Role of Socket Design, Flexibility and Suspension in Transfemoral Sockets during Walking

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Background

Socket Design

Ischial Containment (IC) sockets encompass the pelvis and hip joint limiting hip range of motion and compromising comfort (Tranberg et al. 2011). With the advent of vacuum-assisted suspension (VAS) there has been an increasing interest in brimless sockets (Kahle 2002; Fairley 2008; Strachan et al. 2011; Kahle & Highsmith 2011, 2012).

Purpose of the Study

By systematically altering an IC socket, the purpose of this case study was to assess the role socket brim and flexibility have on stability, comfort, suspension and gait parameters during walking.

Methods

Subject

- 29 year old male with a unilateral transfemoral amputation due to trauma (height 182cm; weight 83.3kg).
- Relatively long residual limb (48% of leg length) with firm skin tissue.

Apparatus

- 8 camera motion analysis system (Motion Analysis Corporation)
- 6 force plates (AMTI) embedded in the middle of a 12m walkway.

Intervention

- An IC socket (modified NU/RIC design) with silicone seal-in suction suspension and one-way valve.
- Constructed of a rigid carbon frame with posterior U-shaped fenestration and 1.5” Dacron strap over gluteal region; and flexible thermoplastic inner socket with ½” flexible brim extending proximal to the carbon frame.
- Subject was assessed by a Certified Prosthetist as having total contact and appropriate containment in the socket.
- Prosthetic alignment was unchanged for conditions 1 to 6.
- Prosthetic components for all test conditions included a C-leg with torsion pylon (Otto Bock) and Highlander foot (Freedom Innovations).

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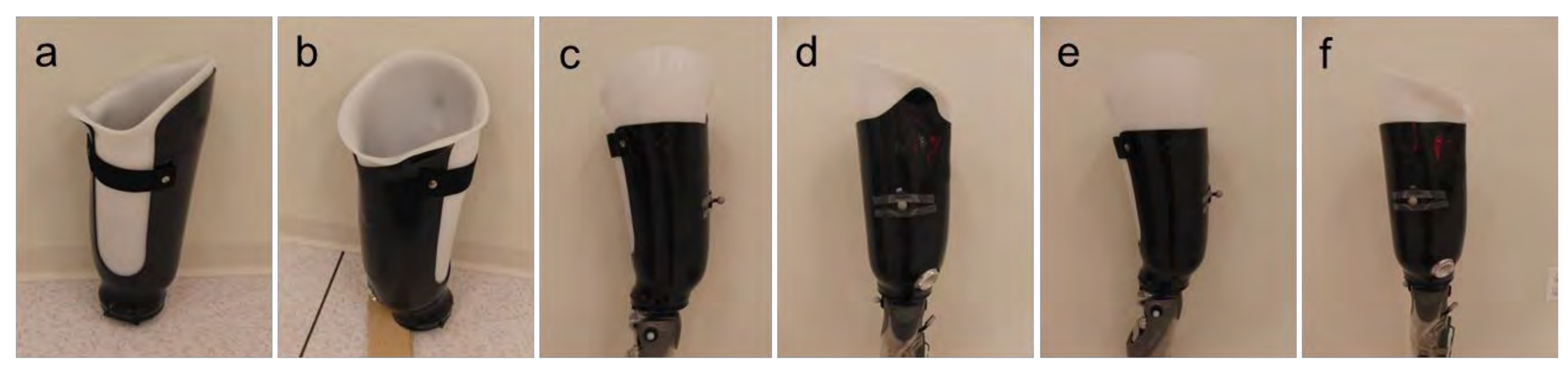
Procedures

- Gait analysis was conducted on a single day.
- Helen Hayes marker set was used (Kadaba et al. 1989).
- Subject walked at comfortable self-selected speed in 7 socket conditions:

1. Intact IC socket (a,b);
2. IC socket with lateral proximal frame removed (c,d);
3. IC socket with anterior medial frame removed (e,f);
4. Brimless socket with rigid frame (g,h);
5. Brimless socket with more flexible frame (i, j, k, l);
6. Condition 5 with VAS (e-pulse, Otto Bock);
7. Condition 6 with alignment adjustment.



Condition 1: (a) posterior lateral view (b) posterior medial view

Condition 2: (c) lateral view (d) anterior view

Condition 3: (e) lateral view (f) anterior view

Condition 4: (g) anterior view (h) superior view

Condition 5: (i) anterior view (j) medial view (k) posterior view (l) lateral view

Data Analysis

For each socket condition we recorded:

- Subjective comments
- Socket Comfort Score (Hanspal et al. 2003)
- Walking speed - assessed as an indicator of overall function
- Step width - assessed as an indicator of coronal socket stability
- Maximum lateral trunk lean during prosthetic limb stance - assessed indicator of coronal plane socket stability
- Swing phase foot rotation range of motion - assessed as an indicator of socket suspension

Results

Relationship Between Variables

- Socket comfort score and step width (r = 0.6)
- Socket comfort score and maximum lateral trunk lean during prosthetic side stance (r = 0.7)
- Socket comfort score and walking speed (r = -0.35)
- All other correlations were poor.

Socket	SCS	Comments	Speed (m/s)	Step Width (cm)	Max Lateral Trunk Lean (degrees)	Swing Foot Rotation ROM (degrees)
1	2	Lots of pressure on IT	1.7	15.4	**2.6**	12.0
2	2	Still pressure on IT	1.6	15.6	3.4	12.0
3	5	Still pressure on IT but not as bad, alignment is off – toes are too in	1.7	**14.2**	4.3	**10.7**
4	4	Socket more comfortable but foot feels too far back	1.7	15.1	4.0	15.5
5	2	Socket feels like it wants to come off	1.6	17.9	3.2	12.7
6	4	Way better, rotational wobble gone	1.7	15.0	3.3	15.7
7	**6**	That’s more like it!	**1.8**	16.3	3.7	10.9

Results for socket conditions #1 to #7. Bold indicates “best” result for each variable, red indicates the “worst” result. IT = ischial tuberosity. SCS = socket comfort score (0 = least comfortable; 10 = most comfortable).

Discussion

- Removing the brim of an IC socket alters gait.
- Although socket comfort score seemed to relate well to the biomechanical data, other subjective comments did not.
- For this subject no one condition clearly provided the greatest comfort, fastest speed, smallest step width, least coronal plane trunk motion in prosthetic stance and least transverse plane foot motion in swing.

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