Strategies for Maximizing the Anterior Control of the Lower Limb in Orthotic Management of Stroke

Management of Chronic Stroke

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How we got here...

Challenges of Chronic Stroke

- Contracture
- Well established abnormal gait pattern
- Hypertonicity or over-recruitment
- Chronic weakness
- Joint laxity
- Decreased level of fitness

The current situation

- Focus on swing phase
- Not accommodating contracture
- Not basing orthotic prescription on a sound understanding of gait and biomechanics
- Reluctance to utilize AFOs based on unfounded assumptions

Current Trends - Orthotists

- Retrospective study over a 3 month period of time; multiple orthotic providers nationwide
- 2363 subjects with stroke, 2416 devices; average age: 62
- Most common device provided – Custom Articulated (40.98%)
- Devices which provide best stance control/stability
  - Solid
  - GRAFO
  - Double upright

Seale J, DiBello T, unpublished data

Current Trends – PTs

- Focus on swing limb dysfunction
- Often don’t identify weakness in plantarflexors as cause of stance instability
- Reluctance to provide solid ankle device
- Philosophy on orthotics: wait to prescribe, try to do without, inhibits recovery

Seale J, Utsey C, unpublished data
Effect of AFOs on Muscle Activation

- Literature Review
  - 11 studies in individuals with neurological disorders
  - Diagnoses included: CVA, SCI, peripheral “foot drop,” & children with CP
  - Electromyography (EMG) of LE muscles while walking with & w/out AFOs
  - Multiple types of AFOs investigated (solid, hinged, oil-damper, PLS, etc)

- Weaknesses of the Literature
  - Variability in muscles tested
  - Variability in braces tested
  - Only 1 long-term outcome
  - Some used surface electrodes, some used intramuscular electrodes
  - Variability in data collected and analyzed

Effect of AFOs on Muscle Activation

Summary of the Evidence

- Of the 11 studies, 20-30:
  - 6 showed equal or more normalized EMG in AFO
  - 4 showed less normalized EMG in AFO
  - 1 showed equal, more normalized, and less normalized EMG in AFO depending on the muscle tested
  - No notable trend toward the rigidity of the brace resulting in more or less normalized EMG

- No clear evidence that:
  - AFOs decrease muscle activation in pts with neurological disorders
  - More rigid braces exaggerate any possible negative side effects of bracing
  - There is a long-term detriment to muscle activation, function, or impairments

The Issue of Contracture

- At least half of adults with stroke develop at least one contracture within six months
  - Contracture of the plantarflexors is common
  - PF contracture has an enormous impact on lower extremity biomechanics
  - Associated with increased knee hyperextension during stance
  - Poor effectiveness of our interventions to treat contracture
  - Contracted muscle → Weak muscle
  - Gastroc length often not considered when prescribing/designing AFO

Our solution

Replicating a more normal biomechanical lever profile

Key factors

- Ground reaction AFO design
- Rigid materials
- Casting at gastroc length
- Wedging to accommodate contracture
- Tuning for optimal shank to vertical angle

<table>
<thead>
<tr>
<th>Outcome Measures</th>
<th>No AFO</th>
<th>AAFO</th>
<th>GRAFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUG (sec)</td>
<td>Ave = 54.76, SD = 38.14</td>
<td>Ave = 34.97, SD = 19.7</td>
<td>Ave = 38.86, SD = 26.66</td>
</tr>
<tr>
<td>Gait Speed (m/sec)</td>
<td>Ave = 0.33, SD = 0.24</td>
<td>Ave = 0.54, SD = 0.38</td>
<td>Ave = 0.51, SD = 0.38</td>
</tr>
<tr>
<td>6 MWT (feet)</td>
<td>Ave = 455.0, SD = 464.07</td>
<td>Ave = 715.87, SD = 544.50</td>
<td>Ave = 700.36, SD = 629.17</td>
</tr>
</tbody>
</table>

Observation revealed that majority of subjects hyperextended knee during stance in no AFO condition; hyperextension not fully corrected in AAFO, but normalized in advanced design GRAFO.

3 of 9 subjects had immediate positive response in all 3 outcome measures in advanced design GRAFO, with average increase of 57.5 ft in 6 MWT, 0.19 m/sec in gait speed, and 14.87 sec on TUG between AAFO and GRAFO.
• 70yo female
• CVA 4.5 years ago
• Right hemiparesis
• Has worn “traditional” AFO for 4.5 years
• Walks with Single Point Cane

<table>
<thead>
<tr>
<th>Functional Outcomes</th>
<th>Walking Endurance (6MWT)</th>
<th>Walking Speed (10MWT)</th>
<th>Transitional Movement + Walking Speed &amp; Balance (TUG)</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (no AFO)</td>
<td>460.58 ft</td>
<td>0.42m/s comf. 0.47m/s fast</td>
<td>29.28 seconds</td>
<td>Knee hyper-extension</td>
</tr>
<tr>
<td>Traditional AFO</td>
<td>548.17 ft</td>
<td>0.43m/s comf. 0.50m/s fast</td>
<td>25.43 seconds</td>
<td>Knee hyper-extension</td>
</tr>
<tr>
<td>Non Articulated GRAFO</td>
<td>729.00 ft</td>
<td>0.57m/s comf. 0.67m/s fast</td>
<td>20.78 seconds</td>
<td>No knee hyper-extension</td>
</tr>
<tr>
<td>Non Articulated GRAFO Follow-up</td>
<td>727.17 ft</td>
<td>0.55m/s comf. 0.73m/s fast</td>
<td>19.06 seconds</td>
<td>No knee hyper-extension</td>
</tr>
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</table>

• 38yo male with lupus
• CVA 7.5 years ago, right hemiparesis
• Has worn “traditional” AFO for 7.5 years
• Walks without assistive device

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<tr>
<td>Baseline (no AFO)</td>
<td>662.83 ft</td>
<td>0.40m/s comf. 0.62m/s fast</td>
<td>26.87 seconds</td>
<td>Knee hyper-extension</td>
</tr>
<tr>
<td>Traditional AFO</td>
<td>1342.58 ft</td>
<td>0.74m/s comf. 0.99m/s fast</td>
<td>12.93 seconds</td>
<td>Knee hyper-extension</td>
</tr>
<tr>
<td>Advanced GRAFO</td>
<td>1654.75 ft</td>
<td>0.85m/s comf. 1.35m/s fast</td>
<td>11.56 seconds</td>
<td>No knee hyper-extension</td>
</tr>
<tr>
<td>Advanced GRAFO Follow-up</td>
<td>1805.00 ft</td>
<td>0.97m/s comf. 1.53m/s fast</td>
<td>10.57 seconds</td>
<td>No knee hyper-extension</td>
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