

# Usefulness of Microscopic Procedures in Composite Grafts for Fingertip Injuries

Dong In Jo, Yu Kwan Song, Cheol Keun Kim, Jin Young Kim<sup>1</sup>, Soon Heum Kim\*

Departments of Plastic and Reconstructive Surgery, <sup>1</sup>Emergency Medicine, Konkuk University Chungju Hospital, Konkuk University School of Medicine, Chungju, Korea

**Purpose:** Fingertip amputations are the most common type of upper limb amputations. Composite grafting is a simple and cost-effective technique. Although many factors have investigated the success of composite grafting, the success rate is not high. Therefore, this study was conducted to investigate whether the microscopic procedure process during composite grafts improves the success rate.

**Materials and Methods:** Thirteen cases of unreplantable fingertip amputation underwent a microscopic resection procedure for composite graft in the operating room. The principle of the procedure was to remove the least devitalized tissue, maximize the clean tissue preservation and exact trimming of the acral vessel and to remove as many foreign bodies as possible.

**Results:** All fingertips in the thirteen patients survived completely without additional procedures.

**Conclusion:** Composite grafting allows for the preservation of length while avoiding the donor site morbidity of locoregional flaps. Most composite grafts are performed as quickly as possible in a gross environment. However, we take noticed the microscopic resection. This process is thought to increase the survival rate for the following reasons. First, the minimal resection will maximize the junction surface area and increase serum imbibition. Second, sophisticated trimming of injured distal vessels will increase the likelihood of inosulation. Third, accurate foreign body removal will reduce the probability of infection and make it possible to increase the concentration and efficiency in a microscopic environment. Although there is a need for more research into the mechanisms, we recommend using a composite graft under the microscopic environment.

**Key Words:** Finger injuries, Amputation, Transplants, Survival rate

Received April 29, 2017  
Accepted May 1, 2017

\*Correspondence to: Soon Heum Kim  
Department of Plastic and Reconstructive Surgery, Konkuk University Chungju Hospital, Konkuk University School of Medicine, 268 Chungwon-daero, Chungju 27478, Korea  
Tel: +82-43-840-8860  
Fax: +82-43-840-8960  
E-mail: PSongsuture@outlook.com  
ORCID: <http://orcid.org/0000-0001-9773-4753>

Financial support: None.  
Conflict of interest: None.

## INTRODUCTION

The fingertip amputations are the most common injury of upper extremity in daily life. Reconstruction with microanastomosis is ideal treatment; however, many fingertip injuries are not amenable to replantation due to the cutting level or mechanism of injury or lack of surgical expertise.<sup>1</sup> Especially,

the vessels in the distal to the lunula are diminutive in size and successful microanastomosis is very difficult. When replantation is unfeasible, alternative methods can be used. Its range from secondary intension and skin grafts to various local and locoregional flaps.<sup>2-6</sup> Though problem of these treatment is stiffness related to prolonged immobility and donor site morbidity.<sup>7</sup> Among these methods, composite grafting has many advantage

owing to it used the patient's own avulsed tissue. The procedure is technically simple and to allows for the preservation of function while avoiding the donor site morbidity.

In addition, it is a time-efficient and cost-effective technique.<sup>8</sup> However, survival rate of composite grafting is unpredictable in fingertip, hence most surgeons are skeptical about it. It depends on the injury type and patient's factor, but several studies report suggested techniques for improving the survival<sup>9-14</sup>: (1) increasing the contact surface area,<sup>12</sup> (2) ice-cooling the graft,<sup>11</sup> (3) using moist-exposed dressing,<sup>10</sup> (4) using pharmacologic agents,<sup>13</sup> (5) using hyperbaric oxygen.<sup>9,14</sup> Although these factors have been studied to determine the success of composite grafting, the survival rate is not high. Therefore, we assessed distal digital amputations with respect to the surgical procedure process not post-operative management to improve graft survival. This study aimed to explain the usefulness of microscopic procedure in composite grafting in distal digital amputation.

