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**THIGHPLASTY PROCEDURE FOR IMPROVED  
PROSTHESIS FIT AND FUNCTION**

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An abstract graphic on the left side of the slide. It features a vertical strip of various geometric shapes in shades of orange, red, and yellow. A prominent silhouette of a hand with fingers spread is positioned in the center of this strip. The background of the entire slide is a solid orange color.

# BACKGROUND

# THE CHALLENGE: FAT RESIDUAL LIMBS

## Facts

- 2/3 of Americans are overweight
- 1/3 are obese
- Subcutaneous fat is soft
  - It has low compliance
  - This reduces efficiency and control of this important interface
- Residual limbs with excess fat are more difficult to fit
  - Hard to pull soft tissues into sockets
  - Hard to grab skeletal structures
    - Distal femur
    - Ischium
- Residual limbs with excess fat have more complications
  - Pain from tissues hanging over walls
  - Sores from walls not getting into the socket
  - Worse prosthesis control due to compliant interface
- Very few people lose significant amounts of weight

## WHY NOT PERFORM SURGERY TO REMOVE EXCESS FAT?

### **Options:**

- Thighplasty
- Liposuction

Change the human to better fit the technology.

# COMPREHENSIVE CASE STUDY

## **Pre- and post-thighplasty**

- Obese transfemoral amputee

### **1. Tissue distribution**

- MRI

### **2. Socket-limb stiffness**

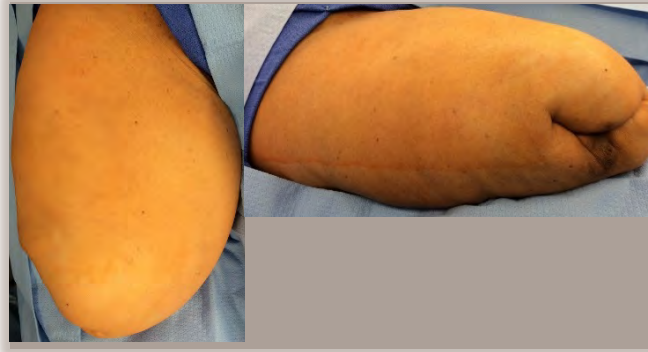
- 2 kinds of sockets tested

### **3. Comprehensive Outcomes**

- Clinical, questionnaire, metabolics

## TISSUE DISTRIBUTION AND SURGERY

- Patient was an overweight 50-year-old Hispanic female (adjusted BMI of 29)
  - Had a right transfemoral amputation over 35 years ago secondary to osteosarcoma
- 
- Tissue removal liposuction (2 liters; 2042 g, **4.5 lbs**)
  - Tissue removal medial excision (772.5 g, **1.7 lbs**)
  - Total: **6.2 lbs**



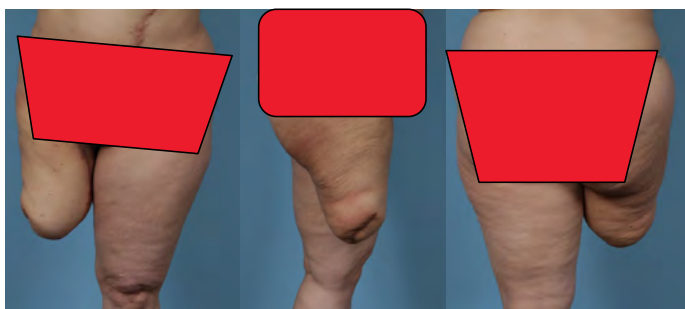
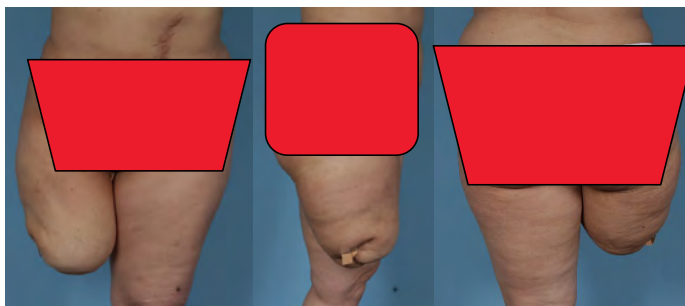
An abstract graphic on the left side of the slide, composed of various geometric shapes like circles, squares, and rectangles in shades of orange, red, and yellow. A silhouette of a hand is visible, reaching upwards. The background of the entire slide is a solid orange color.

