REHABILITATION TECHNOLOGY

FOR

MEDICAL ELECTRONIC ENGINEERING

Ts. ZUNUWANAS MOHAMAD, PhD

WAN ROSEMEHAH WAN OMAR, PhD

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Preface

I have provided a piece of information related to rehabilitation technology in accordance with the field of medical electronic engineering. This is a new field in medical electronic engineering where learning includes the introduction of rehabilitation technology, orthotic technology, amputation, prostatic technology and technological accessories.

It is hoped that the publication of this book will help engineering students to better understand the latest technology in the field of rehabilitation.

Zunuwanas Mohamad & Wan Rosemehah Wan Omar

Contents

CHAPTER ONE

INTRODUCTION TO REHABILITATION

1.1 WHAT IS REHABILITATION

Rehabilitation, commonly known as rehab is a scientifically developed procedure for ensuring the recovery from any kind of disability, injury or the habit. Rehabilitation is a slow but a steady process. Rehabilitation can help if you have an illness or impairment that makes it more difficult for you to work, study or live independently. Rehabilitation is based on an individual plan with a set of defined goals.

a) maintaining and restoring the physical capacity to function
b) choosing a suitable occupation or line of education
c) helping to finish an education
d) staying in or returning to working life
e) Adjusting to life with an illness or impairment.