## MATERIALS AND METHODS

This study is a retrospective case series. Patients data were collected from medical record of Konkuk University Hospital. Under the microscopic field, total 13 cases of complete fingertip amputation were treated by composite graft from February 2016 to January 2017. All patients were treated in the operating room and evaluated that microscopic anastomosis was impossible. The patients were reviewed for sex, smoking history, diabetes history, injury type, location, amputation level, and presence of fracture.



**Fig. 1.** Orange line can be confirmed that the fingerprint is connected through the wound boundary.

## Surgical technique

After 2% xylocaine was infiltrated for digital nerve block, the amputated part and stump were washed with heparin solution (100 units of heparin/1 mL of normal saline). Under the microscopic field (OPMI Neuro/NC4; Carl Zeiss, Göttingen, Germany), all procedure were performed and the following important principles were applied.

1) Minimal resection was done to remove the devitalized tissue as much as possible (minimal effective resection as if peeling off the onion skin).

2) We tried trimming the end of the crushed blood vessel as precisely as possible (sophisticated clean cutting).

Prophylactic antibiotics (ZINPERAZONE INJ, 1 g/A; Kuk Je Pharma, Seongnam, Korea) was administered at all. Bleeding control was done with gauze soaking epinephrine. Composite graft was accurate attached as a docking through fingerprint with 6/0 blue nylon sutures in simple interrupted technique (Fig. 1). We confirmed that fresh bleeding on the dermal plane was permeated during suturing. The graft was handled carefully using microsurgical instruments only when needed.

In the case of a fracture, 23 G needle was used instead of K-wire to minimize tissue damage. When the nail-bed is damaged, repair was done with 7/0 catgut sutures. The average operation time was 30 minutes.

## Postoperative management

Lipo-PGE<sub>1</sub> (ALOSTIN, 10 µg/2 mL/A; Dong Kook Pharmaceutical, Seoul, Korea) mixed with 500 mL physiologic normal saline was administered for 7 days. Antibiotics (ZIN-

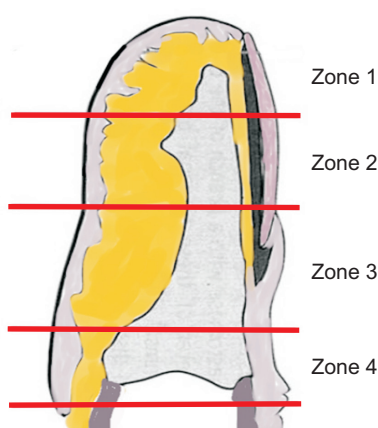


**Fig. 2.** The figure show floppy gentle open dressing.

PERAZONE INJ, 1 g/A; Kuk Je Pharma) was used for 7 days after surgery and Infrared heat lamp (InfraRed 300; Daekyung Co., Pocheon, Korea) was applied to the surgical site for 5 days. During the hospital stay, floppy gentle open dressing was maintained with moist gauze (Fig. 2). All composite grafts survived completely with a follow-up of 1 to 3 months.

## RESULTS

Under the microscopic field, thirteen fingertip amputations



**Fig. 3.** Classification of fingertip amputation by Ishikawa. Zone 1 and zone 2 are divided into a midline between tip and nail base. Zone 3 and zone 4 are divided into a midline between nail base and distal interphalangeal joint.

of 13 patients were treated by composite grafting. There were six men and 7 women with a mean age of 41.3 years (range, 24–57 years). Crushing injury by machine was the most common type. According to Ishikawa classification,<sup>15</sup> there were six cases of zone 1 and 7 cases of zone 2 (Fig. 3). Most of the patients were injured while working at the industrial zone (Table 1). All patients who underwent composite grafting survived without additional procedure. Case 1 is a patient suffering from crush injury by a machine. Congestion was observed on the postoperative day, but a pinkish portion appears slightly in the center of the graft in the 3 day after surgery.

On the postoperative day 7, we found an increase in pinkish color around the proximal margin and performed total stitch out. The 23 G needle fixed to the fracture site and nail anchoring suture were removed on 2 weeks postoperatively. On the 30 postoperative days, some skin scabs were observed but we were able to identify a fully viable graft (Fig. 4).