# RESULTS

# APPEARANCE

**Pre**

Limb circumference			
proximal	mid	distal	
65	58	54cm	<b>pre</b>
64	55	47cm	<b>post</b>



**Post**



## APPEARANCE

Pre



Post



Amputated leg is now smaller than her intact limb, even with her prosthesis on.

## PRE- AND POST-OPERATIVE MRI

Image 5: Pre-op

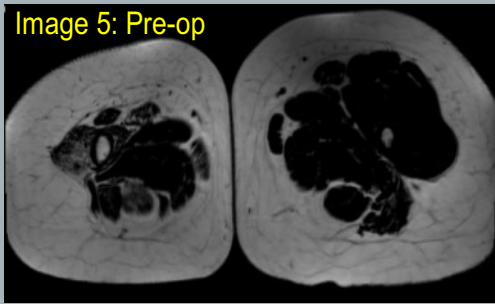


Image 4: Pre-op

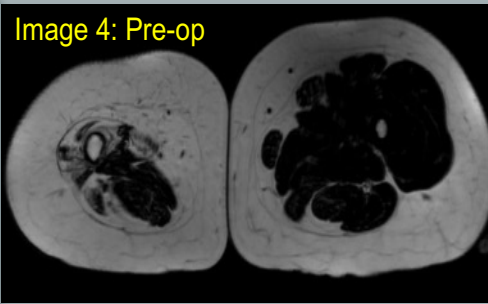


Image 5: Post-op

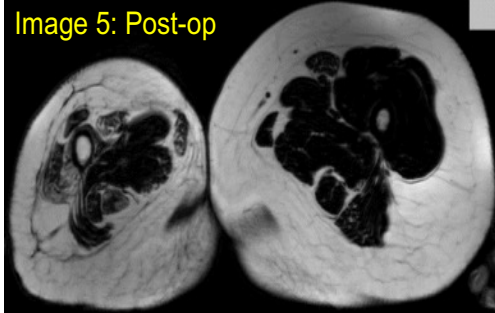
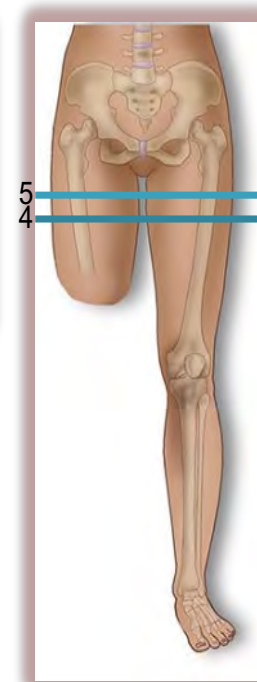
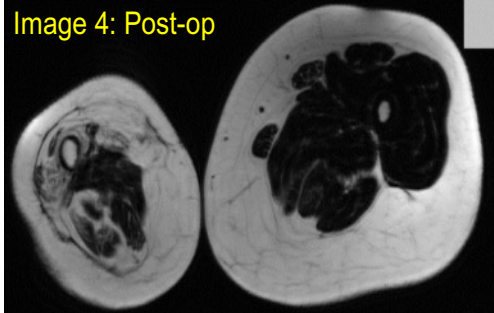
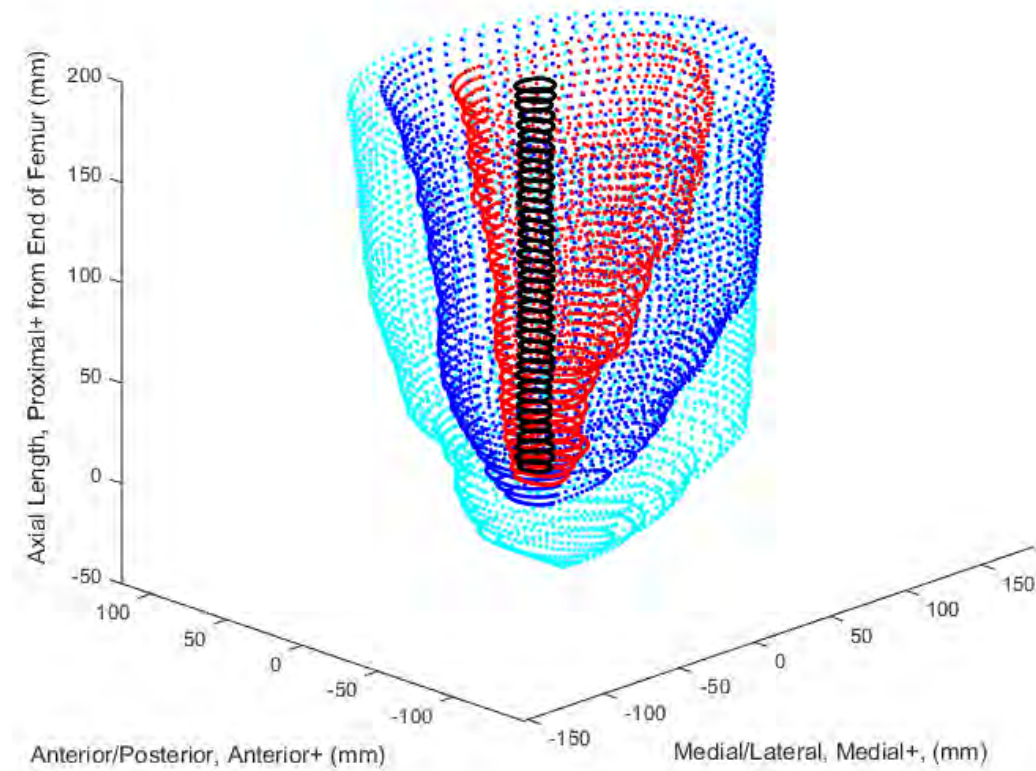


