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Prosthetic and orthotic devices

February 22, 2023

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Presenters

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Objectives

1. Discuss the medical treatment course for claimants with an amputation.
2. Review the safety, functional, and financial considerations related to the claimant with an amputation.
3. Describe the different types of upper and lower limb prosthetic devices, their advantages, and their potential disadvantages.
4. Discuss the benefits and potential risks of orthotic devices.
5. Review the differences between off-the-shelf and custom-made orthotic devices.
6. Describe the different types of orthotic devices, their indications, and important considerations when they are used.

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Prosthetic devices

Effects of comorbid conditions on amputations

Comorbid conditions

- Diabetes
- Tobacco use
- Vascular disease
- Heart disease
- Depression
- Obesity
- Arthritis
- Substance abuse
- Aging claimant

Complications

- Infection
- Impaired wound healing
- Contractures
- Deconditioning
- Pain
- Worsening depression
- Sedation
- Falls

Impact on use of prosthesis

- Weakness
- Impaired cognition
- Decreased endurance
- Lack of motivation

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Hospital course

Postoperative care

- Pain control
- Minimize blood loss
- Adequate nutrition
- Control swelling
- Falls prevention
- Early range of motion and mobilization
- Prosthetic vendor referral

Discharge planning

- Home
- Subacute nursing facility
- Acute inpatient rehabilitation
- DME
- Follow-up
  - Providers
  - Physical medicine
  - Prosthetic vendor

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Post-discharge recovery and rehabilitation

Pain control

- Postsurgical pain
- Phantom limb pain
  - Sensations
  - Pain
    - Anticonvulsants and antidepressants
    - Desensitization techniques
    - Mirror therapy
    - “Movement” of the missing limb

Wound care

- Surgical wound management
- Compression (wrap / shrinker)
- Precautions with elevation
- Weight-bearing limitations
- Nutrition and hydration
- Scar mobilization

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Post-discharge recovery and rehabilitation

Residual limb shaping

- Elastic bandages (ACE wrap)
- Shrinker socks

Mobilization

- Range of motion
- Strengthening of other limbs
- Ambulation
- Stair climbing

Endurance

- Cardiovascular fitness
- Energy conservation techniques
- Joint protection

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Prosthetic vendor referral

Physician preference

- Surgeon or physiatrist
- Order set

Claimant contact

Usually established prior to discharge from the hospital or rehabilitation center

- Introductory information
- Residual limb care
- Safety and precautions
- Estimated timeline for first prosthetic device

Peer visit

- Former patient
- Amputee coalition

Outpatient prosthetic evaluation

- Medical history
- Physical examination
- Functional assessment
  - Prior
  - Current
  - Potential level of function and goals
    - Realistic
    - Meaningful
    - Unlikely to be more functional than prior to amputation

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Prosthesis timeline

Immediate postoperative prosthesis

- Applied immediately after surgery
- Initial weight-bearing
- Only used until temporary prosthesis is created

Temporary prosthesis

- Provided within several months after amputation
- Essential components only
- Gait training
- Safety

Definitive (final) prosthesis

- Created three to six months after amputation
- Occasional use of some components from temporary prosthesis
- Additional costs
- Lifetime dependent upon wear and repairs
- Repairs vs. replacement

Characteristics of the population: Gender and Age

	Dysvascular	Trauma	Cancer
Male	60%	78%	36%
Age			
< 45	16%	46%	43%
45-64	58%	44%	42%
>=65	26%	20%	15%

South Med. J 95(8):875-883,2802
Limb Amputation and Limb Deficiency
Timothy R. Dillingham, D.D. et. al.

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Percent using a prosthesis

	Dysvascular	Trauma	Cancer
Never	18%	19%	24%
<8 hrs/day	22%	18%	11%
>=8 hrs/day	60%	63%	66%

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Percent using a prosthesis: Level of amputation

	Upper limb	Lower limb
Never	49%	16%
<8 hrs/day	27%	17%
>=8 hrs/day	29%	67%

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Current activity by age

	18-44	45-54	55-64	>=65
Working or school	66%	49%	35%	9%
Looking for work	12%	11%	5%	2%
Homemaker	8%	5%	5%	6%
Retired-disability	14%	33%	42%	28%
Retired-other	0%	2%	13%	55%

