Treatment of complex injuries in the hand
-Combined technique using microsurgery and external fixator-

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Project

Microarm II 号機の血管縫合

Microarm III 号機の動作状態
Presentation today

1. First web plasty using with Ilizarov mini fixator
2. Finger replantation at the PIP joints level
   - Utility of the external fixator for joint function recovery
3. Bone lengthening by the Ilizarov mini fixator
(Introduction)

Contracture of 1st web following severe hand trauma is one of the important factor of hand dysfunction.

We have applied Ilizarov mini fixator for the 1st web contracture. The technique introduced here is modified original Ilizarov technique.
The patients ranged in age from 19-65 (average 46).

Six male and one female.

Patients suffered open fracture of digits, crush or degloving injuries in the hands.
Method 1

Comosed of two M3 rods
Simple procedure

Lengthening: 0.5mm both in palmar and radial direction.
Method 2

—M4 rod—

Linkage between index and thumb is composed of two rods that cross each other at 90 degree of angles.

Lengthening: 0.5mm both in palmar and radial direction.
Radial abduction
Index-thumb distance
94 %
Active radial abduction angle
93.8 %

Palmar abduction
Index-thumb distance
95 %
Active radial abduction angle
84.9 %

Compared with contralateral side >84.9 %
65 y.o. male,
Complex injuries in the hand

Parascapular flap performed at the first operation
Before web-plasty

2 months after the operation
final results (3 months after)

Radial abduction
Index-thumb distance
14.2/15cm (94.6%)
Active radial abduction angle
58/60 degree (94.8%)

Palmar abduction
Index-thumb distance
12.8/13.5cm (94.8%)
Active radial abduction angle
74/86 degree (86%)

Compared with contralateral side >84.9%
30 y.o. male, Suffered by the printing machine

Medial plantar flap
Web plasty by the external fixator

Grade I
(Chen’s score)

Compared with contralateral side >87%
65 y.o. male: By press machine

Replantation performed
1st web plasty by the Ilizarov mini fixator
Grade I
(Chen’s score)

Compared with contralateral side >94%
60 y.o. male
Rt thumb, index crush injury
Index replanted at the thumb base.

Application for pollicization
Grade II
Index moved gradually by the external fixator
Case

Bilateral degloving injuries
Medial plantar flap and Ilizarov mini external fixator used for 1st web widening
Throw the baseball ball
Function of both hand 5 years after
Discussion: how to manage the web contracture?

- Advancement flap, Z plasty
- Pedicled flap—dorsal interosseus flap
  - groin flap
- Free flap—peroneal flap
  - perforator flap
- release of the adductio

Deficiency of the donor vessel, or after free flap?
Finger replantation at the PIP joints level - Utility of the external fixator-
Finger replantation at the PIP joints level
-Utility of the external fixator-
(Introduction)

The key for the functional recovery of the replanted finger is successful primary reconstruction, planning of the secondary reconstruction and following rehabilitation.

We present management of amputated fingers at the proximal phalanx or PIP and MP joints level using with external fixator.
(Materials and methods)

• Twenty five fingers in thirteen patients including clean cut, degloving and crush injuries.
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<tr>
<th>TAM/JSSH Score</th>
<th>Thumb</th>
<th>Index</th>
<th>Middle</th>
<th>Ring</th>
<th>Little</th>
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<td>58/</td>
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<td>61/64</td>
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<td>50/</td>
<td>48/</td>
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<td>59.7/</td>
<td>62/</td>
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<tr>
<td>13</td>
<td>51/61</td>
<td>49/60</td>
<td>44.5/62</td>
<td>63/64</td>
<td></td>
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<tr>
<td>Average</td>
<td>72.5/71</td>
<td>54.9/70.8</td>
<td>54.1/61.6</td>
<td>54.6/63</td>
<td>56.8/63.3</td>
</tr>
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</table>
(Results and case presentation)

Replantation cases at the PIP joint level that Compass PIP joint hinge applied
24 y.o. male : Rt index amputation by the ice cutter

Clean cut : joint 、 Flexor tendon suture (FDP 4-strand suture) 、 Soft tissue reconstruction
Venous flap used (aVF) to avoid the tension of soft tissue above the artery.
4 weeks after replantation, CPH was applied to allow joint traction
4 weeks: Assist active ROM started
6 weeks: Passive ROM exercise started
Between the exercise, joint was fixated at the angle of -10 to 20 degrees.
6 years from replantation

TAM: 77%

JSH score: 91 points

Excellent
Case: Modified Ilizarov mini external fixator
“Global Hinge fixator”
Cost-osteochondral graft after replantation

- Lt index incomplete amputation
X ray on admission
Before cost-osteochondral graft

- Passive ROM

Flexion 60°

Extension -30°
Computer assisted costo-osteochochondral graft

- Digital data acquired from CT.

Yellow: Mirror image of the normal side
According to the 3D data, milling of the bone was automatically done.
19 months from cost-osteochondral graft

TAM : 75 %
Flexion 80 degrees, extension -5 degrees
19yo, rt-ring finger incomplete amputation
Global Hinge fixator (GH fixator)

Passive movement bar

M3 (joint space tractin)

Center of rotation 1.2mm wire
Joint defect still exist!!
Normal side

Automatic milling by Computer assisted method
After 5 years
Osaka Nagai park
Move of the rotation center

Rotation center change
Globalhige-N (Double Hinge)

Inner hinge and outer (Guide) hinge
Rt middle and ring finger, incomplete amputation
2019/4/4
Replanted
Double GH hinge applied (Global Hinge)
55 male. Rt thumb complete amputation, Rt index incomplete amputation.

