First french TMR
Preliminary results (1 year)
Targeted muscle reinnervation
(réinnervation musculaire ciblée)

Dr de Keating-hart (Nantes)
Dr Pierrart (Bobigny, Calais)
Conflicts of interest

- Dr de Keating-hart: yes (ottobock)
- Dr Pierrart: yes (ottobock)
Dr Kuiken (Chicago)

« Develop a neurological interface with artificial limb »
Amputation level
Criteria

- Amputation level
- Skin quality
- Motivation +++
- 2 years of rehabilitation
- Prosthetic coast

Prerequisites:
- Level of amputation should be transhumeral or higher. Also bilateral amputees have an indication for TMR
- Being self-motivated and proactive
- Cognitive fitness to relearn how to activate and coordinate new targeted muscles
- Time, endurance and commitment for the rehabilitation process (about 2 years)
- Commitment of family or partner (and employer)
- Willingness to travel and to spend time for surgery, therapy and check-ups
- Good physical ability (able to carry the prosthesis afterwards, up to nearly 3 kg) → physical training is therefore a main focus during every TMR stage
- Mental stability or in psychological attendance follow the rehabilitation process
- Understanding of the whole TMR process (including surgery and postoperative consequences, such as nerve pain)
- Financial reimbursement has to be clarified (before starting the rehabilitation)

Expectations:
- Current prosthetic dual site control system does not meet the patient’s need (e.g. switching between joints is too slow for operating the arm)
- Personal desire/expectations of a TMR prosthesis is consistent with realistic functionality (essential for a good fitting result!)
- Why is TMR going to be the optimal solution?
- Show videos or TMR prosthesis to create realistic expectations

Medical state (after discussing that TMR is the best solution for the patient)
- Neura
- Phantom pain
- Condition of the residual limb (soft tissue, volume, scars, ROM, etc.)
- State of nerves/muscle of the residual limb and the transferred nerves
- Expected number of targeted muscles

Patient assessment in a team
For Targeted Muscle Reinnervation
Elbow Dynamic Arm Plus / hand
Myobock

ottobock
Conventional prosthesis

- 2 electrodes = 2 contractions = 2 signals
  \[ \Rightarrow \textbf{6 electric mouvements} \]  (pictures: Dr Kuiken)
Problems

- Tired: concentration: co-contraction
- Sequential control
- Unphysiological
- Non natural motor brain pattern
- Misuse, prosthesis
TMR Goal

- 2 electrodes > 5 - 6 electrodes.

- Intuitive and physiological use of prosthesis.

- How to do ? : **Targeted muscle reinnervation** to improve the use of prosthesis, **using new contractile muscular areas**

- **Neurotization** : *ulnar nerve / median nerve / deep branch of radial nerve*
Surgical procedure

- Denervation/Neurotization

- Brachialis

- Biceps (long head)

- Musculocutaneous n.

- Biceps (short head)

- Radial n.

- Triceps (Medial head)

- Ulnar n.

- Triceps (Lateral head)

- Deep branch Radial n.

- (Brachioradialis (distal amputation))

- Median n.
Biceps short head
Adipofascial flap
<table>
<thead>
<tr>
<th>TMR</th>
<th>Nerve used</th>
<th>Muscle target</th>
<th>Fonction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Musculocutaneous n.</td>
<td>Biceps (long head)</td>
<td>Elbow flexion</td>
</tr>
<tr>
<td></td>
<td>Ulnar n.</td>
<td>Biceps (short head) ou Brachialis</td>
<td>Fingers flexion</td>
</tr>
<tr>
<td></td>
<td>Radial n.</td>
<td>Triceps (long medial head)</td>
<td>Elbow Extension</td>
</tr>
<tr>
<td></td>
<td>Median n.</td>
<td>Brachialis ou Biceps (short head)</td>
<td>Pronation</td>
</tr>
<tr>
<td></td>
<td>Deep branch radial n.</td>
<td>Triceps (lateral head)</td>
<td>Fingers Extension</td>
</tr>
<tr>
<td></td>
<td>(Deep branch Radial n.)</td>
<td>(Brachioradialis m. (exist?))</td>
<td>(Supination)</td>
</tr>
</tbody>
</table>
Earnings

- Improve control of prothesis

- Simultaneous, fluid and natural movements of elbow, wrist and hand

- Via natural neurological pattern.
TEAM

Chirurgical team: JULES VERNE CENTER, NANTES
- Dr de Keating Hart / Dr Pierrart

RPM team:
- Tourmaline center: Dr Eveno / Claire Bonimacsi (ergotherapist)