## DISCUSSION

The ideal treatment of fingertip amputation is microsurgical replantation. However replantation is often impossible in reality and composite grafting can be an alternative method. There have been many studies to improve the unstable success rate of composite grafting. Rose et al.<sup>12</sup> introduced the ‘cap technique’ to salvage the amputated distal part. Entire soft tissue of the

**Table 1.** Overview of patient characteristics

Case No.	Age (yr)	Sex	Location	Zone of injury	Type of injury	Place of injury	Distal phangeal fracture	DM	Smoking
1	51	F	Rt. index finger	Zone 2	Crushing	Industrial zone	No	No	No
2	29	M	Lt. ring finger	Zone 2	Guillotine	Industrial zone	No	No	No
3	51	F	Rt. ring finger	Zone 2	Crushing	Industrial zone	No	No	No
4	49	M	Lt. ring finger	Zone 1	Crushing	Industrial zone	Yes	No	Yes
5	46	F	Rt. little finger	Zone 2	Crushing	Industrial zone	Yes	No	No
6	34	M	Rt. middle finger	Zone 1	Crushing	Industrial zone	No	No	No
7	45	M	Rt. little finger	Zone 1	Crushing	Industrial zone	No	No	Yes
8	57	M	Rt. middle finger	Zone 1	Crushing	Industrial zone	No	Yes	Yes
9	25	M	Lt. middle finger	Zone 1	Crushing	Industrial zone	No	No	No
10	24	F	Lt. ring finger	Zone 1	Guillotine	House	No	No	No
11	45	F	Rt. ring finger	Zone 2	Crushing	Industrial zone	No	No	Yes
12	34	F	Rt. index finger	Zone 2	Crushing	Industrial zone	Yes	No	No
13	47	F	Lt. index finger	Zone 2	Crushing	Industrial zone	Yes	No	Yes

DM: diabetes mellitus, F: female, M: male, Rt.: right, Lt.: left.

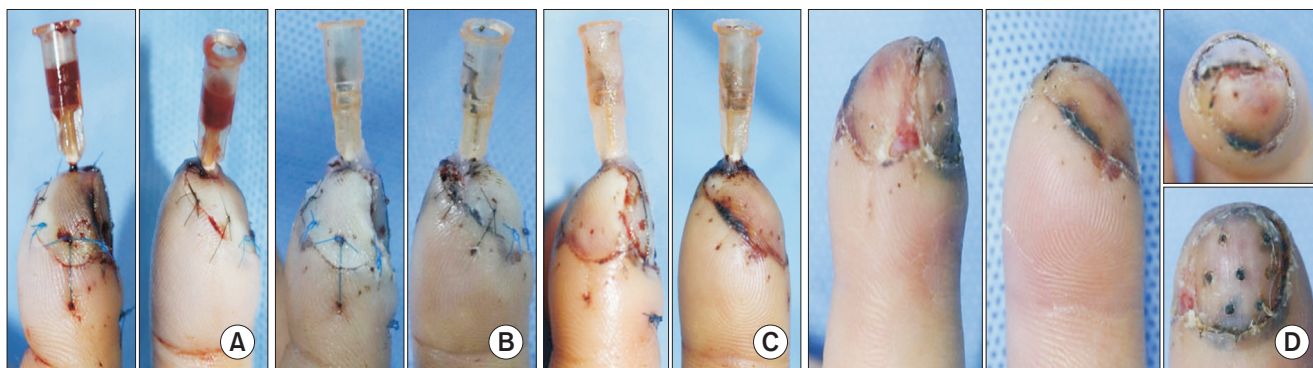


Fig. 4. The figures show postoperative day (A) 1, (B) 3, (C) 7, and (D) 30.

