OPEN

PRS GLOBAL OPEN

IDEAS AND INNOVATIONS

Hand/Peripheral Nerve

Functional Improvement with Free Vascularized Toe-to-hand Proximal Interphalangeal (PIP) Joint Transfer

İsmail Melih Kuzu, MD*
Reşit Burak Kayan, MD*
Kahraman Öztürk, MD†
Ethem Güneren, MD*

Background: Reconstruction of small joints of fingers is still challenging in hand surgery. Implant arthroplasty and arthrodesis have some limitations in the reconstruction of small finger joints. Free vascularized PIP joint transfer from second toe to finger is a promising autogenous reconstructive alternative.

Methods: In this prospective study, 7 cases of free vascularized PIP joint transfer were analyzed. The measurements for active and passive range of motion (ROM), grip, and pinch strength has been done preoperatively and 1-year postoperatively. The functional change in daily life quality and work-related activities was evaluated with Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.

Results: Mean follow-up period was 20.3 months (12–25). Preoperative mean active and passive ROM values were 3.6° (0–14°) and 11.9° (0–29°), respectively. Postoperative 1-year measurements revealed a mean active ROM of 24.1° and a mean passive ROM of 31.6°. Mean grip and pinch strength increased from 52.1 to 58.6 lbs and from 5.1 to 5.9 lbs, respectively. Mean preoperative and postoperative DASH-scores were 41.3 and 30.3.

Conclusion: The improvement in ROM, increasing grip strength, and declining DASH scores in our study support that free vascularized joint transfer improves patients' daily life quality and work-related activities via providing a functional joint if performed with appropriate indications, careful planning, and meticulous surgical execution. Free vascularized joint transfer provides an autogenous, painless, mobile, and stable joint. It also has the advantages of composite tissue reconstruction and lacks the disadvantages of arthrodesis and synthetic joint implants. *(Plast Reconstr Surg Glob Open 2018;6:e1775; doi: 10.1097/GOX.0000000000001775; Published online 9 July 2018.)*

INTRODUCTION

The hand is one of the most complicated structures in the human body. Although traumatic injuries of the small joint of the fingers are relatively rare, the recovery period and treatment of these traumas are pretty challenging. Frequently, even with the ideal treatment, they may heal with sequelae. The sequelae of even one proximal interphalangeal (PIP) joint often results in global hand dysfunction, disabilities in work-related activities, and impairment of daily-life activities.[1]

*From the *Department of Plastic, Reconstructive and Aesthetic Surgery, Bezmialem Vakif University, Istanbul, Turkey; and †Department of Hand Surgery, Metin Sabancı Baltalimanı Bone Diseases Training and Research Hospital, Istanbul, Turkey.*

Received for publication December 18, 2017; accepted March 13, 2018.

DOI: 10.1097/GOX.0000000000001775

Reconstruction of small joints, particularly PIP joints, is still a challenging entity. Arthrodesis as one of the ultimate reconstructive options has the disadvantage of static/immobile reconstruction. Because of thin soft-tissue coverage, delicate anatomy and functional work load of the finger joints, joint arthroplasty and implants frequently bring with potential complications such as infection, implant loosening, joint contractures, and dislocation resulting in revision rates as high as 33% and removal rates of 20%.[2,3]

With the help of cumulative knowledge and experience gained from the introduction and popularization of toe transfers, free vascularized transfer of the PIP joint from second toe becomes one of the major alternatives for finger joint reconstruction, especially for young and active patients.[4,5] It has sufficient stability and range of motion (ROM), lacks long-term disadvantages of joint implants,

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.*

Supplemental digital content is available for this article. Clickable URL citations appear in the text.