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Team approach

Physician

Case worker

Physical Therapist

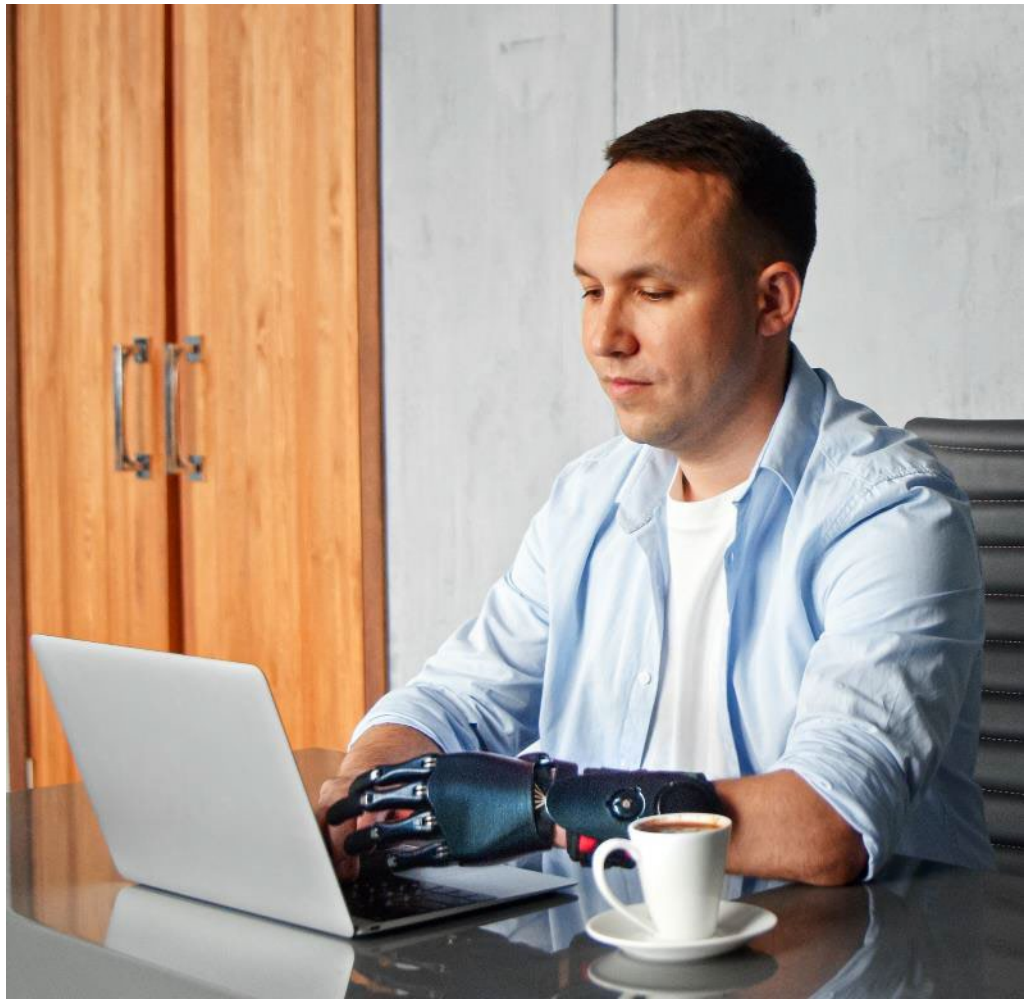
Family members

Occupational therapist

Prosthetist

Keep in mind…

- Everyone is different, as will be their prostheses
- Age is never a deciding factor for prosthetic intervention "Functional" age is important
- There are very few contraindications for a prosthesis
- Patients discuss with other patients - pros and cons
- Generally, new amputees have limited understanding of
  - What to expect
  - What is possible



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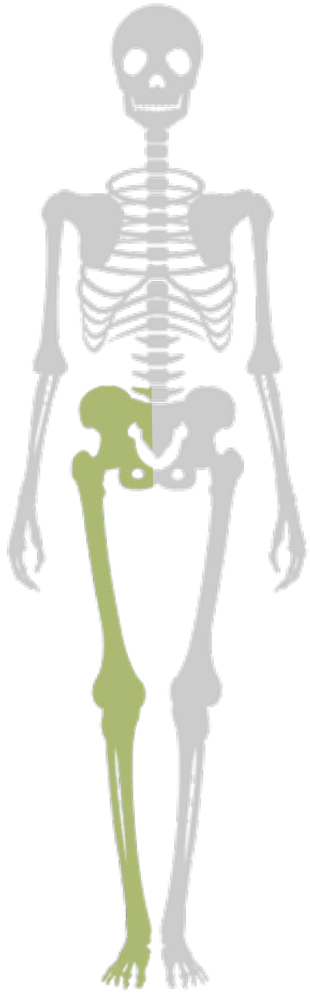
Amputation site selection (lower limb)

