Microsurgical practice
in French forward surgical facilities

L. Mathieu, A. Ghabi, S. Amar,
J.C. Murison, A. Chataigneau, A. Poichotte, M. Levadoux

Percy Military Hospital, Clamart, France
To analyze the microsurgical practice of French orthopedic surgeons during their deployment in various theatres of operations.

Retrospective study about all patients operated on in all French forward surgical facilities between 2003 and 2015.

Inclusion criteria: Patients who underwent a microsurgical procedure in the field.
Results

Demographics

2,589 patients were operated on for extremity trauma

287 (11%) presented with hand injuries

56 (2.1%) were included → Mean age : 32 ± 11 years

→ Male to female ratio : 5
Most patients were managed in Afghanistan and Chad (42/56)

<table>
<thead>
<tr>
<th>Theatre of operations / Facility</th>
<th>Nb. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan / CSH</td>
<td>31</td>
</tr>
<tr>
<td>Central African Republic / FST</td>
<td>1</td>
</tr>
<tr>
<td>Chad / FST</td>
<td>11</td>
</tr>
<tr>
<td>Charles-de-Gaulle carrier / FST</td>
<td>1</td>
</tr>
<tr>
<td>Ivory Cost / FST</td>
<td>5</td>
</tr>
<tr>
<td>Jordan / FST</td>
<td>1</td>
</tr>
<tr>
<td>Kosovo / FST</td>
<td>4</td>
</tr>
<tr>
<td>Mali / FST</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>56</td>
</tr>
</tbody>
</table>

CSH = combat support hospital
FST = forward surgical team
## Results

### Demographics

The distribution among French soldiers, foreign soldiers and local civilians was homogenous.

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Operated patients (n=2589)</th>
<th>Operated patients with hand injury (n=287)</th>
<th>Study patients (n=56)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender, n (%)</strong></td>
<td>2237 (86.4%) males</td>
<td>262 (91.3%) males</td>
<td>47 (83.9%) males</td>
</tr>
<tr>
<td></td>
<td>352 (13.6%) females</td>
<td>25 (8.7%) females</td>
<td>9 (16.1%) females</td>
</tr>
<tr>
<td><strong>Children &lt;16 yo, n (%)</strong></td>
<td>452 (17.5%)</td>
<td>40 (14%)</td>
<td>5 (9%)</td>
</tr>
<tr>
<td><strong>Status, n (%)</strong></td>
<td>452 (17.5%) French soldiers</td>
<td>109 (38%) French soldiers</td>
<td>15 (26.8%) French soldiers</td>
</tr>
<tr>
<td></td>
<td>362 (14%) foreign soldiers</td>
<td>27 (9.4 %) foreign soldiers</td>
<td>13 (23.2%) foreign soldiers</td>
</tr>
<tr>
<td></td>
<td>1556 (60%) local civilians</td>
<td>127 (44.2%) local civilians</td>
<td>17 (30.4%) local civilians</td>
</tr>
<tr>
<td></td>
<td>219 (8.5%) others</td>
<td>24 (8.4%) others</td>
<td>11 (19.6%) others</td>
</tr>
<tr>
<td><strong>Mechanism, n (%)</strong></td>
<td>647 (25%) ballistic trauma</td>
<td>73 (25.4%) ballistic trauma</td>
<td>24 (42.8%) ballistic trauma</td>
</tr>
<tr>
<td></td>
<td>1942 (75%) other trauma</td>
<td>214 (74.6%) other trauma</td>
<td>35 (57.2%) other trauma</td>
</tr>
</tbody>
</table>
Results
Injury mechanism

24 Combat related trauma

- Bullet 12
- Blast 6
- Fragment 6

32 Non-combat related trauma

- Knife 16
- Vehicle crash 4
- Crushing 5
- Glass 4
- Other 3
An overall of **59 injuries** were analyzed:

29 isolated nerve injuries

28 nerve and arterial injuries

2 isolated arterial injuries

33 (56%) injuries were located **at the hand level**
Results

Injury pattern

Nerve injuries (n=57)

- Neck & shoulder  n=4
- Arm  n=2
- Elbow  n=6
- Forearm & wrist  n=7
- Hand  n=33

Arterial injuries (n=30)

- Brachial artery  n=2
- Radial artery  n=3
- Ulnar artery  n=3
- Superficial volar arch  n=1
- Digital arteries  n=22
- Central pulp artery  n=1
Results

*Surgical parameters*

Patients were treated by (orthopedic) **hand surgeons in 34 cases** and by **orthopedic surgeons** who were not hand surgeons **in 22 cases**

Using **magnification loupes**

in 38 cases

Using **operating microscope**

in 18 cases (KaIA CSH)
Results
Surgical parameters

Nerves injuries (n=57)

- Neurolysis: n=6
- Direct suture: n=38
- Autografting: n=7
- Nerve transfers: n=5 (Oberlin procedure & flap reinnervation)
- Vein wrapping: n=1 (Neuroma)

Fibrin glue used only in KaIA CSH (n=15)
Results

Surgical parameters

Arterial injuries (n=30)

Electrocautery or ligation  
\[ n = 17 \]

End-to-end suture  
\[ n = 11 \]

Venous grafting  
\[ n = 2 \]
Results

Functional / vascular outcomes

Outcomes of nerve repair were not evaluated because long-term follow-up was impossible to achieve in the case of most patients.

Revascularization procedures were successful in 6 / 9 cases:

- Digital revascularization: 3 / 6
- Proximal revascularization: 3 / 3
Discussion

Forward surgical facilities

Dedicated providing life-and limb-saving procedures before evacuation

Microsurgical means are usually not available

Only Klem et al. reported free flaps in US combat support hospitals
The routine practice of nerve repair in the combat zone differs from the US or UK army recommendations (Penn-Barwell et al.)

In some cases, **this permitted the avoidance of evacuation** of soldiers or contractors.

Many **local nationals also benefitted from primary or secondary nerve repair**.
Discussion

Digital revascularization

Despite small and heterogenous our series of digital revascularization is unique

No digital replantation was described before in forward surgical facilities

Mostly for isolated non-combat related injuries

Digital replantation in forward surgical units: a cases study

Laurent Mathieu\textsuperscript{1,2,*}, Michel Levadoux\textsuperscript{3}, Emmanuel Soucaney de Landevoisin\textsuperscript{4}, Tarun J. McBride Windsor\textsuperscript{5}, and Sylvain Rigel\textsuperscript{1,2}

\textsuperscript{1} Department of orthopedic traumatology reconstructive surgery, Percy Military Hospital, Clamart, France
\textsuperscript{2} Department of surgery, French Military Medical Academy, École du Val-de-Grâce, Paris, France
\textsuperscript{3} Hand surgery unit, Saint-Roch private clinic, Toulon, France
\textsuperscript{4} Department of orthopedic surgery and traumatology, Laferan Military Hospital, Marseille, France
\textsuperscript{5} Department of thoracic surgery, Percy Military Hospital, Clamart, France
Discussion

Microsurgical training & equipment

This was possible because:

1- Many French **military orthopedic surgeons completed a microsurgery degree**, even those who are not hand surgeons

2- Deployed orthopedic surgeons often **brought their own microsurgical equipment**
Conclusion

Soldiers and local population can benefit from microsurgery in the field

Training to microsurgery is essential for any deployed orthopedic surgeon

Minimal microsurgical equipment should be available in any forward surgical facility