Case Number	Age	Etiology	Occupation	Dominant Hand	Recipient Finger	Donor Toe	Flap Dominant Artery	Fixation Material	Pre-op Passive ROM	Post-op Passive ROM	Pre-op Active ROM	Post-op Active ROM
1	31	Open fracture	Handworker	Right	Left hand D4	Left foot D2	Dorsal	Cerclage wire	0°	53°	0°	43°
2	30	Replantation	Handworker	Right	Right hand D4	Right foot D2	Dorsal	Cerclage wire	29°	38°	0°	28°
3	25	Open fracture	Handworker	Right	Right hand D3	Right foot D2	Dorsal	Cerclage wire	0°	21°	0°	18°
4	16	Closed fracture	Student	Right	Left hand D3	Left foot D2	Plantar	Kirschner wire	14°	19°	11°	13°
5	45	Open fracture	Handworker	Right	Right hand D3	Right foot D2	Dorsal	Cerclage + Kirschner wire	19°	41°	0°	29°
6	40	Replantation	Handworker	Right	Left hand D4	Left foot D2	Dorsal	Plate-screws + Kirschner wire	0°	22°	0°	16°
7	19	Closed fracture	Student	Right	Left hand D2	Right foot D2	Plantar	Plate-screws + Cerclage wire	21°	27°	14°	22°
Mean	**29.4**								**11.9°**	**31.6°**	**3.6°**	**24.1°**

Fig. 1. Table showing patient details and active–passive ROM values.

thereby allows painless, autogenous reconstruction with a composite flap. Other advantages are growth potential due to transfer of epiphyseal growth plates in children and minimal donor-area morbidity.[6–8] The successful transfer and ultimate functioning of joints reconstructed by transfer represent a state-of-the-art accomplishment in plastic surgery.

According to our literature review, results of free vascularized toe-to-hand PIP joint transfer is discussed concerning the changes in ROM and grip strength[9,10] but not investigated in terms of functional change in pain relief, daily-life quality, and work-related activities with an objective and consistent method such as a questionnaire.[11] We tried to evaluate these terms with the help of Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire in our study.

PATIENTS AND METHODS

In this prospective study, 7 cases of free vascularized PIP joint transfer were analyzed. The measurements for active/passive ROM, grip/pinch strength has been done and DASH-questionnaire has been filled preoperatively and 1-year postoperatively.

All patients were male and right-handed. Mean patient age was 29.4 (16–45). Mean follow-up period was 20.3 months (12–25). Details of the etiology, type and location of the trauma, recipient area and flaps are given in Figure 1. Operated PIP joints were totally ankylosed in 3 cases and severely damaged in the 4 others.

Flap design includes a skin island on the tibial side of second toe, a superficial vein in connection with this island and tibial side digital artery (Fig. 2). After defining ideal length of bones, the phalanges were cut and flap was divided (Fig. 3).

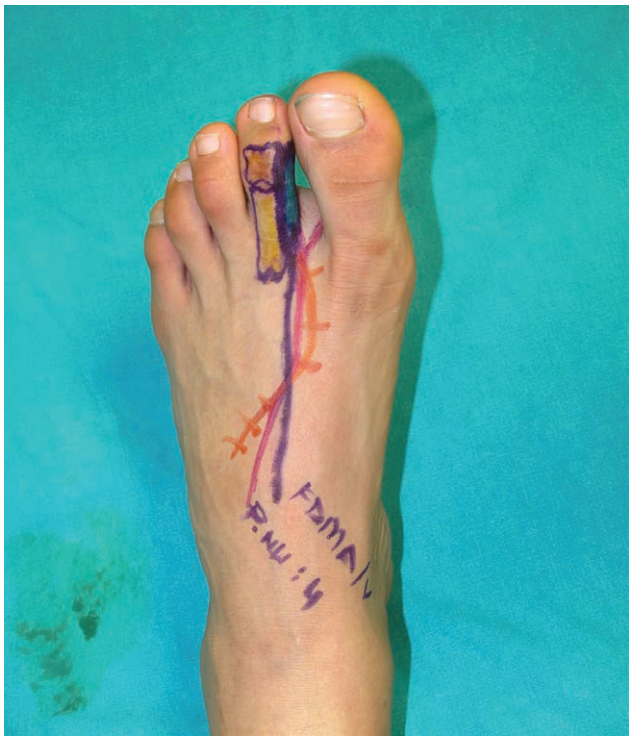

Fig. 2. Flap design.

Fig. 3. Flap on the table with markings. A, tibial side digital artery; V, dorsal vein; N, tibial side digital nerve; and T, extensor tendon.

RESULTS

Mean active ROM was 3.6° (0–14°) preoperatively and increased to 24.1° (13–43°), similarly mean passive ROM increased from 11.9° (0–29°) to 31.6° (19–53°) in postoperative 1-year measurements (Fig. 1).

