent second toe to reconstruct the thumb and index finger, or the distal half of the distal phalanx of the great toe was included in a wrap around flap combined with the adjacent second and third toes to reconstruct the thumb, index, and long fingers, all based on the common vascular pedicle of the dorsalis pedis artery and greater saphenous vein. Williamson et al<sup>11</sup> also described harvesting the entire great toe, second toe, and third toe from the same foot to reconstruct the thumb, index, and long fingers. Yu<sup>15</sup> performed a unique case of unilateral metacarpal hand reconstruction, missing all 4 fingers but with half the proximal phalanx of the thumb remaining. A skin-nail flap including half the distal phalanx of the great toe, together with the adjacent combined second-third toes from one foot, was used to reconstruct the thumb, index, and long fingers, and in the same operation, the combined second-third toes from the contralateral foot were used to reconstruct the ring and small fingers. The dorsalis pedis arterial pedicle of this combined transfer was anastomosed into the deep plantar branch of the other combined transfer, and similarly the saphenous vein pedicle of one transfer was anastomosed into a side branch of the other transfer. Julve and Villen<sup>24</sup> reported using the great toe and second toe as a single anatomical monobloc, based on a common vascular pedicle, to reconstruct the thumb and small finger, the thumb and index finger, or the thumb and long finger in 3 unilateral metacarpal hands.

There are very few reports of posttraumatic reconstruction of bilateral metacarpal hands and even fewer in children.<sup>14,15</sup> Reconstruction of bilateral metacarpal hands missing a thumb is more difficult than bilateral metacarpal hands missing just 4 fingers, because it usually requires more than 4 toe transfers. There are 3 options for reconstruction of bilateral type II (Wei), type III (Pinal), level B (Kotkansalo), or R5(m or p) (Jones) metacarpal hands: bilateral great toes to reconstruct both thumbs and bilateral second toe transfers to reconstruct one finger in each hand (4 toes); a trimmed great toe transfer for the thumb and either combined second-third toes or combined third-fourth toes to reconstruct the long and ring fingers

of the dominant hand and either a second toe or third toe to reconstruct the nondominant thumb and a third or fourth toe to reconstruct the nondominant ring finger (5 toes); or as in this case 2 great toe transfers to reconstruct both thumbs and either bilateral combined second-third toe transfers or combined third-fourth toe transfers to reconstruct 2 fingers on each hand (6 toes). Wei et al<sup>14</sup> described 6 patients with bilateral metacarpal hands. Three patients had type I metacarpal hands (IA and IC, IA and IIB, and IA and IA) who underwent reconstruction with 4 toe-to-hand transfers using bilateral combined second-third toe transfers. Three patients had bilateral type II metacarpal hands (IIA and IIB, IIA and IIC, and IIC and IIC), including one 7-year-old child. All 3 patients underwent reconstruction, with 5 toe transfers performed in 2, 3, or 4 stages. Yu and Huang<sup>20</sup> reported 6 patients who underwent bilateral metacarpal hand reconstruction with either a wrap around flap and second toe or a wrap around flap and combined second-third toes harvested from each foot.

The most number of complete toes ever transferred to reconstruct bilateral metacarpal hands has been 5. To our knowledge, there has not been a previous report describing transfer of 6 complete toes for reconstruction of bilateral metacarpal hands. Wei et al<sup>14</sup> stated that “although using 6 toes seems an even better option for tripod pinch in both hands, they were reluctant to consider this because of increased donor site morbidity.” These authors also stated that “they had never harvested both great toes because harvesting both great toes would have increased the morbidity of the donor feet,” and in these cases, they had selected the great toe for reconstruction of the dominant thumb and a lesser second or third toe for reconstruction of the nondominant thumb. Furthermore, there is very little objective data documenting hand function after metacarpal hand reconstruction. Only 3 of 14 previous studies have provided functional outcome data.<sup>4,11,25</sup> Similarly, there is very little information regarding morbidity after multiple toes have been harvested from one or both feet or gait analysis of these donor feet.<sup>19,25,26</sup>

## Conclusions

This case demonstrates that bilateral metacarpal hands either in an adult or a child can be successfully reconstructed using 6 toe transfers. When transferring 2 or more toes sequentially from the same foot, one toe transfer (usually the great toe, occasionally the second toe) must be dissected on the dorsal circulation, whereas the second transfer (a second toe, combined second-third toe monobloc, or combined third-fourth toe monobloc) must be dissected on the plantar circulation. In this case, the great toes were harvested based on the dorsal circulation of the foot, the first dorsal metatarsal artery; the combined monobloc second-third toes were harvested based on the plantar circulation of the foot, the second plantar metatarsal artery. Theoretically, all 6 toe transfers could have been performed simultaneously in one operation, or alternatively, the 6 toe transfers

could have been performed in 2 stages (bilateral great toe transfers followed by bilateral combined second-third toe transfers). However, because this child had so much to lose with the failure of any one transfer, which would necessitate a complete change in surgical strategy, we felt that the safest option was to perform staged sequential transfers. Functional and psychological outcomes have been remarkable; furthermore, even after harvesting both great toes and both second-third toes, the remaining fourth and fifth toes can be preserved and gait analysis has confirmed minimal or no morbidity in either foot.

