UCSF
University of California
San Francisco

Advances in Prosthetic Technology

UCSF Osher Mini-Medical School for the Public

Matthew Garibaldi, MS, CPO
Director
Assistant Clinical Professor
Richard Nguyen, CPO
Clinical Chief

2/22/2018

Any sufficiently advanced technology is indistinguishable from magic.

Arthur C. Clarke

What is a Prosthesis?

noun | pros·the·sis | \prä·ˈthē·səs, ˈprä·thə-\

Definition: an artificial device to replace or augment a missing or impaired part of the body

What is a Prosthesis?

Internal vs. External Prosthesis

What is a Prosthesis?

Restoration vs. Functional

What is a Prosthesis?

External Functional Device

Prosthesis

Orthosis

Anatomy of a Prosthesis

What makes up a prosthetic device

-Socket: human interface

7 Advances in Prosthetic Technology

Anatomy of a Prosthesis

What makes up a prosthetic device

-Socket: human interface

-Joint Replacement: elbow or knee

8 Advances in Prosthetic Technology

Anatomy of a Prosthesis

What makes up a prosthetic device

-Socket: human interface

-Joint Replacement: elbow or knee

-Terminal Device: hand or foot

9 Advances in Prosthetic Technology

Prosthetic Sockets

Historical Perspective on Sockets

Carved Wooden sockets

Socket

Joint

Terminal Device

Upper Extremity

Modern Prosthetics

Taking a manual mold of the residual limb

Hand Cast

- Plaster
- Positive model
- Vacuum form
- Test socket
- Final socket

Socket

Joint

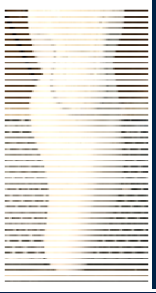
Terminal Device

Upper Extremity

Modern Prosthetics

Taking a manual mold of the residual limb

Hand Cast
- Plaster
- Positive model
- Vacuum form
- Te
- Fir



Socket
Joint
Terminal Device
Upper Extremity

13 Advances in Prosthetic Technology

Modern Prosthetics

Taking a manual mold of the residual limb

Hand Cast
- Plaster
- Positive model
- Vacuum form
- Test socket
- Final socket

Socket
Joint
Terminal Device
Upper Extremity

14 Advances in Prosthetic Technology

Modern Prosthetics

Taking a manual mold of the residual limb

Hand Cast
- Plaster
- Positive model
- Vacuum form
- Test socket
- Final socket

Socket
Joint
Terminal Device
Upper Extremity

15 Advances in Prosthetic Technology

Modern Prosthetics

Taking a manual mold of the residual limb

Hand Cast
- Plaster
- Positive model
- Vacuum form
- Test socket
- Final socket

Socket
Joint
Terminal Device
Upper Extremity

16 Advances in Prosthetic Technology

Modern Prosthetics

Digital mold of the residual limb

Digital Scan
- 3D Digital Scan
- 3D CAD model
- Foam carving
- 3D print

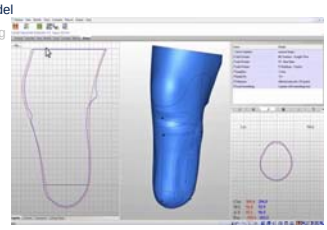
Socket
Joint
Terminal Device
Upper Extremity

17 Advances in Prosthetic Technology

Modern Prosthetics

Digital mold of the residual limb

Digital Scan
- 3D Digital Scan
- 3D CAD model
- Foam carving
- 3D print



Socket
Joint
Terminal Device
Upper Extremity

18 Advances in Prosthetic Technology

Modern Prosthetics

Digital mold of the residual limb

Digital Scan
- 3D Digital Scan
- 3D CAD model
- Foam carving
- 3D print

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Digital mold of the residual limb