proximal stump was excised and the exposed bone was covered with the amputated part. Fractured distal phalangeal piece of the amputated part was excised. The principle of this method is increasing the surface area of contact between the graft and the recipient bed. The cap technique is preserve normal sensibility and nail matrix, but the finger is shortened. Although Uysal et al.<sup>16</sup> suggested to save some soft tissue of stump, soft tissue resection is inevitable for cap technique. In the process, some of the healthy soft tissue is also removed and we thought that this affects the survival rate. Under the microscopic field, soft tissue of the stump and amputated graft is preserve to the maximum and make a full connection between the clean tissues as a spacecraft docked at station. For enhanced graft-take, plasmatic circulation is important in the early stage. As the contact surface of healthy cells increase, the serum imbibition is maximized.<sup>17</sup> The minimal resection under the microscope connects graft and recipient bed precisely. This improves the chance of inosculation by lining up of the ruptured vessels.<sup>18</sup> We confirmed successful inosculation by observing the pink skin color of the reattached portion. Fingertip vessels around lunula are divided into proximal palmar arterial arch and proximal dorsal arterial arch from proximal palmar digital artery. In the sterile matrix area, microvessels are branched from each disal arch.<sup>10,19</sup> Eo et al.<sup>11</sup> have reported that numerous vascular channels and capillaries filled with fresh red blood cells was identified in amputated fingertip. In particular, vascular budding is formed in clean cutting vessels of distal stump and neovascularization and endothelial cell proliferation are observed.<sup>20,21</sup> Microscopic minimal resection is possible to preserve the vessel of amputated part and stump maximally (Fig. 5). It would that induce the increase the opportunity of angiogenesis and inosculation. The use of microscopic

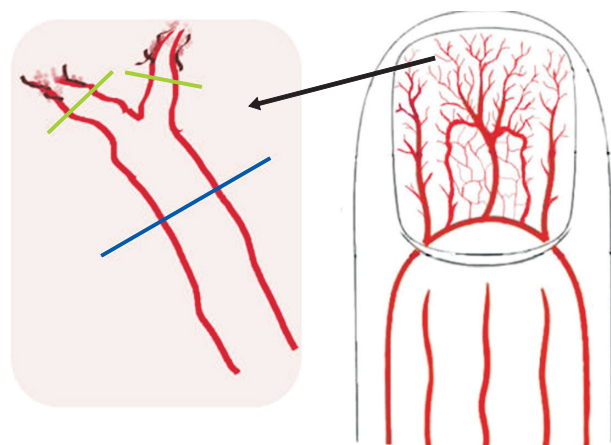


Fig. 5. This figure shows that sophisticated clean cutting is possible to cut the end of the vessel in green line instead of blue line.

surgical instruments can be also minimize tissue damage by elaborate control the tension of the suture. It is that preserves the dermal plexus as much as possible and improves the skin survival rate.<sup>22,23</sup>

Additionally, we noticed that it could clean up the crushed margin a little more under the microscopic field and it will be reduced the probability of infection. And we thought that the procedure with the experienced surgical team in the operating room was improve the concentration of the surgeon rather than the treatment in the emergency room and lead to effective results. Microscopic resection is excellent compared with magnifying glass in term of providing a high magnification (200 times magnification) environment and sharing the surgical field with the assist. In a high magnification environment, the probability of neuroma incidence can be reduced by confirming and treating ruptured terminal nerve.<sup>24</sup>

The limitation of the our study is the small number of

patients. In addition, surgical results can vary depending on proficiency in dealing with microscopic equipment. Further, there was no effective comparison due to the absence of the control group. However, despite these limitations, microscopic procedure is very useful. In future studies, we intend to include a larger patient case to enhance our results and recommendations.

## CONCLUSION

In summary, microscopic procedure is thought to increase the survival rate for the following reasons. First, minimal resection will maximize the junction surface area and increase the serum imbibition. Second, sophisticated trimming of injured distal vessels will increase the likelihood of inosculation. Third, accurate foreign body removal will reduce the probability of infection and it is possible to increase the concentration and efficiency in microscopic environment. We recommend using composite graft under the microscopic environment.