Image 4: Post-op



# INFLUENCE ON TISSUE DISTRIBUTION



## CLINICAL OUTCOMES OF PATIENT PRE- AND POST-SURGERY

A. Clinical Outcome	Pre-Surgery	Post-surgery	% Improvement
10-Meter Walk Test (comfortable, m/s)	0.76	0.80	+5.3
10-Meter Walk Test (fast, m/s)	1.01	1.01	0
6-Minute Walk Test (ft.)	1202	1339	+11.4
5-times Sit-to-Stand Test (sec.)	17.11	12.88	+24.7
4-Square Step Test (sec.)	9.80	7.73	+21.1
4-Square, half prosthesis inside (sec.)	4.62	3.21	+30.6
4-Square, half prosthesis outside (sec.)	4.78	3.54	+26.1

# X-RAY FOR DISPLACEMENT<sup>1</sup>

204 U. Erikson and U. James

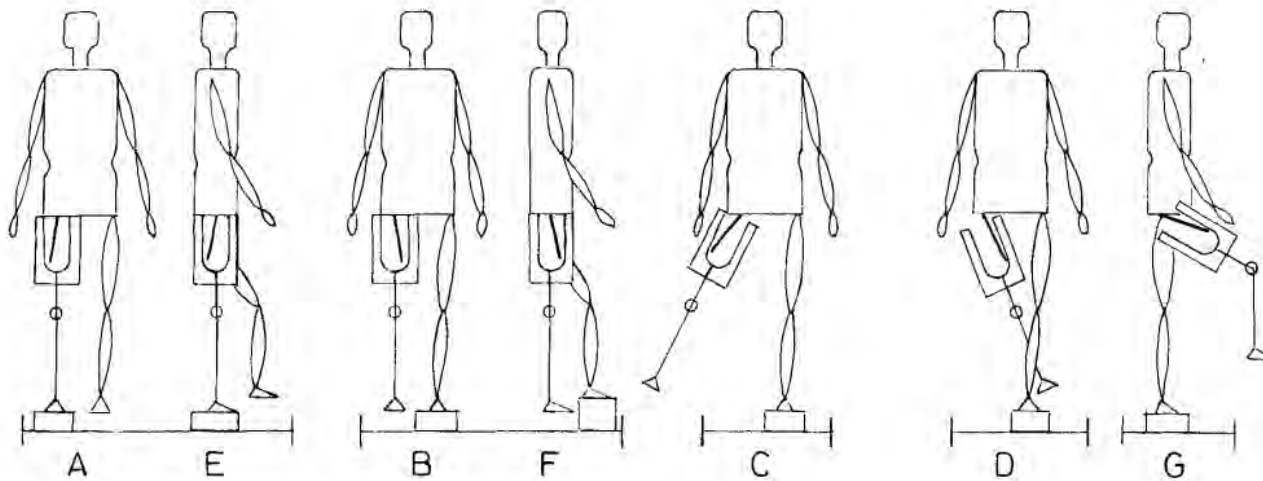
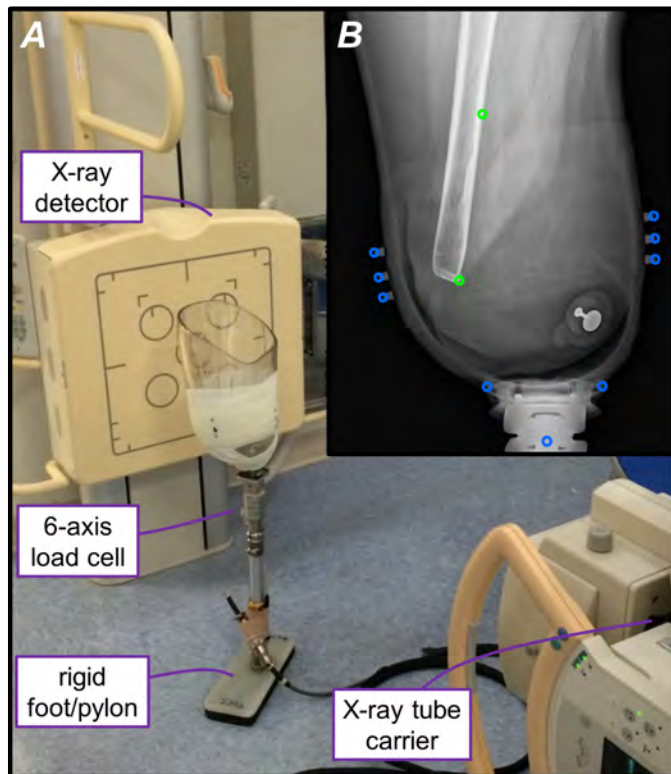