- Hemicorporectomy
- Hemipelvectomy
- Hip disarticulation
- Transfemoral (above-the-knee)
- Knee disarticulation
- Transtibial (below-the-knee)
- Ankle disarticulation (Syme's)
- Midtarsal (Chopart)
- Tarsometatarsal junction (Lisfranc)
- Transmetatarsal
- Partial foot/partial toe



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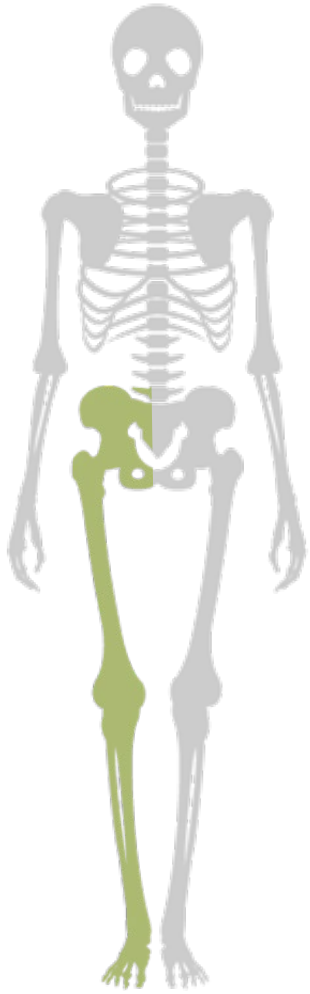

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Amputation site and additional energy required for walking

25%

Single below-the-knee

41%

Bilateral below-the-knee

60-70%

Single above-the-knee

>200%

Bilateral above-the-knee

Cuccurullo, Sara J. Physical Medicine and Rehabilitation Board Review. 3rd ed. New York: Demos Medical, 2015. Page 477.

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Lower limb prosthesis components are determined by claimant's K-level

Medicare defines K-levels based on the ability or **potential** to ambulate and navigate the environment.

K-level	Functional level of amputee
K0	**No ability or potential** to ambulate or transfer safely with or without assistance and a prosthesis does not enhance quality of life or mobility.
K1	Ability or potential to use a prosthesis for transfers or ambulation on level surfaces **at fixed cadence**.
K2	Ability or potential for ambulation with the ability to traverse **low-level environmental barriers** such as curbs, stairs, or uneven surfaces.
K3	Ability or potential for ambulation with **variable cadence** - a typical community ambulatory with the ability to traverse most environmental barriers may have activity that demands prosthetic use beyond simple locomotion.
K4	Ability or potential for ambulation that **exceeds basic ambulation** skills, exhibiting high impact, stress, or energy levels.

Lower limb prosthesis components are determined by claimant's K-level

Medicare defines K-levels based on the ability or **potential** to ambulate and navigate the environment.

K-level	Functional level of amputee	Type of prosthesis
K0	**No ability or potential** to ambulate or transfer safely with or without assistance and a prosthesis does not enhance quality of life or mobility.	Not eligible for a functional prosthesis
K1	Ability or potential to use a prosthesis for transfers or ambulation on level surfaces **at fixed cadence**.	External keel, SACH feet or single axis ankle/feet, single-axis, constant friction knee
K2	Ability or potential for ambulation with the ability to traverse **low-level environmental barriers** such as curbs, stairs, or uneven surfaces.	Flexible-keel feet and multi-axial ankle/feet, single-axis, constant friction knee
K3	Ability or potential for ambulation with **variable cadence** - a typical community ambulatory with the ability to traverse most environmental barriers may have activity that demands prosthetic use beyond simple locomotion.	Flex foot and flex-walk systems, energy storing feet, multi-axial ankle/feet, or dynamic response feet, fluid and pneumatic control knee, microprocessor knee
K4	Ability or potential for ambulation that **exceeds basic ambulation** skills, exhibiting high impact, stress, or energy levels.	Any ankle foot system appropriate, any ankle knee system appropriate, including microprocessor

