Multilevel surgery based on gait analysis in ambulant children with cerebral palsy

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Multilevel surgery

Surgery at more than one level
  hip, knee, femur, ankle, foot

soft tissue procedures
  tenotomy, tendon transfer
bony procedures
  osteotomy, arthrodesis
Ambulant children with CP

During the last two decades treatment strategy has changed

Previously
surgery at one level only,
new operations often necessary later

Now
all abnormalities are corrected in one operation:

multilevel surgery
Multilevel surgery

**Advantage**

Only one operation and postop period

**but**

greater surgical trauma, more demanding postop rehabilitation

The advantages are greater than the disadvantages if the outcome is satisfactory
Conditions of success  Multilevel surgery

• optimal preop evaluation
• correct choice of procedures and surgical technique
• optimal postop treatment
Preoperative evaluation

Clinical examination

unpredictable

Gage 1994: "before gait analysis, I startet with a spastic child who walked badly and ended with a spastic child who walked differently"

3-dimensional gait analysis

useful, but some subjectivity in its interpretation
3-dimensional gait analysis

Vicon system
6 videocameras
markers
PC data unit

force plate
ground reaction force
Gait analysis

- videofilm
- kinematic and kinetic curves
- all 3 planes and levels

Ex: **Knee** (sagittal)

  - kinematic preop (red)
  - and 1 year post-op (blue)

grey belt: normal variation
multidisciplinary team
carries out and evaluates the pre- and postop gait analyses and make recommendations for treatment

Team members
• Child neurologist
• Orthopaedic surgeon
• Orthotists
• Physiotherapists

**Aim of our first study on the role of gait analysis**

How is **preoperative planning changed** by the use of gait analysis in ambulatory children with CP?
Patients 2002-04

- 60 ambulatory children with spastic CP
- 27 girls and 33 boys
- age 10 (4 – 18) years
Results

320 specific surgical procedures proposed either clinically, by gait analysis, or both

overall agreement clin/gait analysis recommendations in 158 of these procedures, 49%

agreement varied in relation to types of operative procedure, 25 – 73 %
Agreement between gait analysis and surgery

During subsequent surgery the gait analysis recommendations were followed by the orthopaedic surgeons in more than 90% of the specific procedures.
Common deformities in ambulant children with CP

- hip flexion
- internal femoral rotation
- knee flexion
- ankle equinus
Hip clinical indications for surgery

**Flexor spasm**
- flexion contracture
- increased lumbar lordosis

Thomas test

**Adductor spasm**
- Scissoring gait
- Reduced hip abduction
Hip indications for surgery based on gait analysis

- Anterior pelvic tilt
- Reduced extension of hip in stance
Surgery

Psoas tenotomy

Psoas ”over the brim” in ambulant children

Psoas distally in non-walkers
Adductor tenotomy

indications

the legs tend to cross each other during gait
reduced abduction
subluxation

Add. longus, gracilis

Sometimes parts of add. brevis
Rotational deformities are common in CP, especially intoeing gait.

Hip
increased internal and
decreased external hip rotation
Intoeing

walk with internal rotation, usually
caused by increased femoral anteversion

Gait analysis:
increased femoral rotation
(green graph)
Rotational femoral osteotomy

- transverse osteotomy, sub- or pertrochanteric
- external rotation of distal fragment
- often bilateral surgery

Fixation: straight plate, blade-plate or Locked Compr. Plate (LCP)
Knee often affected

- hamstrings spasm

- flexed knees
- crouch gait

- increased popliteal angle
Gait analysis knee

Flexion contracture in stance phase

flexion

extension
Hamstrings tenotomy

Semitendinosus and gracilis: tenotomy

**Semimembranosus:**
- fasciotomy, elongation of muscle by knee extension

Postop:
- knee immobilizer to keep knee straight
Knee

rectus femoris often very spastic

walk with stiff knees

pos Ely Duncan test
Knee indications for surgery of rectus femoris

gait analysis

spastic rectus femoris

• reduced knee motion

• delay in max knee flexion in swing (green arrow)
Rectus femoris transfer to sartorius

eliminates spastic rectus,
better knee flexion in swinging
Patient, boy, 14 years
spastic diplegi

2 years ago: bilat. adductor tenotomies and femoral derotations

now: crouch gait
Surgery
bilat psoas- and hams. tenotomies
and rectus fem transfer

good result
patient satisfied

improved knee kinematics
better extension in stance phase
earlier max flexion in swing
Ankle  pes equinus very common in CP children

clinical examination

reduced dorsiflexion

Silverskiöld’s test:
more dorsiflexion with flexed
than with extended knee:
spastic gastrocnemius
Ankle indications for surgery based on gait analysis

Hemiplegia
left side

equinus left foot

normal right foot (green curve)
Spastic triceps surae

**gastrocnemius** most spastic
soleus less spastic

**Gastrocnemius sliding**

no elongation of soleus, which is
the most important for ankle power

plaster postop
5 weeks
Achilles tendon lengthening

various techniques

Z-plasty

2 transverse incisions

3 incisions
Multilevel surgery

Postoperative

Physiotherapy

Orthoses

GRAFO  ground reaction ankle foot orthosis
Various types of AFO (ankle foot orthosis)

**GRAFO**  Ground Reaction AFO
**HAFO**  Hinged AFO (leddet)
**PLS**  Posterior Leaf Spring orthosis (pils)
**SAFO**  Solid AFO

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GRAFO

HAFO

PLS

SAFO
Discussion

3-D gait analysis can assess gait abnormalities in a more objective and detailed way than clinical evaluation alone.