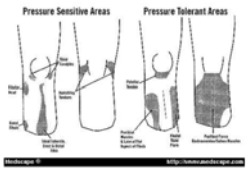
Digital Scan
- 3D Digital Scan
- 3D CAD model
- Foam carving
- 3D print

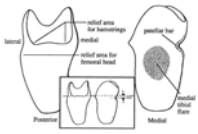
Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Socket Technology

Transtibial Socket Design
- Paltellar Tendon Bearing
- Total Surface Bearing
- Elevated Vacuum
- Adjustable





Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Socket Technology

Transtibial Socket Design

- PTB
- Total Surface Bearing
- Elevated Vacuum
- Adjustable

Socket

Joint

Terminal Device

Upper Extremity

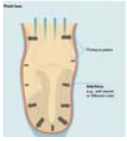
UCSF

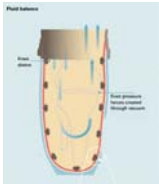
Modern Prosthetics

Socket Technology

Transtibial Socket Design

- PTB
- Total Surface Bearing
- Elevated Vacuum
- Adjustable





Socket

Joint

Terminal Device

Upper Extremity

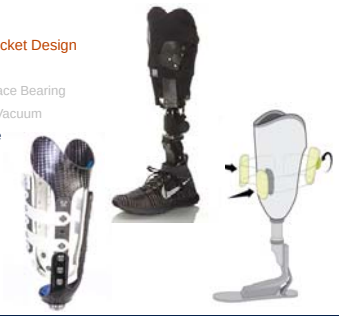
UCSF

Modern Prosthetics

Socket Technology

Transtibial Socket Design

- PTB
- Total Surface Bearing
- Elevated Vacuum
- Adjustable



Socket

Joint

Terminal Device

Upper Extremity

UCSF

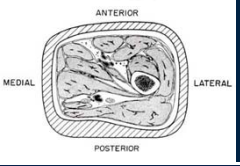
UCSF

Modern Prosthetics

Socket Technology

Transfemoral Socket Design

- Quad
- Ischial Containment
- VECTR



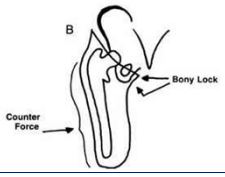
Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Socket Technology

Transfemoral Socket Design

- Quad
- Ischial Containment
- VECTR



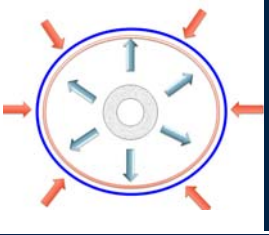
Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Socket Technology

Transfemoral Socket Design

- Quad
- Ischial Containment
- VECTR



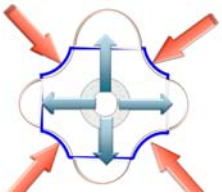
Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Socket Technology

Transfemoral Socket Design

- Quad
- Ischial Containment
- VECTR



Socket
Joint
Terminal Device
Upper Extremity

Future Prosthetics

Eliminating the socket

Osseo Integration - OPRA

- Fixture
- Abutment
- Axor II

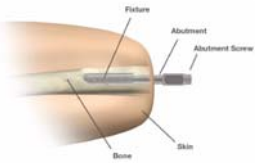
Socket
Joint
Terminal Device
Upper Extremity

Future Prosthetics

Eliminating the socket

Osseo Integration - OPRA

- Fixture
- Abutment
- Axor II



Socket
Joint
Terminal Device
Upper Extremity

Future Prosthetics

Eliminating the socket

Osseo Integration - OPRA

- Fixture
- Abutment
- Axor II

Socket

Joint

Terminal Device

Upper Extremity

UCSF

Future Prosthetics

Eliminating the socket

Osseo Integration - OPRA

- Fixture
- Abutment
- Axor II

Socket

Joint

Terminal Device

Upper Extremity

UCSF

Future Prosthetics

Eliminating the socket

Socket

Joint

Terminal Device

Upper Extremity

UCSF

UCSF

Prosthetic Knees

Historical Perspective

Mid – late 1500s

- Ambroise Pare
  - -French army barber/surgeon
  - -Father of modern amputation surgery
  - -Introduced modern amputation procedures
  - -Created ground breaking above-knee devices such as a locking knee joints for stability during stance.