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Lower limb prostheses

Type

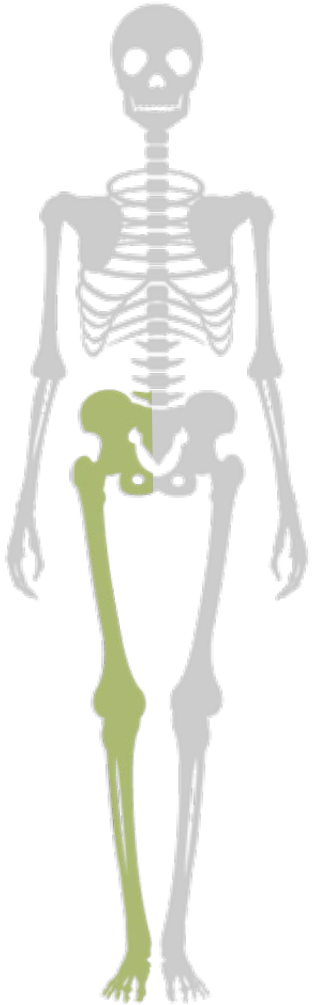
- Functional considerations
- Knee and ankle components

Special considerations

- Amputation site
- Cognitive abilities
- Residual strength and range of motion
- Endurance
- Claimant weight
- Comorbid conditions

Potential complications

- Contractures
  - Knee
  - Hip
- Gait deviations
- Fall risk
- Abandonment of prosthesis



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Components of a lower limb prosthesis

- Suspension
- Socket
- Knee
- Lower leg (shank)
- Foot/ankle

Partial foot

- Partial toe
- Toe disarticulation
- Metatarsal ray resection
- Transmetatarsal (TMA)
- Lisfranc & Chopart






Syme

Ankle disarticulation

- Challenging cosmesis
- Doors/windows for donning
- Weight-bearing end
- Limited foot options

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Transtibial

Resection through tibia and fibula

Anatomical knee joint preserved

Requires 25% more energy than normal

Knee disarticulation

Entire femur and condyles intact

Advantages

- Good end-bearing surface
- Lower trimline
- Long lever arm for power/control

Disadvantages

- Limited space for attachment components
- Prosthetic knee center lower than anatomical knee which causes gait deviation and sitting anomaly

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Transfemoral

Resection through femur

Requires 66% more energy than normal

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Lower extremity prosthetics
Microprocessor-controlled knees

Frequency of falling

66%

Transfemoral (TF) amputees experienced a fall within the previous year

4%

General population fall annually

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Gauthier-Gagnon, C (1999) Arch Phys Med Rehabil 80(6): 706-13. (n=396)

Incidence rate (per 100,000 persons) of injuries by mechanism - Corso, P, E Finkelstein, T Miller, I Fiebelkorn and E Zaloshnja (2006). "Incidence and lifetime costs of injuries in the United States." Inj Prev 12(4): 212-8.

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Hip Disarticulation / Transpelvic

- Slow fixed cadence
- Component selection and alignment similar for both levels
- Prosthetic fitting typically limited to motivated and physiologically vigorous individuals
- Lack of comfort most common reason for NOT wearing prosthesis at these levels
- Energy requirements up to 200% of normal ambulation

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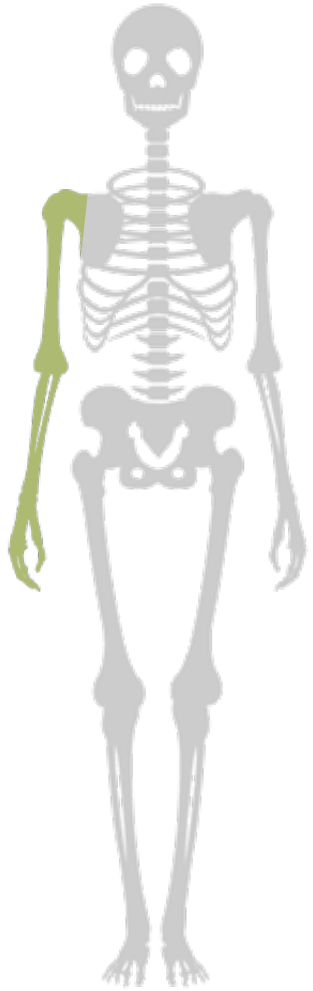
Amputation site selection (upper limb)