### 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 this study.

### Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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### References

1. Michon J, Dolich B. Metacarpal hand. *Hand*. 1974;6:285-290.
2. Wei F-C, El-Gammal TA, Lin C-H, et al. Metacarpal hand: classification and guidelines for microsurgical reconstruction with toe transfers. *Plast Reconstr Surg*. 1997;99:122-128.
3. Del Piñal F, Garcia-Bernal FJ, Delgado J. Reconstruction of metacarpal hand by combined second and third toe transfer. *Rev Esp Cir Ortop Traumatol*. 2007;51(1):15-24.
4. Kotkansalo T, Vilkki SK, Elo P. The functional results of post-traumatic metacarpal hand reconstruction with microvascular toe transfers. *J Hand Surg Eur Vol*. 2009;34:730-742.
5. Jones NF, Kaplan J. A new documentation system for congenital absent digits. *Hand*. 2012;7:391-399.
6. Wright TW, Hagen AD, Wood MB. Prosthetic usage in major upper extremity amputations. *J Hand Surg Am*. 1995;20:619-622.
7. Lutz BS, Wei FC, Chen SH, et al. Functional reconstruction of the metacarpal hand with multiple toe transplantations. *Tech Hand Up Extrem Surg*. 1999;3:37-43.
8. Gordon L, Leitner DW, Buncke HJ, et al. Hand reconstruction for multiple amputations by double microsurgical toe transplantation. *J Hand Surg Am*. 1985;10:218-225.
9. Gu YD, Zhang GM, Cheng DS, et al. Free toe transfer for thumb and finger reconstruction in 300 cases. *Plast Reconstr Surg*. 1993;91:693-700.
10. Lister GD, Kalisman M, Tsai TM. Reconstruction of the hand with free microvascular toe-to-hand transfer: experience with 54 toe transfers. *Plast Reconstr Surg*. 1983;71:372-384.
11. Williamson JS, Manktelow RT, Kelly L, et al. Toe-to-finger transfer for post-traumatic reconstruction of the fingerless hand. *Can J Surg*. 2001;44:275-283.
12. Kay SP, Wiberg M. Toe to hand transfer in children. Part 1: technical aspects. *J Hand Surg Br*. 1996;21:723-734.
13. Tsai TM, Jupiter JB, Wolff TW, et al. Reconstruction of severe transmetacarpal mutilating hand injuries by combined second and third toe transfer. *J Hand Surg Am*. 1981;6:319-328.
14. Wei F-C, Lutz BS, Cheng S-L, et al. Reconstruction of bilateral metacarpal hands with multiple-toe transplantations. *Plast Reconstr Surg*. 1999;104:1698-1704.
15. Yu ZJ. Reconstruction of a digitless hand. *J Hand Surg Am*. 1987;12:722-726.
16. Wei F-C, Colony LH, Chen H-C, et al. Combined second and third toe transfer. *Plast Reconstr Surg*. 1989;84:651-661.
17. Holle J, Frielinger G, Mandl H, et al. Grip reconstruction by double-toe transplantation in cases of a fingerless hand and a handless arm. *Plast Reconstr Surg*. 1982;69:962-968.
18. Venkatramani H, Bharwaj P, Sierakowski A, et al. Functional outcomes of post-traumatic metacarpal hand reconstruction with free toe-to-hand transfer. *Indian J Plast Surg*. 2016;49:16-25.
19. Gulgonen A, Gudemez E. Toe-to-hand transfers: more than 20 years follow-up of five post-traumatic cases. *J Hand Surg Br*. 2006;31:2-8.
20. Yu ZJ, Huang Y. Sixty-four cases of thumb and finger reconstruction using transplantation of the big toe skin-nail flap combined with the second toe or the second and third toes. *Plast Reconstr Surg*. 2000;106:335-341.
21. Wei FC, Coessens B, Ganos D. Multiple microsurgical toe-to-hand transfer in the reconstruction of the severely mutilated hand. *Ann Chir Main Memb Super*. 1992;11:177-187.
22. Wei FC, Seah CS, Chen HC, et al. Functional and esthetic reconstruction of a mutilated hand using multiple toe transfers and iliac osteocutaneous flap: a case report. *Microsurgery*. 1993;14:388-390.
23. Tan BK, Wei FC, Lutz BS, et al. Strategies in multiple toe transplantation for bilateral type II metacarpal hand reconstruction. *Hand Clin*. 1999;15:607-612.
24. Julve GG, Villen GM. The multiple monoblock toe-to-hand transfer in digital reconstruction. A report of ten cases. *J Hand Surg Br*. 2004;29:220-227.
25. Chung KC, Kotsis SV. Outcomes of multiple microvascular toe transfers for reconstruction in 2 patients with digitless hands: 2- and 4-year follow-up case reports. *J Hand Surg Am*. 2002;27:652-658.
26. Maruccia M, Kiranantawat K, Yeo MS, et al. Donor Site of toe transfer: is combined second and third toe transfer the better choice? A 31 years of long-term follow-up. *Microsurgery*. 2014;34:500-501.