Orthoprosthetic team:
- Sylvio Bagnarossa : BOP technologie
Entre 6 et 24 mois, (1h/semaine)

Suivi du patient

Evaluation

Préparation à la chirurgie (10 à 20 heures)

Thérapie

Chirurgie

Rééducation post-opératoire

3 mois post op, Réinnervation (10 à 20 heures)

Rééducation prothétique

Essayage

Fabrication de la prothèse

Entraînement au contrôle du signal

Équipe de rééducation et famille

Personnes
Tests

Ergo:
- 12k50
- 12k100

*Box and block test
*SHAP (Southampton Hand Assessment Procedure)
*Clamp test
*ESAT
## Results

<table>
<thead>
<tr>
<th>Test</th>
<th>12K100 before TMR</th>
<th>12K100 after TMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box and Block test (60 sec)</td>
<td>2 cubes</td>
<td>8 cubes</td>
</tr>
<tr>
<td>Clamp test</td>
<td>36&quot;81</td>
<td>15&quot;51</td>
</tr>
</tbody>
</table>

**Quality of life tests:** improve with 12k100 with TMR procedure
# LE SHAP (Southampton Hand Assessment Procedure)

## Participant ID
- ..................................

## Assessor
- ..................................

## Your SHAP Times

### Abstract Objects
- **Light Sphere:** 27.94
- **Heavy Sphere:** 9.75
- **Light Tripod:** 90.00
- **Heavy Tripod:** 12.79
- **Light Power:** 14.25
- **Heavy Power:** 5.00
- **Light Lateral:** 30.88
- **Heavy Lateral:** 20.57
- **Light Tip:** 100.00
- **Heavy Tip:** 100.00
- **Light Extension:** 47.50
- **Heavy Extension:** 11.97

### Activities of Daily Living (ADLs)
- **Pick Up Coins:** 100.00
- **Button Board:** 43.47
- **Simulated Food Cutting:** 100.00
- **Page Turning:** 39.96
- **Jar Lid:** 76.12
- **Glass Jug Pouring:** 100.00
- **Carton Pouring:** 100.00
- **Lifting a Heavy Object:** 100.00
- **Lifting a Light Object:** 100.00
- **Lifting a Tray:** 100.00
- **Rotate Key:** 31.12
- **Open/Close Zip:** 45.04
- **Rotate A Screw:** 100.00
- **Door Handle:** 9.71

## Your SHAP Scores

### Functionality Profile
- **Spherical:** 7
- **Tripod:** 4
- **Power:** 9
- **Lateral:** 0
- **Tip:** 2
- **Extension:** 3

### Index of Function Score
- **Index of Function:** 5

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## Participant ID
- ..................................

## Assessor
- ..................................

## Your SHAP Times

### Abstract Objects
- **Light Sphere:** 19.06
- **Heavy Sphere:** 27.44
- **Light Tripod:** 60.02
- **Heavy Tripod:** 48.09
- **Light Power:** 6.47
- **Heavy Power:** 12.78
- **Light Lateral:** 11.28
- **Heavy Lateral:** 11.56
- **Light Tip:** 27.37
- **Heavy Tip:** 10.13
- **Light Extension:** 100.00
- **Heavy Extension:** 14.53

### Activities of Daily Living (ADLs)
- **Pick Up Coins:** 100.00
- **Button Board:** 100.00
- **Simulated Food Cutting:** 100.00
- **Page Turning:** 38.63
- **Jar Lid:** 11.13
- **Glass Jug Pouring:** 100.00
- **Carton Pouring:** 100.00
- **Lifting a Heavy Object:** 5.91
- **Lifting a Light Object:** 7.36
- **Lifting a Tray:** 40.07
- **Rotate Key:** 82.03
- **Open/Close Zip:** 53.53
- **Rotate A Screw:** 100.00
- **Door Handle:** 3.23

## Your SHAP Scores

### Functionality Profile
- **Spherical:** 7
- **Tripod:** 0
- **Power:** 30
- **Lateral:** 7
- **Tip:** 3
- **Extension:** 0

### Index of Function Score
- **Index of Function:** 11
Box and block test
In progress!

TMR and **TMS**: electrodes (Integrum, Sweden).
Coming soon…. 

- Bluetooth system: Medtronic?
- MOVEO fondation (Pr Thomas Gregory, Avicenne)
http://www.tmr-rehabilitation.com

- Site international (Europe)
- Information générale sur la TMR
- Contacts dans les différents pays
REFERENCES


References


Thanks!

ottobock.