- Forequarter
- Shoulder disarticulation
- Transhumeral (above-the-elbow)
- Elbow disarticulation
- Transradial (below-the-elbow)
- Wrist disarticulation
- Transcarpal
- Transmetacarpal
- Transphalangeal



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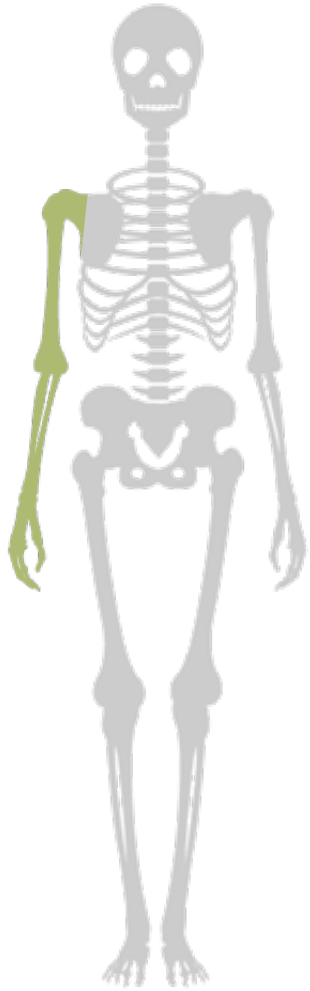

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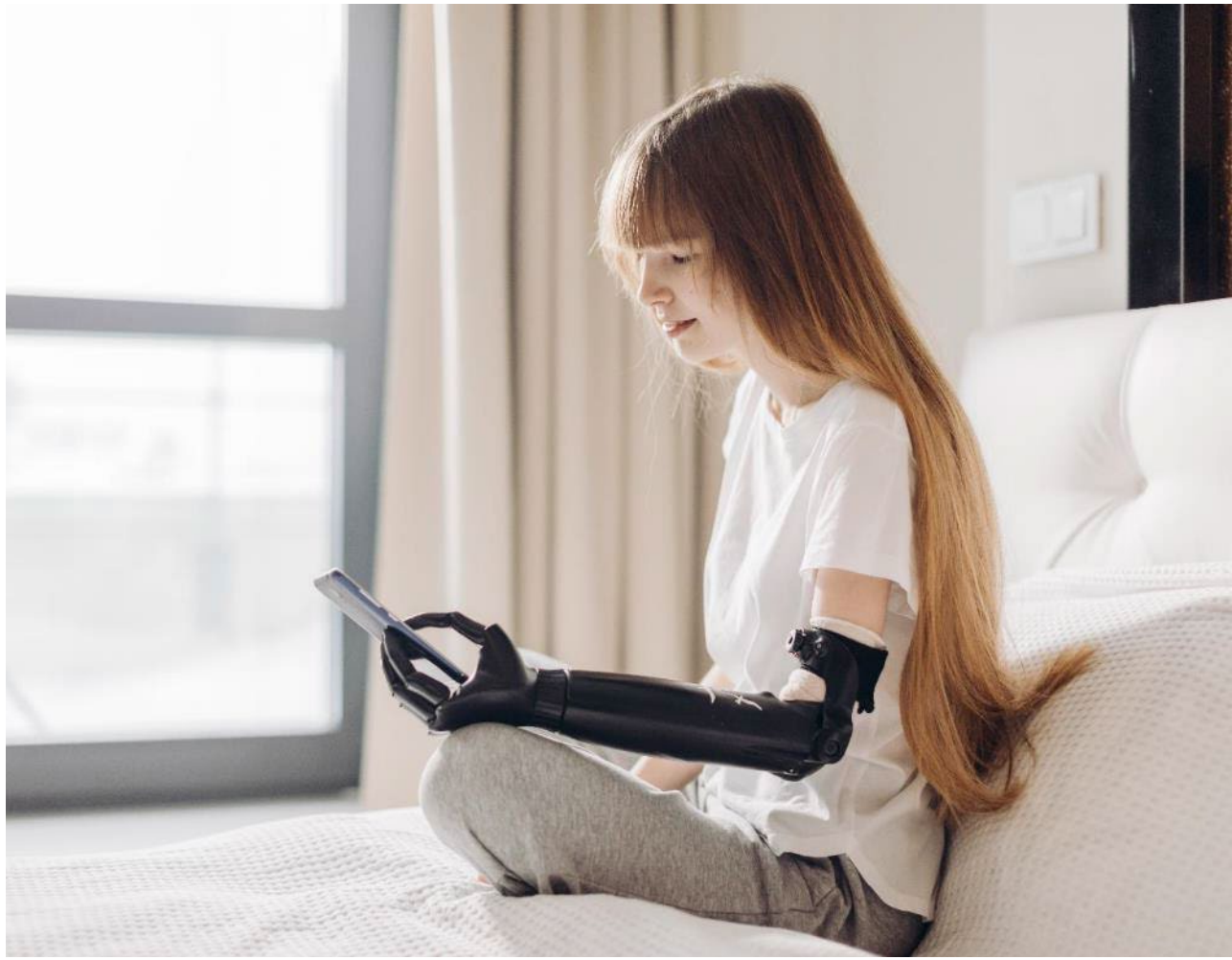
Upper extremity amputees