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Knee Joint Technology

Knees

- Mechanical
- Hydraulic
- Microprocessor Controlled
- Powered

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Knee Joint Technology

Knees
- Mechanical
- Hydraulic
- Microprocessor Controlled
- Powered

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Knee Joint Technology

Knees
- Mechanical
- Hydraulic
- Microprocessor Controlled
- Powered

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Knee Joint Technology

Knees
- Mechanical
- Hydraulic
- Microprocessor Controlled
- Powered

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Knee Joint Technology

Knees

- Mechanical
- Hydraulic
- Microprocessor Controlled
- Powered

Socket

Joint

Terminal Device

Upper Extremity

40 Advances in Prosthetic Technology

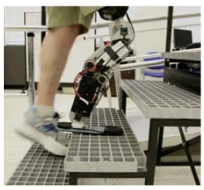
UCSF

Future Prosthetics

Knee Joint Technology

Future Technology

- Bionic Powered Knee/Foot



Socket

Joint

Terminal Device

Upper Extremity

41 Advances in Prosthetic Technology

UCSF

Prosthetic Feet

42 Advances in Prosthetic Technology

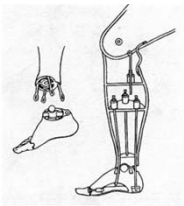
UCSF

UCSF

Historical Perspective

17th – 19th Century

- 1858, Douglas Bly
- "Dr. Bly's Anatomical Leg"
- Ankle joint formed by ivory ball
- Vulcanized rubber foot
- Revered as most complete and success invention ever attained in artificial limbs



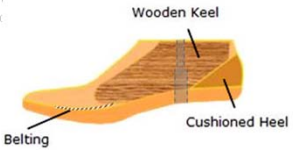
Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Prosthetic Foot Technology

Feet

- Conventional feet (CF)
- Energy-Storage-and-Return (ESR)
- Articulated Feet
- Dynamic Response
- Microprocessor Controlled Feet
- Bionic



Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Prosthetic Foot Technology

Feet

- Conventional feet (CF)
- Energy-Storage-and-Return (ESR)
- Articulated Feet
- Dynamic Response
- Microprocessor Controlled Feet
- Bionic feet

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics

Prosthetic Foot Technology

Feet

- Conventional feet (CF)
- Energy-Storage-and-Return (ESR)
- Articulated Feet
- Dynamic Response
- Microprocessor Controlled Feet
- Bionic feet

Socket

Joint

Terminal Device

Upper Extremity

46 Advances in Prosthetic Technology

UCSF

Modern Prosthetics

Prosthetic Foot Technology

Feet

- Conventional feet (CF)
- Energy-Storage-and-Return (ESR)
- Articulated Feet
- Dynamic Response
-
-

Socket

Joint

Terminal Device

Upper Extremity

47 Advances in Prosthetic Technology

UCSF

Modern Prosthetics

Prosthetic Foot Technology

Feet

- Conventional feet (CF)
- Energy-Storage-and-Return (ESI
- Articulated Feet
- Dynamic Response
- Microprocessor Controlled Feet
- Bionic feet

Socket

Joint

Terminal Device

Upper Extremity

48 Advances in Prosthetic Technology

UCSF

UCSF

Modern Prosthetics

Prosthetic Foot Technology

Feet

- Conventional feet (CF)
- Energy-Storage-and-Return (ESR)
- Articulated Feet
- Dynamic Response
- Microprocessor Controlled Feet
- Bionic feet

Socket

Joint

Terminal Device

Upper Extremity

Upper Extremity Prosthetics

Historical Perspective

Early 1500s

- Gotz Von Berlichingen
- German engineering
- Articulated hands
- Mechanical masterpieces

