TIBIAL FORCES MEASURED IN VIVO AFTER TOTAL KNEE ARTHROPLASTY

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Shiley Center for
Orthopaedic Research & Education

Introduction

• Tibial Forces
  – PE Wear & Cold Flow
  – Stress Distribution
  – Stress Transfer to Bone
Modeling Tibia Forces

- Complex Geometry
- Multiaxial
- Soft tissues
- Bi-articular muscles

In Vitro

- Normal knees
  - Perry, JBJS-A, 1975
  - Singerman, J Biomech, 1999
- TKA
  - Kaufman, J Biomech, 1996
In Vitro

Normal knees
- Singerman, J Biomech Eng, 1999

In Vivo

• Hips
  - Rydell, Acta Orthop Scand, 1966
  - English, J Biomed Eng, 1979
  - Davy, JBJS-A, 1988
  - Hodge, JBJS-A, 1989
  - Bergmann, J Biomech, 1993
Objective

Measure tibial forces in vivo using a tibial component instrumented with load cells
Instrumented Tibial Tray

- Kaufman, J Biomech 1996

Instrumented Tibial Tray

- Kaufman, J Biomech 1996
Instrumented Tibial Tray

- Kaufman, J Biomech 1996

Instrumented Tibial Tray

- Kaufman, J Biomech 1996
**Instrumented Tibial Tray**

- 8 strain gauges
- Full wheatstone bridge
- 2x240 Ω gauges per arm

**Force transducers**
- Kaufman, J Biomech 1996

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**Wireless Prototype**

- Microtransmitter
- Antenna

- D’Lima, ORS 1999
Telemetry

Multiplexer
A/D conversion

Power coil

Microprocessor
Instrumented Prosthesis
(See separate assembly videos)

Instrumented Prosthesis

(See separate assembly videos)

Instrumented Prosthesis
Instrumented Prosthesis

(See separate assembly videos)
Safety Testing

- Antenna
Safety Testing

Electron Beam Weld

Structural Testing

Posts
Hermeticity testing

- Weld
- Antenna

(See separate surgery video)

Surgery
Feb. 27, 2004
Before Soft Tissue Balance

(See separate balance videos)

After Soft Tissue Balance

(See separate balance videos)
1994 - 2004

Post Operative Rehab

• Passive Leg Raise
  – 0.34 BW
Post Operative Rehab

- Active Leg Raise
  - 0.84 BW

Post Operative Rehab

- Standing
  - 1.17 BW
(See separate post-op video)

Post Operative Walking

<table>
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<tr>
<th>Time</th>
<th>Normalized BW</th>
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<tr>
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Walking

- Postop Day 3
  - 1.26 BW

Normalized BW

Time
Walking

- Postop Day 6
  - 1.7 BW

Walking

- 3 weeks
  - 2.13 BW
Walking

(See separate walking video)

6 weeks

Walking

- 6 weeks
- 2.13 BW
Mean Peak Tibial Forces

Walking: Center of Force

- Heel Strike
- Mid Stance
- Toe Off
Walking: Center of Force

Effect of Shoes

Normalized BW

Percent Gait Cycle
Stair Climbing

Stair Ascent

(See separate stair-climbing video)
Chair Rise

- Tibial Forces
- Ground Reaction Forces
- Knee Kinematics

Knee Flexion (degrees) vs. Normalized BW for Tibial Force and Ground Reaction Force.
Summary

- Instrumented prosthesis sensitive to intraop soft tissue balance
- Tibial forces ~ Knee moments
- Tibial forces - Lower
On Going

- Athletic Activities
  - Golf
  - Doubles Tennis
  - Ski

- Fluoroscopic Analysis
  - Tibiofemoral Contact
- Knee Models
Next Generation

- 6 components
- Faster Data Update
- RF range

*Kirking, ISTA 2003, San Francisco
*Kirking, J Biomechanics, in review, 2004

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