- The goal of Prosthetic Rehabilitation is to provide appropriate function to meet the goals and abilities in order to return to work.
- There are many prosthetic options and adaptations
- One prosthetic system typically does NOT meet all of the needs of an individual

There is NO standard prosthesis or protocol



Factors influencing success

50%

Upper limb amputees
do not use a prosthesis

Long-term implications

- Overuse injuries
- Psychosocial
- Posture

We take for granted the simple bimanual tasks we do every day.

Upper extremity prosthetics

“Golden Period” of within 30 days

93%

Success rate for patients fitted within 30 days

42%

Success rate for patients fitted after 30 days

Upper limb prostheses

Options

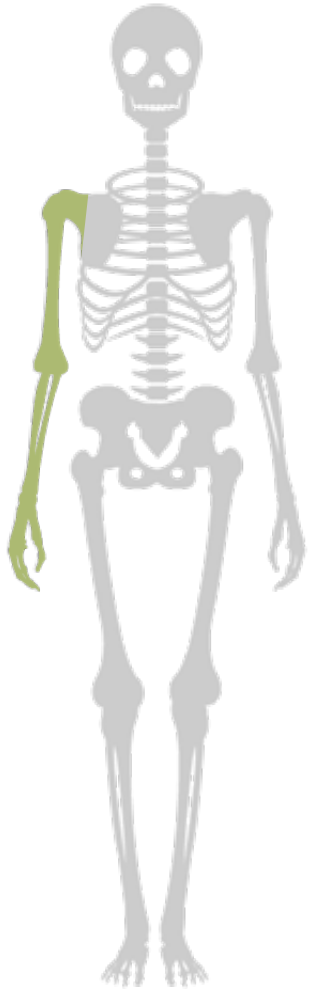
- No prosthesis
- Passive (semi-prehinsile, cosmetic)
- Manual/body powered (cable operated)
- Myoelectric
- Hybrid
- Adaptive / activity specific

Special considerations

- Amputation site
- Cognitive abilities
- Residual strength and range of motion
- Durability requirements

Potential complications

- Overuse injuries
- Skin wounds
- Abandonment of prosthesis



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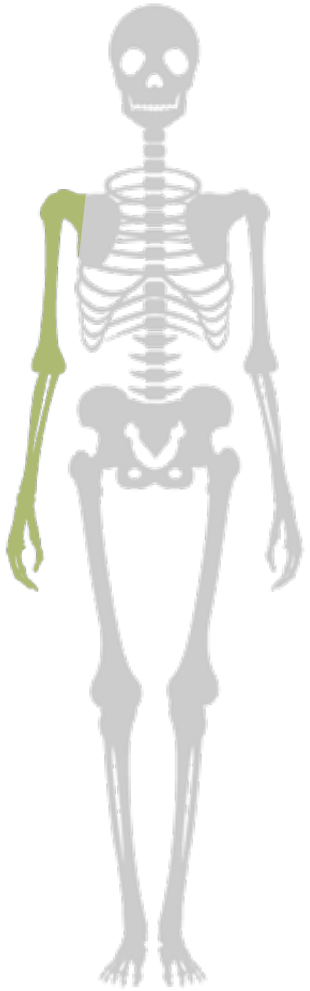
Components of an upper limb prosthesis

- Suspension
- Socket
- Upper arm
- Elbow
- Forearm
- Wrist
- Terminal device (hand)
  - Functional vs. cosmetic
  - Hand vs. hook
- Control system
  - Body powered
  - Myoelectric



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Bad first experience with a prosthesis

- Unaware of options
- Limited functional ability
- Not worth the “hassle”
- Lack of sufficient prosthetic training
- Development of one-handedness
- Unnatural look

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Passive prosthesis

A cosmetic restoration with limited functional capabilities

Used for functional activities that do not require active prehension

Typically digits can be manipulated to enhance function

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Upper extremity prosthetics: Custom cosmetic restoration

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Prosthesis options

Cable operated prosthesis

Powered and controlled by gross body movements captured by a harness system.

