Evaluation of Alignment Methods for Transtibial Prostheses

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Intro: Developing Countries

- 3-4 million people in need of a prosthesis (Murdoch 1990)
- <5% people have access to medical care (WHO, 2003)
  - 80% in remote, rural areas (Sethi, 1989)
  - Unaffordable
  - Few trained specialists
Intro: Monolimb Appropriate Technology

- Fewer components
- Affordable
- Durable

Delivered on initial fit
(Valenti 2001)

- >1,000 fittings
  - Burma, Thailand, China, Vietnam, El Salvador

Monolimb initial fit, Burma 2007
Intro: Prosthetic Alignment

- Modular Design
  - Bench Alignment
    - Static Alignment
    - Dynamic Alignment
    - Delivery of Definitive Prosthesis

- Monolimb
  - Bench Alignment
    - Definitive Delivery of Prosthesis

Monolimb fabrication, Thailand 2007

www.ap.gatech.edu/mspo
Intro: Appropriate Alignment

“...good alignment can be achieved on the basis of [patient] measurements, if an easy procedure and fabrication fixture can be developed to assist with alignment...” CIR 2007

Two Alignment Methods: **VAA, ABA**
Research Goal

**Question:** Which alignment method (VAA, ABA, TRAD) requires the least magnitude of alignment changes to result in optimal gait?

**Hypothesis:** An alignment method based on patient measurements (VAA, ABA) will require a lower magnitude of change to arrive at appropriate prosthetic alignment.
Methods: Subjects

- 8 transtibial amputees
  - 18-65yo, <220lbs, healthy
- 8 students of prosthetics
  - Georgia Tech, MSPO
  - NUPOC
- 2 prosthetists per amputee/student pair
Protocol: Alignment Capture

1. Student captures VAA, ABA alignments on amputee
Vertical Alignment Axis (VAA)

- Socket center at PTB level projects onto alignment reference center
- Socket angles determined by natural attitude of limb during weight bearing

Wu et al, 1981
Vertical Alignment Axis (VAA)

- Coronal and sagittal planes intersection
Anatomical Based Alignment (ABA)

- Hip, knee, and ankle joint centers lie along a common axis in frontal and sagittal planes.
Protocol: Assemble and Dynamically Align

2. Students assemble 3 prostheses
   - VAA, ABA, TRAD
   - Quantify bench alignments

3. Prosthetists dynamically align 3 prostheses
   - Quantify dynamic alignments
Data

Alignment Parameters
Quantitative

1. Height
2. Toe-out
3. Foot posterior
4. Socket flexion
5. Foot inset
6. Socket adduction
Results

Absolute Change from Bench to Dynamic Alignment

No statistical significance (p<0.05) by repeated measures analysis
Discussion: Zahedi et al, 1986

- Alignment of Lower Limb Prostheses
  - A wide range of alignments are considered acceptable by the amputee and prosthetist
  - Average acceptable ranges
    - 45mm socket shifts
    - 10º socket tilts
  - Values depend on patient activity level and level of amputation
Discussion

Where these magnitudes of change of any significance to the amputee?
Discussion: Amputee Subjective Feedback

Overall Gait Quality Ratings by Amputee

- **Bench**
  - VAA: [X]
  - ABA: [X]
  - TRAD: [X]

- **Dynamic**
  - VAA: [X]
  - ABA: [X]
  - TRAD: [X]

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<th>VAA</th>
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Conclusion

Hypothesis: An alignment method based on patient measurements (VAA, ABA) will require a lower magnitude of change to arrive at appropriate prosthetic alignment.

NOT SUPPORTED
Limitations

- Soft heel of SACH foot
- Student inexperience
- ABA
  - Difficulty palpating anatomy
  - Does surface anatomy correspond to joint centers?
- VAA and ABA
  - Base of support assumed “fist-width apart”
Future Directions

- Control student, vary amputees
  Test accuracy of alignment methods
- or -
- Control amputees, vary student
  Test if little training is necessary
- or -
- Control student, vary amputee BMI
  Test effects of body composition
References


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Scott C
My classmates
My subjects
Methods

- Height, ABA
- Height, VAA
- Alignment Board
- Toe out, VAA
Alignment Board

- Align 3 things:
  - Etched line on plexiglass
  - Marker line on board
  - Marker alignment line on socket
Step Asymmetry

Step Length Asymmetry

Difference in step length (cm) (sound vs. prosthetic)

VAA | ABA | TRAD

Bench | Dynamic
Averaged Results

Average Change from Bench to Dynamic Alignment

-30.0
-20.0
-10.0
0.0
10.0
20.0

Height (mm)  Toe out (°)  Foot posterior (mm)  Socket flexion (°)  Foot inset (mm)  Socket adduction (°)

VAA  ABA  TRAD
Monolimb Recipients