Joint space is narrow
Joint traction by the Ilizarov mini fixator

Joint space
23 months after replantation

Tenolysis performed 4 months after replantation

Extension -10
Flexion 52 degrees
50 male incomplete amputation of Rt. index

1 months after from replantation bone graft with Ilizarov fixator performed. Structure of the fixator changed.

Reconstructed by the Ilizarov mini fixator.

Active ROM exercise under PIP joint traction.
Active ROM of PIP joint is 85 degrees.
External fixator VS Simple tenolysis

Simple tenolysis  :  10 digits
Average TAM  :  54.4  %

External fixator  :  9 digits
Average TAM  :  55.8%

* Including crush and local crush injuries
External fixator application for joint ROM

• Early application of the external fixator such as CPH and modified Ilizarov mini (Global hinge fixator) enable traction of the PIP joint.

• With the same device, we make it possible to allow both passive and active ROM exercise.
Bone lengthening by the Ilizarov mini fixator
38 male: crush injury of the lt. hand

44mm / 241 days

1cm / 54.7 days

SW test blue
Rt. Middle finger incomplete amputation (FDP preserved).
Wire insertion prevents the shortening of finger. Bone transport performed by using Ilizarov mini fixator.

Finally, before consolidation, proximal phalanx angulated.
Angulation of the proximal phalanx enabled the grip of the finger.
51yr. Male: Press machine injury

Covered by abdominal flap
Both bone lengthening and web plasty performed.
After lengthening of both bone and web, separation of finger performed

Bone lengthening: 0.5mm / day
Web plasty: 0.75mm / day
All fingers were degloved.
Great toe transfer performed on admission
Great toe transfer performed on admission.
Dorsal ulnar artery perforator flap also Performed.
After 5 months peroneal flap performed
Thumb metacarpal bone lengthening started.

2017/4/13
11 days

Double lengthening of metacarpal bone

2017/5/1
33 days, lengthening stopped

2017/5/16
104 days, Bone consolidation

2017/7/25
Now, three fingers, but,,,
New middle finger was cut, and widened to make new bone
① Double lengthning of the thumb
② Thumb contracture release
③ 3rd and 4th interdigital space widening
④ Third metacarpal bone lengthning
⑤ Widening of the 4th interdigital space
⑥ 4th metacarpal bone lengthning
⑦ Little finger contracture release
⑧ Widening between thumb and little finger
Lengthening of the Amputation Stumps of the Distal Phalanges Using the Modified Ilizarov Method

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**Purpose:** The purpose of this study was to introduce the technique for distraction lengthening of the traumatic amputation stumps of distal phalanges less than 10 mm long by using the Ilizarov minifixer (Ito Medical Instruments, Tokyo, Japan) and to report the treatment results and the problems we encountered.

**Method:** Six patients (3 men and 3 women) underwent lengthening of the traumatic amputation stumps of distal phalanges using the Ilizarov minifixer. The mean pre-operative length of the distal phalanges was 6.0 mm and the mean deficiency in length was 9.5 mm compared with the contralateral finger or thumb.

**Results:** In 5 of the 6 patients callus lengthening was completed without early consolidation or bone failure related to the traction wires. The mean gain in lengthening of the distal phalanx was 6.8 mm and the mean final length of the distal phalanx was 12.8 mm. After surgery 4 patients had onychoplasty and advancement flap coverage of the distal phalangeal tip because of excessive skin tension and 1 patient had arthrodesis because of flexion contracture of the distal interphalangeal joint. The patients were satisfied with the cosmetic improvement of their fingertips.

**Conclusions:** Although this callus distraction method required multiple surgical procedures it is considered worthy of more frequent application especially in young patients. (J Hand Surg 2003; 28A:316–322. Copyright © 2003 by the American Society for Surgery of the Hand.)

**Key words:** Lengthening, Ilizarov method, distal phalanx, eternal fixator, amputation stump.

**Figure 1.** Ilizarov minifixer consists of (A) a semicircular rod, (B) hollowed bolts and nuts, (C) washers, and (D) slotted washers. (E) Hollowed bolts travel on the rod.

**Figure 2.** (A) Amputated distal phalanx. (B) Two distal wires are fixed on the distal bolt and 3 proximal wires on the proximal bolt. (C) Corticotomy is done between the 2 proximal wires of the distal phalanx.
Comparison between Phalanges and Metacarpals Distraction Lengthening in Traumatic Hand Amputation with Ilizarov mini fixator

Thepparat Kanchanathepsak, Hiroyuki Gotani*, Yoshitaka Tanaka, Kosuke Sasaki and Tulyapruet Tawonsawatruk

* Riscot2017、Injury special issue

Table 1 Summary of patient data

<table>
<thead>
<tr>
<th>Digit No.</th>
<th>Gender</th>
<th>Age (y)</th>
<th>Affected part</th>
<th>Fixation time (d)</th>
<th>Increase in length (mm)</th>
<th>Healing index* (d/cm)</th>
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<td>1</td>
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* Significant statistical difference in HI between phalanges and metacarpals, P = 0.0005. Digit No. 9-10 are for the same patient, digit No. 11-14 are for the same patient, digit No. 15-17 and No. 26 are for the same patient, digit No. 18-22 are for the same patient, and digit No. 24-25 are for the same patient.
Conclusion

• We think that external fixators are also useful for reconstructing missing fingers, and that “Formative hand surgery” centered on soft tissue and bone lengthening with an external fixator is an effective solution to the treatment of various deformities and losses after hand trauma.