Mean grip and pinch strength increased from 52.1 to 58.6 lbs and from 5.1 to 5.9 lbs., respectively. Grip strength changes revealed that especially in 3 cases the values increased more than 25% (Fig. 4), and these cases also have relatively higher ROM values. These findings support the successful joint transfer as the ideal reconstruction method for the young and actively working patients.

Mean preoperative and postoperative DASH scores were 41.3 and 30.3. A change above 10 points might be interpreted as functionally significant[12] and declining DASH scores are interpreted as improved functional status. Mean decrease in our series is 11 points, and 4 of the decreasing scores are above 10 points. Mean value of work module DASH scores decreased from 70 to 25 points (Fig. 4).

The only case for which the performing arts module DASH score was calculated had a decrease from 100 to 0, and therefore can be interpreted as a total recovery from nonfunctioning state. This patient was considered as the most favorable case, with decreasing standard DASH score from 50.8 to 5 and work module DASH-score from 75 to 25 points and the highest postoperative ROM values (**See**

Case Number	Age	Pre-op Grip Strength (lbs)	Post-op Grip Strength (lbs)	Pre-op Pinch Strength (lbs)	Postop Pinch Strength (lbs)	Extensor Lag	Pre-op DASH Score	Post-op DASH Score	Pre-op DASH Work Module	Post-op DASH Work Module	Pre-op DASH Performance Module	Post-op DASH Performance Module
1	31	50	70	3	6	29°	50.8	5	75	25	100	0
2	30	95	90	4	4	45°	54.2	43.3	50	31.25	-	-
3	25	10	30	2	3	42°	51.6	45	100	43.75	-	-
4	16	55	50	7	6	53°	20	24.2	-	-	-	-
5	45	60	75	9	10	17°	23.3	13.3	43.75	12.5	-	-
6	40	30	35	2	3	21°	58.3	46.6	81.25	62.5	-	-
7	19	65	60	9	9	48°	32.5	35	-	-	50	50
Mean	**29.4**	**52.1**	**58.6**	**5.1**	**5.9**	**36.4°**	**41.3**	**30.3**	**70**	**25**	**75**	**25**

Fig. 4. Table showing detailed grip and pinch strengths, DASH scores.

Video Graphic 1. See video, Supplemental Digital Content 1, which displays details in Case 1. This video is available at ***http://links.lww.com/PRSGO/A776***.

video, Supplemental Digital Content 1, which displays details in Case 1. This video is available at ***http://links.lww.com/PRSGO/A776***).

In postoperative 1 year, all joints are evaluated in terms of extensor lag. A mean value of 36.4° (17–53°) were calculated (Fig. 4).

In 1 case, early postoperative (12 hours) exploration was required due to arterial compression in the subcutaneous tunnel.

DISCUSSION

Mean active ROM values after free vascularized PIP joint transfer reported in literature range between 23.6° and 53.7°.[2] In our series, mean active ROM was 24.1°. The reported highest active ROM value is 63°[13]; in our series, it is measured as 43°. If the cause of relatively low mean active ROM is investigated, we encounter 3 cases that might be interpreted as average results with active postoperative ROM values lower than 20°.

First of these cases required early postoperative revision surgery due to arterial insufficiency. Possibly the lower ROM value resulted from the necrosis of the hyaline cartilage due to the early ischemia. After ischemic period, the hyaline cartilage transforms to the fibrous cartilage, which significantly limits gliding and motions of the joint.

Bony fixation in the second case was maintained by plate-screws and the patient undergone a revision surgery for tenolysis. This may be the result of excessive soft-tissue dissection and periosteal stripping during the implementation of plate-screws.

The last case with average result did not continue the intense physiotherapy and rehabilitation program. This indicates the importance of patient motivation and compatibility with physiotherapy for the optimal result after joint transfer.

Many bony fixation techniques such as cerclage wires, K-wires, plate, and screws are defined between finger and joint flap.[9,14] All of them are used in our series, and best results were obtained with cerclage wires. Main determining factors for fixation methods are bone stock, bone quality, and sizes of phalanges. Bone fixation certainly requires careful planning. Major discrepancies between donor and recipient phalanges will result in complications.