Excursion: Body motions used for control

Force: Force associated with those body motions

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Prosthesis options

Cable operated prosthesis

Powered and controlled by gross body movements captured by a harness system.

Excursion: Body motions used for control

Force: Force associated with those body motions

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Hooks – Hosmer designs

In general, hooks are used for function versus a hand. They offer a better visual of the object being manipulated.

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Prosthesis options

Electrically powered prosthesis

- Battery system
- Various Control Options: Myoelectric (single or dual site), Switch – rocker, pull, push, Touch Pads, Servo control.

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Prosthesis options

Electrically powered prosthesis

- Battery system
- Various Control Options: Myoelectric (single or dual site), Switch – rocker, pull, push, Touch Pads, Servo control.

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Hybrid prosthesis: body powered + external power

- A prosthesis utilizing various control strategies
- Most universal configurations:
  - Cable-driven elbow / electric hand
  - Passive elbow / electric hand

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Prosthesis options

Adaptive prosthesis

A prosthesis that is designed for a specific activity or an adaptation to an existing prosthesis

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Copyright TRS Prosthetics

Prosthesis options

Adaptive prosthesis

A prosthesis that is designed for a specific activity or an adaptation to an existing prosthesis

Copyright Texas Assistive Devices

Copyright TRS Prosthetics

Multiple prosthesis

- Many prosthetic users rely on more than one prosthesis to perform diverse types of activities and tasks.
- The secondary prosthesis may also serve as a back-up prosthetic system.

Partial hand

Passive/cosmetic restoration

- Cosmetic appearance
- Protection of tender areas
- Augmentation of active grasp

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Passive/mechanical

- Augmentation of active grasp
- Less expensive than cosmetic glove

Copyright naked prosthetics

Externally powered

- Myoelectric

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Transphalangeal → **Transmetacarpal** → **Transcarpal**

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Prosthesis options

Wrist disarticulation / transradial

- The longer the limb, the more supination/pronation is preserved
- Control
  - Body powered
  - Externally powered

Prosthesis options

Wrist disarticulation / transradial

- The longer the limb, the more supination/pronation is preserved
- Control
  - Body powered
  - Externally powered

Elbow disarticulation / Transhumeral

Crucial Factors

- Length of the bony lever arm
- Quality & nature of soft-tissue coverage
- Shape and muscle tone of the residual limb
- Flexibility, ROM, & stability of proximal joints

Successful long-term use

- Comfort
- Perceived value to patient

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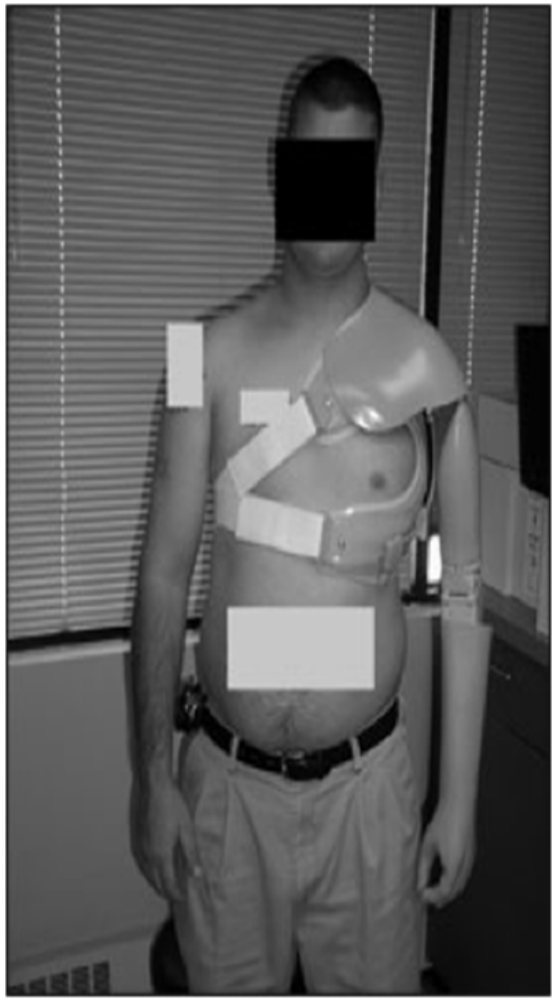
Shoulder Disarticulation/Interscapulothoracic (Forequarter)

