Science Fiction to Science Fact

A look at the Past, Present, and Future of Prosthetic Devices

Matthew Parente, MS, PT, CPO, FAAOP
What is this all about?

Prosthesis

Orthosis

Do they have the anatomy?
Where Art Meets Science

https://charidimosart.wordpress.com/page/12/
What do we need to know?

- Knowledge of:
  - Anatomy
  - Biomechanics
  - Material Science
  - Physiology
  - Psychology
  - Computer science
  - Physics
  - Tissue mechanics
  - Rehabilitation science
  - Research
  - Engineering & Design
  - Marketing
  - Statistics
How do we do it?

Situational
Patient
Specific
Problem
Solving
Prosthetic Goals

- Replace structural support of skeletal system
- Transfer forces through the residual soft tissue to the femur
- Stabilize the bony anatomy in a natural position for posture and force production
- Restore function
Newton’s Cradle
Inspiration

“Learn from yesterday, live for today, hope for tomorrow. The important thing is not to stop questioning.”

Albert Einstein
Those who cannot learn from history are doomed to repeat it. George Santayana
THERE IS NO INSTANCE OF A NATION BENEFITTING FROM PROLONGED WARFARE.

Sun Tzu
“IN THE MIDST OF CHAOS, THERE IS ALSO OPPORTUNITY.”
- SUN TZU
Back to the bike...
Back to the bike...
ARTIFICIAL LEGS

WE ARE INCORPORATING, IN THE SECOND EDITION OF OUR SURGICAL INSTRUMENT CATALOGUE, ARTIFICIAL LEGS

This line was omitted from the first edition for the reason we had not at that time determined what was the best practical leg made. We are now furnishing the medical profession the MOST DURABLE, UP TO DATE ARTIFICIAL LEG.

OUR LEGS EMBODY THE LATEST AND MOST RELIABLE IMPROVEMENTS
For generations, the U.S. hastily mobilized men and money at the outbreak of war, then just as hastily drew down at the return of peace. But after 1945, the nation never fully dismobilized, investing its new global commitments with a large standing force—one that was increasingly professional, but also increasingly separated from society. Over time, relative death rates declined as training improved, as the increasingly hardware-intensive force put an ever-larger share of troops in safer rear-area jobs, and, above all, as medical advances slashed the deaths from infected wounds and camp epidemics that had devastated 19th-century armies. And as America moved from the mass military of World War II to smaller forces fighting "limited wars" in Korea, Vietnam, and the Gulf, the number of deaths declined as well.

Unprecedented defense spending helped the country out of the Great Depression. Fifty-six percent of eligible males were in uniform—and 97 percent of those who came home alive.

Disease in the ranks and statements on the battlefield made the Civil War bloodier even than WWI.

Post-war reform turned the old state militias into the modern National Guard.

The end of the draft sealed the shift from mass mobilization to a professional standing military.

DISENTANGLEMENT OF CONFLICT

<table>
<thead>
<tr>
<th>Conflict</th>
<th>Total Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revolutionary War</td>
<td>25,324</td>
</tr>
<tr>
<td>War of 1812</td>
<td>2,267</td>
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<tr>
<td>Mexican War</td>
<td>11,283</td>
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<tr>
<td>Civil War</td>
<td>496,232</td>
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<tr>
<td>Spanish-American War</td>
<td>2,489</td>
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<td>World War I</td>
<td>116,916</td>
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<td>World War II</td>
<td>405,399</td>
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<td>Korean War</td>
<td>36,974</td>
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<td>Vietnam War</td>
<td>58,009</td>
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<tr>
<td>Persian Gulf War</td>
<td>332</td>
</tr>
<tr>
<td>Post-9/11</td>
<td>5,796</td>
</tr>
</tbody>
</table>

NOTES: (1) Revolutionary War and Civil War personnel figures are estimates. Post-9/11 figures include only personnel serving in-theater, not all personnel serving worldwide during the conflict. (2) Defense spending based on Treasury Department figures for War Department and Navy Department outlays for 1795-1933 and on Defense Department figures for total national defense outlays (excluding Energy Department and other non-DDC spending) for 1940-2010. (3) Noncombat deaths from the War of 1812 (disease, accidents, etc.) are not available. (4) Civil War data for "total serving" and "total deaths" include both Union and Confederate figures; spending data in Union only because of difficulties in capturing by aggregation of Confederate currency and loss of records. (5) Post-9/11 data as of November 2010; post-9/11 total serving as of August 2010.