Nevertheless, orthopedic surgeons vary considerably regarding how closely recommendations from the gait analysis are followed during the subsequent surgery.
Purpose of our second study

To assess the outcome after multilevel surgery in a setting where the orthopaedic surgeons followed the recommendations (90%) from the preoperative gait analysis.

Gait analysis preop and 1-1.5 years postop
47 children underwent surgery, 8 children had non-surgical treatment

Surgical procedures

- Psoas tenotomy 39
- Hamstrings tenotomy 37
- Rectus femoris transfer 50
- Gastroc/achilles elongation 42
- Femoral rotation osteotomy 14
Accordance between initial **clinical** examination, gait analysis, and subsequent surgery

**Group A: agreement** between clinical proposals, gait analysis, and subsequent surgery: 128 specific procedures

**Group B: disagreement**; no surgery had been proposed after clinical examination but 54 surgical procedures were performed based on gait analysis

**Group C: disagreement**; 55 surgical procedures had been proposed after clinical examination but were not performed because they had not been recommended by gait analysis
| Group A, agreement | 17 | 6 | <0.001 | improved |
| Group B, disagreement, more surgery | 13 | 6 | <0.001 | improved |
| Group C, disagreement, no surgery | 8 | 7 | ns | unchanged |

ns = not significant difference
# Kinematic results, Knee level (hamstrings)

<table>
<thead>
<tr>
<th></th>
<th>Minimum knee flexion</th>
<th></th>
<th>p</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>preop</td>
<td>post</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A, agreement</td>
<td>37</td>
<td>12</td>
<td>&lt;0.001</td>
<td>improved</td>
<td></td>
</tr>
<tr>
<td>Group B, disagreement, more surgery</td>
<td>26</td>
<td>11</td>
<td>&lt;0.001</td>
<td>improved</td>
<td></td>
</tr>
<tr>
<td>Group C, disagreement, no surgery</td>
<td>11</td>
<td>21</td>
<td>0.050</td>
<td>deteriorated</td>
<td></td>
</tr>
</tbody>
</table>
## Ankle level (Achilles/gastroc elongation)

<table>
<thead>
<tr>
<th>Group</th>
<th>Preop</th>
<th>Post</th>
<th>P</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A, agreement</td>
<td>-2</td>
<td>13</td>
<td>&lt;0.001</td>
<td>improved</td>
</tr>
<tr>
<td>Group B, disagreement, more surgery</td>
<td>4</td>
<td>17</td>
<td></td>
<td>only 1 patient</td>
</tr>
<tr>
<td>Group C, disagreement, no surgery</td>
<td>13</td>
<td>14</td>
<td>0.772</td>
<td>unchanged</td>
</tr>
</tbody>
</table>

St is stance phase
**Femur rotational osteotomy**

Mean femur rotation in stance phase:

<table>
<thead>
<tr>
<th>Group</th>
<th>Preop</th>
<th>Post</th>
<th>p</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A, agreement</td>
<td>21</td>
<td>4</td>
<td>&lt;0.001</td>
<td>improved</td>
</tr>
<tr>
<td>Group B, disagreement, more surgery</td>
<td>23</td>
<td>7</td>
<td></td>
<td>only 1 patient</td>
</tr>
<tr>
<td>Group C, disagreement, no surgery</td>
<td>7</td>
<td>8</td>
<td>0.950</td>
<td>unchanged</td>
</tr>
</tbody>
</table>

St is stance phase
Overall results

- **satisfactory** in all the 3 groups
- **improvement** in most kinematic variables in operated children
- **no deterioration** in children who did not undergo surgery, apart from a trend towards deterioration in knee flexion contracture
Conclusion

Preoperative gait analysis is useful to

• confirm clinical indications for surgery
• **define indications** for surgery that have **not been proposed** after clinical examination
• **avoid unnecessary surgery** that has been proposed after clinical examination
Consequence

Preoperative 3-dimensional gait analysis is recommended for all ambulant children with cerebral palsy.
Reminder: conditions for success in multilevel surgery

• **preoperatively** clinical evaluation and gait analysis
• **surgery** correct procedures and technique
• **postoperatively** physiotherapy and orthoses

"no chain is stronger than its weakest link"
Thanks for your attention!