Especially, extensor lag is defined as an unavoidable result of free vascularized joint transfer.[15] In the literature, all series report mean extensor lag values ranging between 17.1° and 42.5°.[16] The cause of extensor lag and corrective methods are well defined in literature.[4,5,11,15–17]

The improvement in ROM, increasing grip strength, and declining DASH scores in our study indicate that free vascularized joint transfer improves patients' daily-life quality and work-related activities via providing a functional joint if performed with appropriate indications, careful planning, and meticulous surgical execution.

İsmail Melih Kuzu, MD
Department of Plastic, Reconstructive and Aesthetic Surgery
Bezmialem Vakif University
Vatan Caddesi 34093 Fatih, Istanbul, Turkey
imkuzu@gmail.com

REFERENCES

1. Amadio P, Shin A. *Arthrodesis and Arthroplasty of Small Joints of the Hand, in Green's Operative Hand Surgery.* 6th ed. S. Wolfe, et al., eds. Philadelphia, Pa.: Elsevier/Churchill Livingstone; 2011:389–406.
2. Squitieri L, Chung KC. A systematic review of outcomes and complications of vascularized toe joint transfer, silicone arthroplasty, and PyroCarbon arthroplasty for posttraumatic joint reconstruction of the finger. *Plast Reconstr Surg.* 2008;121:1697–1707.
3. Bravo CJ, Rizzo M, Hormel KB, et al. Pyrolytic carbon proximal interphalangeal joint arthroplasty: results with minimum two-year follow-up evaluation. *J Hand Surg Am.* 2007;32:1–11.
4. Lin YT, Kao DS, Wan DC, et al. Simultaneous reconstruction of extensor mechanism in the free transfer of vascularized proximal interphalangeal joint. *Tech Hand Up Extrem Surg.* 2013;17:20–24.
5. Lin, Y.-T. and C.Y.Y. Loh, A Novel Technique for Correcting Extensor Lag in Vascularized Toe PIP Joint Transfers. *Techniques in hand & upper extremity surgery*, 2016. 20(3): p. 104–107.
6. Singer DI, O'Brien BM, McLeod AM, et al. Long-term follow-up of free vascularized joint transfers to the hand in children. *J Hand Surg Am.* 1988;13:776–783.
7. Ishida O, Tsai TM. Free vascularized whole joint transfer in children. *Microsurgery.* 1991;12:196–206.
8. Tsubokawa N, Yoshizu T, Maki Y. Long-term results of free vascularized second toe joint transfers to finger proximal interphalangeal joints. *J Hand Surg Am.* 2003;28:443–447.
9. Chen SH, Wei FC, Chen HC. Vascularized toe joint transplantation. *Hand Clin.* 1999;15:613–627.
10. Foucher G, Sammut D, Citron N. Free vascularized toe-joint transfer in hand reconstruction: a series of 25 patients. *J Reconstr Microsurg.* 1990;6:201–207.
11. Chen HY, Lin YT, Lo S, et al. Vascularised toe proximal interphalangeal joint transfer in posttraumatic finger joint reconstruction: the effect of skin paddle design on extensor lag. *J Plast Reconstr Aesthet Surg.* 2014;67:56–62.
12. Gummesson C, Atroshi I, Ekdahl C. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. *BMC Musculoskelet Disord.* 2003;4:11.
13. Kimori K, Ikuta Y, Ishida O, et al. Free vascularized toe joint transfer to the hand. A technique for simultaneous reconstruction of the soft tissue. *J Hand Surg Br.* 2001;26:314–320.

14. Kao D, Lin Y, Wei F. *Vascularized Joint Transfer, in The Art of Microsurgical Hand Reconstruction*. Slutsky D, ed. New York, N.Y.: Thieme; 2013:296–303.
15. Waughlock N, Hsu CC, Lam WL, et al. Improving the extensor lag and range of motion following free vascularized joint transfer to the proximal interphalangeal joint: Part 1. An observational and cadaveric study. *Plast Reconstr Surg*. 2013;132:263e–270e.
16. Lam WL, Waughlock N, Hsu CC, et al. Improving the extensor lag and range of motion following free vascularized joint transfer to the proximal interphalangeal joint: Part 2. A clinical series. *Plast Reconstr Surg*. 2013;132:271e–280e.
17. Loh CY, Hsu CC, Lin CH, et al. Customizing extensor reconstruction in vascularized toe joint transfers to finger proximal interphalangeal joints: a strategic approach for correcting extensor lag. *Plast Reconstr Surg*. 2017;139:915–922.