SOURCES: Department of Defense; Oxford Companion to American Military History; Economic History Services (en.wikipedia.org); Historical Statistics of the United States (Cambridge University Press).
Accelerating Growth in Technology

From: seekingalpha.com/article/453871-the-promise-of-accelerating-growth-in-technology
“We have much to learn by studying nature and taking the time to tease out its secrets.”
—David Suzuki
Wood & Leather
Early 1900’s Mechanical Hand
WWI German Prosthetic Arm
Body-Powered Prosthesis
CAD (Insignia)
CAM
Carbon, Silicone, & Composites
Traditional Myoelectric Control

Myoelectrode Position

Fit of Socket
Traditional Myoelectric Prosthesis

Parts of a below-elbow myoelectric prosthesis

- electrodes
- control unit and battery pack
- friction wrist
- socket
- electric hand

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HOW THE i-LIMB WORKS

1. Bionic hand, attached to laminated socket, is slipped over arm

2. When patient decides to move hand, the brain signals are picked up by delicate electrodes

3. Electrodes pass commands to a tiny computer concealed in the back of the artificial hand

4. Computer activates the motors needed to move the fingers

Index finger can be pointed, allowing the wearer to use a keypad

The bionic hand can be covered with artificial skin
i-Limb
Sensor signals are transmitted to stimulate nerves to restore sense of touch

Prosthetic hand controlled by signals from arm muscles
Multi Articulating hands

- I-Limb Quantur
- BeBionic
- Vincent Hand
- Michelangelo
Michelangelo

- Very fast
- Powered positional thumb
- Natural appearance
- Natural relaxed hand posture
- Flexi-wrist
- Multiple grasp patterns
BeBionic

- Thumb position determines grip pattern
- Individually powered fingers
- Many programmable grip patterns
- Small size now available
BebBionic

- 14 Grip patterns
- Can be used without glove
- 4 wrist options
  - MultiFlex
  - Flexion
  - Quick disconnect
  - Short version
I-Limb

- 5 powered digits
- Manually positional thumb
- 24 different grasp patterns
- Can create custom gestures
- Pulsing feature to increase grip strength
- Powered rotational thumb
- Flexion wrist option
- Now with gesture control
Targeted Muscle Reinnervation
Mind-controlled Prosthesis

Mind-controlled bionic arm
A mechanical prosthetic controlled by thought

1. Following amputation nerve endings remain
2. Nerves rerouted to healthy muscle "Targeted muscle reinnervation"
3. When patient thinks about moving arm, muscle contracts
4. Electodes detect the movement, send signal to processor

Development
Rehabilitation Institute of Chicago
Project leader: Dr Todd Kuiken
First developed in 2002
Fitted onto more than 50 amputees

Source: RIC AFP
Luke Arm
Luke Arm

- Requires TMR
- Has multiple degrees of freedom:
  - The shoulder configuration offers 10 powered degrees of freedom.
  - The humeral configuration offers 8 powered degrees of freedom.
  - The radial configuration offers 6 powered degrees of freedom.
- Has multiple configurations for control:
  - EMG
  - IMU (Inertial Measurement unit)
  - Pressure Transducers
  - Pressure switch
  - Rocker switch
  - Linear Transducers
3-D Printed Hands
New Designs
Design process start to finish
OPTIONS AVAILABLE FOR SILICONE INTERFACING

- Zippers
- Anchors
- Multi-durometer
- Multi-color
- Embedded reinforcement
- Variable thickness
- Endless color options
- Embedded electrodes
- Tattoos
- Embedded technology
PREPARING THE SILICONE

• Clean up trim-lines
• Remove any imperfections
• Cure in oven for 8 hours at 130 Degrees
Electric Fingers

ProDigits

Vincent Finger
PARTIAL HAND DESIGN
FINAL FABRICATION
Thank You!

We Learn...
10% of what we read,
20% of what we hear,
30% of what we see,
50% of what we see and hear,
70% of what we discuss,
80% of what we experience,
95% of what we teach others.

- William Glasser
Special Thanks

- Abby Hoffman-Finitis, Med, CP
  - Assistant Professor, University of Hartford, MSPO Program

- Matthew Mikosz, CP
  - National Upper Extremity Specialist, Hanger Clinic