Socket

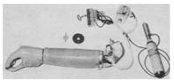
Joint

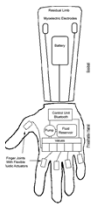
Terminal Device

Upper Extremity

Historical Perspective

World War II
- 1929 – 1945
- U.S. Gov. brokered deal with military companies to improve prosthetic function
- Marked the beginning of the era of modern prosthetics





Socket
Joint
Terminal Device
Upper Extremity

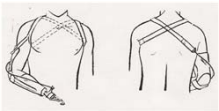
Modern Prosthetics
Upper Extremity Devices

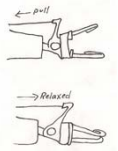
Upper Extremity
- Passive
- Body power
- Electric vs DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA

Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics
Upper Extremity Devices

Upper Extremity
- Passive
- Body power
- Electric vs DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA

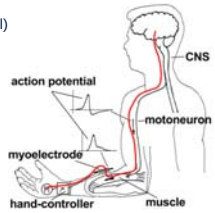




Socket
Joint
Terminal Device
Upper Extremity

Modern Prosthetics
Upper Extremity Devices

Upper Extremity
- Passive
- Body power
- Electric & DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA

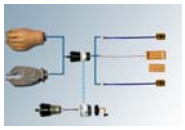


Socket
Joint
Terminal Device
Upper Extremity

55 Advances in Prosthetic Technology

Modern Prosthetics
Upper Extremity Devices

Upper Extremity
- Passive
- Body power
- Electric & DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA



Socket
Joint
Terminal Device
Upper Extremity

56 Advances in Prosthetic Technology

Modern Prosthetics
Upper Extremity Devices

Upper Extremity
- Body power vs external
- Electric vs DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA

Socket
Joint
Terminal Device
Upper Extremity

57 Advances in Prosthetic Technology

Modern Prosthetics
Upper Extremity Devices

Upper Extremity
- Body power vs external
- Electric vs DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA

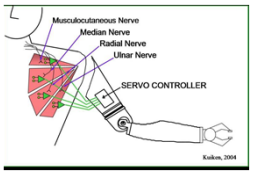
Socket
Joint
Terminal Device
Upper Extremity

58 Advances in Prosthetic Technology

UCSF

Modern Prosthetics
Upper Extremity Devices

Upper Extremity
- Body power vs external
- Electric vs DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA



Socket
Joint
Terminal Device
Upper Extremity

59 Advances in Prosthetic Technology

UCSF

Modern Prosthetics
Upper Extremity Devices

Upper Extremity
- Body power vs external
- Electric vs DME (proportional)
- Sequential vs simultaneous
- Multi-articulating digits
- TMR
- DARPA

Socket
Joint
Terminal Device
Upper Extremity

60 Advances in Prosthetic Technology

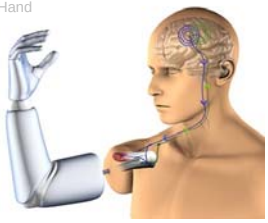
UCSF

UCSF

Future Prosthetics

Upper Extremity Devices

Upper Extremity
- Neural Integration
- Sensing Prosthetic Hand



Socket
Joint
Terminal Device
Upper Extremity

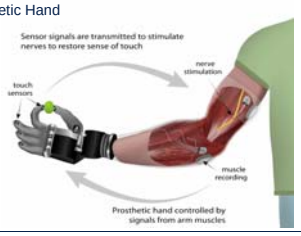
61 Advances in Prosthetic Technology

UCSF

Future Prosthetics

Upper Extremity Devices

Upper Extremity
- Neural Integration
- Sensing Prosthetic Hand



Socket
Joint
Terminal Device
Upper Extremity

62 Advances in Prosthetic Technology

UCSF

UCSF Orthotic and Prosthetic Centers

UCSF

UCSF