Fig. 1. Schematic illustration of the different study positions (A-G).

1. Erikson and James 1973

# INTERFACE STIFFNESS AND INFLUENCE OF SOCKET GEOMETRY



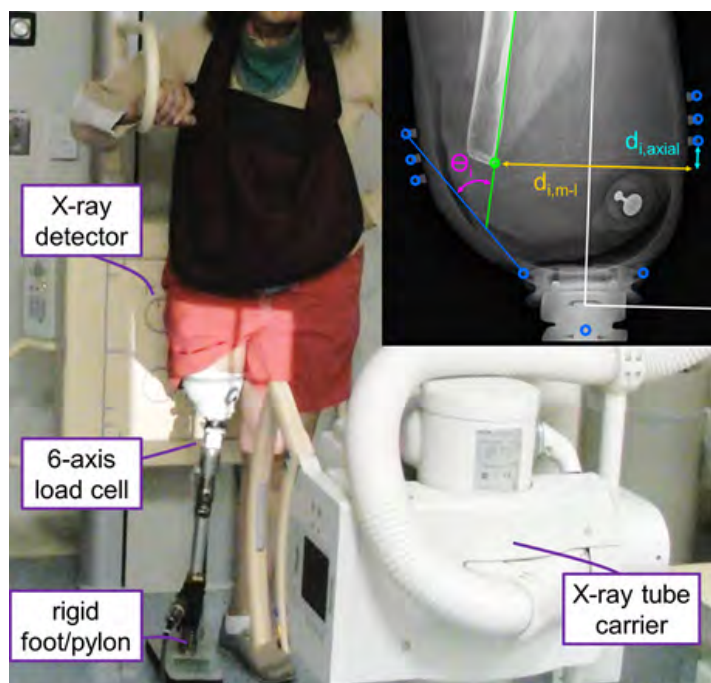
- Isometric patient loading while weight-bearing
- 6-axis load cell
- Visual feedback of load target
- Compute multi-axis stiffness



1. Fey et al. ASB 2015
2. Fey et al. EMBC 2015



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# FEMUR ORIENTATION

Ischial  
Containment

Sub-Ischial  
Containment

Pre-Op



	Isch. Cont.	Sub Isch.
Pre	<b>8.13°</b>	<b>6.81°</b>
Post	<b>4.14°</b>	<b>2.09°</b>

Post-Op





## PRE- AND POST- STIFFNESS DATA IN SUB-ISCHIAL SOCKET

	Pre-surgical	Post-Surgical	Units	% Change
Axial	<b>19</b> (0.81)	<b><u>28</u></b> (2.9)	N/mm	<b>+47.3</b>
Frontal (medial)	<b>160</b> (6.5)	<b><u>261</u></b> (13)	Nm/rad	<b>+63.1</b>
Frontal (lateral)	<b>610</b> (38)	<b>545</b> (38)	Nm/rad	<b>-10.7</b>
Sagittal (anterior)	<b>170</b> (5.0)	<b><u>310</u></b> (20)	Nm/rad	<b>+82.2</b>
Sagittal (posterior)	<b>470</b> (20)	<b><u>502</u></b> (13)	Nm/rad	<b>+6.8</b>

$$K = E \frac{w_b S^3}{6(w_t - w_b)}$$

Potential influence of limb length ( $S^3$ ) or  $E$ ?