## REFERENCES

- David PG, William CP, Robert NH, Scot WW. Green's operative hand surgery. 5th ed. Philadelphia: Elsevier Churchill Livingstone; 2005.
- Holm A, Zachariae L. Fingertip lesions. An evaluation of conservative treatment versus free skin grafting. *Acta Orthop Scand* 1974;45:382-92.
- Hwang E, Park BH, Song SY, Jung HS, Kim CH. Fingertip reconstruction with simultaneous flaps and nail bed grafts following amputation. *J Hand Surg Am* 2013;38:1307-14.
- Kutler W. A new method for finger tip amputation. *J Am Med Assoc* 1947;133:29.
- Gurdin M, Pangman WJ. The repair of surface defects of fingers by trans-digital flaps. *Plast Reconstr Surg* 1950;5:368-71.
- Foucher G, Braun JB. A new island flap transfer from the dorsum of the index to the thumb. *Plast Reconstr Surg* 1979;63:344-9.
- Chen SY, Wang CH, Fu JP, Chang SC, Chen SG. Composite grafting for traumatic fingertip amputation in adults: technique reinforcement and experience in 31 digits. *J Trauma* 2011;70:148-53.
- Dagregori G, Saint-Cast Y. Composite graft replacement of digital tips in adults. *Orthopedics* 2006;29:22-4.
- Friedman HI, Fitzmaurice M, Lefavre JF, Vecchiolla T, Clarke D. An evidence-based appraisal of the hyperbaric oxygen on flaps and grafts. *Plast Reconstr Surg* 2006;117:175S-90S; discussion 191S-2S.
- Son D, Han K, Chang DW. Extending the limits of fingertip composite grafting with moist-exposed dressing. *Int Wound J* 2005;2:315-21.
- Eo S, Hur G, Cho S, Azari KK. Successful composite graft for fingertip amputations using ice-cooling and lipo-prostaglandin E1. *J Plast Reconstr Aesthet Surg* 2009;62:764-70.
- Rose EH, Norris MS, Kowalski TA, Lucas A, Fleegler EJ. The "cap" technique: nonmicrosurgical reattachment of fingertip amputations. *J Hand Surg Am* 1989;14:513-8.
- Fann PC, Hartman DE, Goode RL. Pharmacologic and surgical enhancement of composite graft survival. *Arch Otolaryngol Head Neck Surg* 1993;119:313-9.
- Li EN, Menon NG, Rodriguez ED, Norkunas M, Rosenthal RE, Goldberg NH, et al. The effect of hyperbaric oxygen therapy on composite graft survival. *Ann Plast Surg* 2004;53:141-5.
- Ishikawa K, Ogawa Y, Soeda H, Yoshida Y. A new classification of the amputation level for the distal part of the fingers. *J Jpn Soc Microsurg* 1990;3:54-62.
- Uysal A, Kankaya Y, Ulusoy MG, Sungur N, Karalezli N, Kayran O, et al. An alternative technique for microsurgically unreplantable fingertip amputations. *Ann Plast Surg* 2006;57:544-51.
- Conway H, Stark RB, Joslin D. Observations on the development of circulation in skin grafts. II. The physiologic pattern of early circulation in auto-grafts. *Plast Reconstr Surg* 1951;8:312-9.
- McLaughlin CR. Composite ear grafts and their blood supply. *Br J Plast Surg* 1954;7:274-8.
- Smith DO, Oura C, Kimura C, Toshimori K. Arterial anatomy and tortuosity in the distal finger. *J Hand Surg* 1991;16:297-302.
- Han SK, Chung HS, Kim WK. The timing of neovascularization in fingertip replantation by external bleeding. *Plast Reconstr Surg* 2002;110:1042-6.
- Sadoun E, Reed MJ. Impaired angiogenesis in aging is associated with alterations in vessel density, matrix composition, inflammatory response, and growth factor expression. *J Histochem Cytochem* 2003;51:1119-30.
- Geyer SH, Nöhammer MM, Tinhofer IE, Weninger WJ. The dermal arteries of the human thumb pad. *J Anat* 2013;223:603-9.
- Singh M, Carty M, Nuutila K, Ricci JA, Catterson EJ, Catterson SA. Saved by de-epithelialization: DIEP flap dermal skin regeneration salvage after mastectomy skin flap loss. *Plast Reconstr Surg Glob Open* 2015;10:3:e511.
- Yazar M, Aydın A, Kurt Yazar S, Başaran K, Güven E. Sensory recovery of the reverse homodigital island flap in fingertip reconstruction: a review of 66 cases. *Acta Orthop Traumatol Turc* 2010;44:345-51.