Major challenges

- Prosthesis stability
- Cosmetic appearance (especially natural shoulder profile)



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Orthotic devices

Purpose of an orthotic device

An externally applied device to a body segment that facilitates or improve function by supporting, correcting, or compressing for skeletal deformity or weakness.

Options

- Support and align
- Prevent or correct deformity
- Substitute for function
- Pain relief
- Transfer load from one area to another
- Inhibit tone
- Restrict motion

Special considerations

- Compliance
- Skin breakdown or blisters: too tight or too loose
- Muscle weakness
- Overdependence or overreliance

Differences between off-the-shelf and custom-made orthotic devices

Availability

Patient-fit

Cost

- Devices are often requested by brand-name instead of function
- If physician fits the product, how often is the least expensive device provided or contract with certain company
  - If insurance pays, price is not an issue?
- A prosthetic-orthotic clinic cannot stock all brands in each office(s)
- Brand-specific requests could result in higher cost without improved function or outcome and possibly delay care if certain brand not in stock
- Cost of orthosis or prosthesis includes all practitioner clinical evaluation, casting, fitting, and follow up time
- If deformity present, special circumstances, or measurements are outside of sizing guidelines, custom-made is indicated for

Lower limb orthotic devices: Knee-ankle-foot orthosis (KAFO)

- Single axis
- Posterior offset
- Locking knee (drop lock, bail lock)
- Stance control

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Lower limb orthotic devices: Ankle-foot orthosis (AFO)

- Posterior leaf
- Semi-rigid
- Solid plastic
- Articulated
- Tone-reduction properties
- Carbon

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Lower limb orthotic devices: Knee orthosis (KO)

- Mediolateral stability
- Flexion extension limits (IROM joints)
- Swedish cage: used in the management of knee hyperextension

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Lower limb orthotic devices: Ankle support orthosis (ASO)

- Ankle sprain
- Ankle instability

Copyright AirCast

Copyright DonJoy

Copyright MedSpec

Upper limb orthotic devices

Static

- Immobilize or support
- Help prevent deformity
- Prevent soft tissue contracture
- Allow attachment of assistive devices
- Block a segment

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Dynamic

- To substitute for loss of motor function
- To correct an existing deformity
- Provide controlled directional movement
- Aid in fracture and wound healing

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Finger orthoses

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Upper limb orthotic devices

Cock-up splint/carpal tunnel splint

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Upper limb orthotic devices

Cock-up splint/carpal tunnel splint

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Copyright djoglobal

Tone-reducing splints

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Spinal orthotic devices: Cervical spine

- Soft
- Rigid
- Sterno-occipital mandibular immobilizer (SOMI)
- Halo

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Spinal orthotic devices: thoracic spine

- Thoracic-Lumbar-Sacral Orthosis (TLSO)
- Jewett brace

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Spinal orthotic devices: corsets

- Lumbar
- Kinesthetic reminder

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Managing the whole claim

Psychological
- Evaluation
- Counseling
- Medications for depression and/or PTSD

Wound care
- Monitoring by provider
- Home health

Durable medical equipment
- Cane
- Walker
- Wheelchair
- Hospital bed

Case management
- Coordination of care
- Continuity of care
- Specialized services

Continuity of care
- Discharge planning
- Surgeon
- Primary care
- Rehabilitation providers

Prosthesis timeline and expectations
- Claimant
- Providers
  - Prescriber
  - Prosthetist
- Payer

Repairs and replacement
- Appropriate device and component selection
- Routine follow-up and maintenance

Return to function and work
- Home and vehicle modifications
- Job modifications
- Activity and safety levels

Summary

- Prosthetic and orthotic devices are important in restoring function and improving safety, but they must be prescribed and used appropriately.
- Prosthetic success may be dependent on underlying comorbid conditions.
- Orthotic devices can, in many cases, be off-the-shelf but custom fabrication may be needed in certain circumstances.
- Orthotic devices can provide joint and spine stability, but muscle weakness can develop if used for prolonged periods of time.

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