# CLINICAL OUTCOMES AND QUESTIONNAIRE

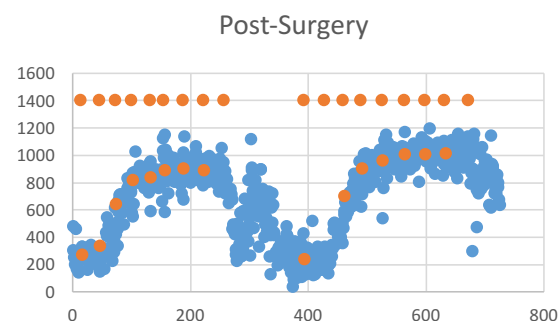
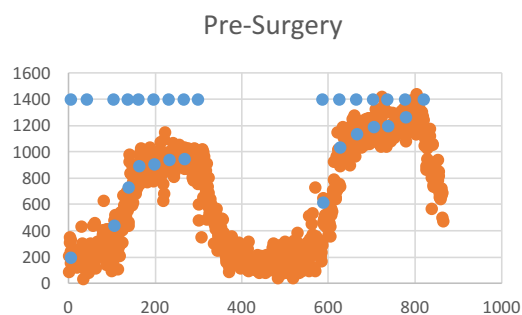
## Clinical Outcomes

	Pre-	Post-	% Improvement
10-meter walk test (comfortable, m/s)	0.76	0.80	5.3
10-meter walk test (fast, m/s)	1.01	1.01	0.0
6-minute walk test (ft.)	1202	1339	11.4
5 times sit-to-stand test (sec.)	17.11	12.88	24.7
4-square step test (sec.)	9.80	7.73	21.1
4-square, half prosthesis inside (sec.)	4.62	3.21	30.6
4-square, half prosthesis outside (sec.)	4.78	3.54	26.1

## Patient Questionnaire (1-7, 1=strongly agree, 4=neither agree nor disagree, 7 strongly disagree)

	Pre-	Post-	Change
Is your socket painful to wear?	3	7	4
Is your socket easy to put on?	1	1	0
Are you able to wear your socket for long periods of time?	3	1	2
Is your socket comfortable while seated?	2	1	1
Is it easy to go from sitting to standing in your socket?	2	1	1
Does your socket affect your ability to walk in your home?	3	7	4
Does your socket affect your ability to walk in the community?	3	7	4
Does your socket affect the distance you can walk in the community?	1	7	6
Do you feel you have good control of your prosthesis with this socket?	7	1	6
Do you feel stable on your prosthesis with this socket?	3	1	2
Do you like the look/shape of your socket?	7	5	2

# METABOLIC AND SPEED OUTCOMES WITH ISCHIAL CONTAINMENT SOCKET



	Pre	Post	Units	% change
E Comfortable	<b>8.20</b> (2.66)	<b>6.65</b> (1.33)	mL/min/kg	<b>-18.9</b>
E Fast	<b>11.73</b> (3.18)	<b>8.03</b> (1.64)	mL/min/kg	<b>-33.5</b>
COT Comfortable	<b>0.158</b> (0.05)	<b>0.113</b> (0.023)	mL/kg/m	<b>-28.5</b>
COT Fast	<b>0.175</b> (0.05)	<b>0.115</b> (0.026)	Nm/kg/m	<b>-34.5</b>

	Speed (m/min)
Pre Comfortable	<b>51.9</b> (2.04)
Pre Fast	<b>67.1</b> (1.72)
Post Comfortable	<b>58.8</b> (0.63)
Post Fast	<b>70.1</b> (2.32)

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# IMPLICATIONS

## DO DATA SUPPORT THE USE OF THIGHPLASTY?

▪ Volume and cosmesis	Yes
▪ Fat reduction	Yes
▪ Anatomical femur containment	Yes
▪ Questionnaire	Yes
▪ Walking distance, long distance	Yes
▪ Walking speed, short distance	Same
▪ Maneuverability	Yes
▪ Sit-to-stand	Yes
▪ Stiffness	<b>For subischial</b>
▪ Metabolics	Yes

## FURTHER IMPLICATIONS

- May allow amputees to use sockets they previously could not wear
- Shifts the focus of research from external devices to improving the human residual limb to work with a prosthesis—an area with little research to date
- Procedure may help inform future clinical care for amputees