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

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, and 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.)

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

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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 3.6º (0–14º) and 11.9º (0–29º), respectively. Postoperative 1-year measurements revealed a mean active ROM of 24.1º and a mean passive ROM of 31.6º. 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.)

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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. 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 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. 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).
RESULTS

Mean active ROM was 3.6º (0–14º) preoperatively and increased to 24.1º (13–43º), similarly mean passive ROM increased from 11.9º (0–29º) to 31.6º (19–53º) 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 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 Fig. 3).

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

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.

Fig. 4. Table showing detailed grip and pinch strengths, DASH scores.
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 36.4º (17–53º) 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 25.6º and 53.7º. In our series, mean active ROM was 24.1º. The reported highest active ROM value is 63º13; in our series, it was measured as 43º. 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 20º.

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 intensive 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. 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. In the literature, all series report mean extensor lag values ranging between 17.1º and 42.5º. The cause of extensor lag and corrective methods are well defined in literature.

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.

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