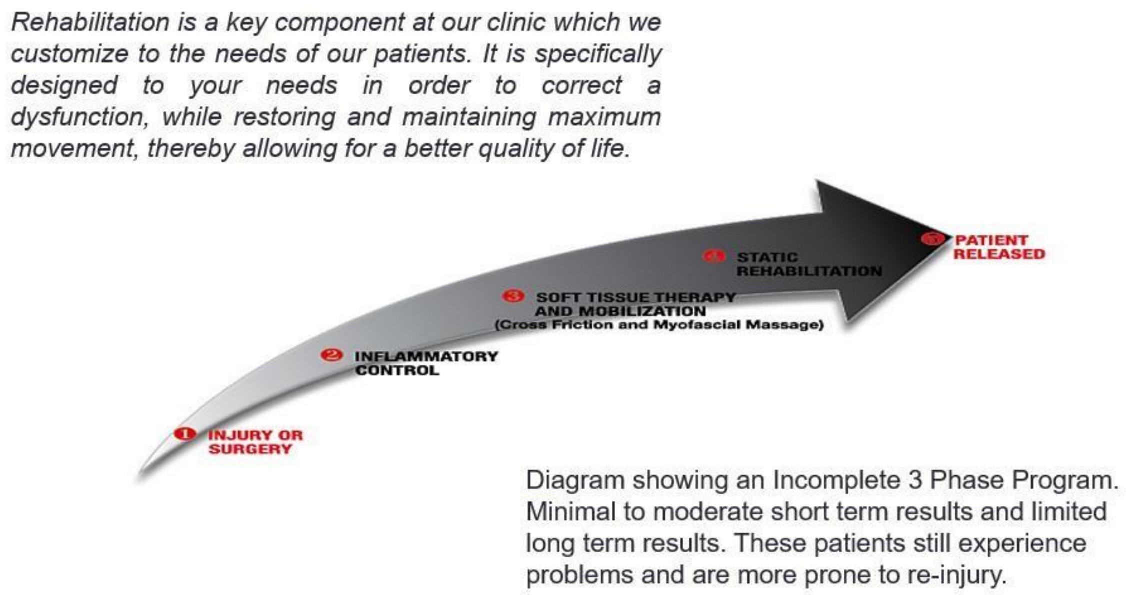


Figure 0-1 3 phase program short-term and long-term results

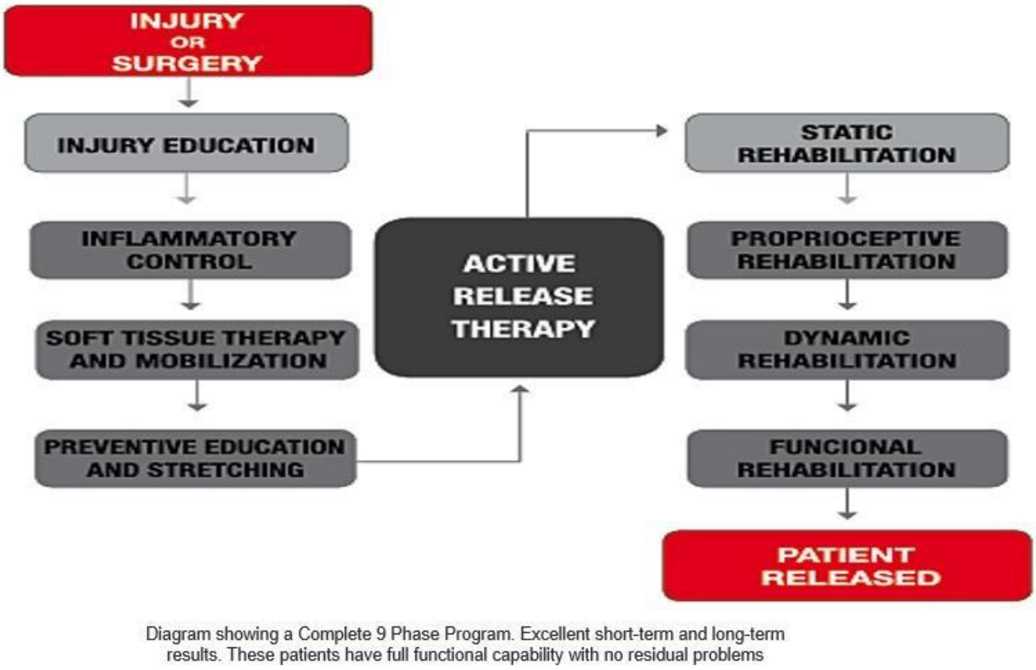


Figure 0-2 : 9 phase program short-term and long-term results

Types of Rehabilitation

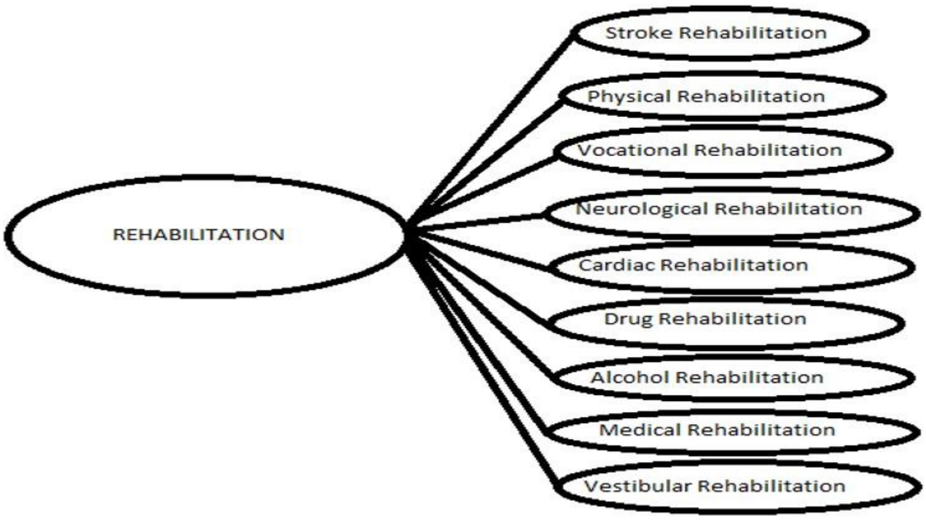


Figure 0-3 : Types of rehabilitation

i. **Stroke Rehabilitation**

This treatment type helps to restore damage that is caused after a stroke, which is the 3rd leading cause for death worldwide.

Figure 1-4: Stroke Rehabilitation

ii. **Physical Rehabilitation**

Physical rehabilitation is for those people whose lifestyle has changed after they have gone through a serious illness, surgery, accident or illness. Here the therapist introduces programs to improve the mobility and functioning of the injured body part of the patient.

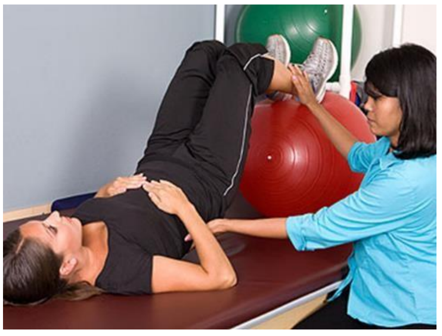


Figure 1-5: Physical Rehabilitation

iii. **Vocational Rehabilitation**

Vocational rehab program is designed to help those people who find it difficult to get employment or retain it after they have gone through certain situation that caused mental or physical disability in them.

Figure 1-6: Vocational Rehabilitation

iv. Neurology Rehabilitation

It helps create a positive thinking in patient. The patient is treated so that he leads a improved life physically, emotionally, and socially.

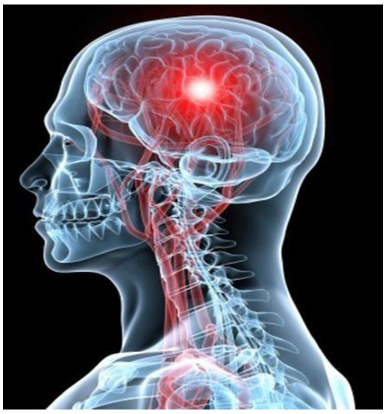


Figure 1-7: Neurology Rehabilitation

v. Cardiac Rehabilitation

Cardiac rehab program is designed to help those people who have heart problem. Heart patients are educated to live a healthy life and reduce stress for the proper Functioning of the heart.

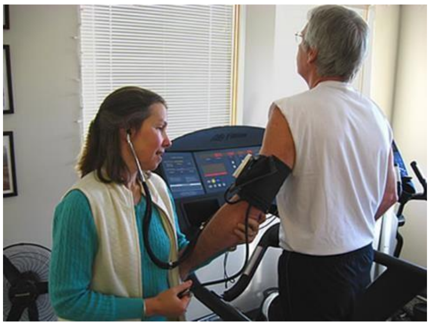


Figure 1-8: Cardiac Rehabilitation

vi. Drug Rehabilitation

Drug rehabilitation programs involve programs that are designed to make an addict free from the addiction of alcohol, prescription drug and street drugs (cocaine, heroin etc)

Figure 1-9: Drug Rehabilitation

vii. Alcohol Rehabilitation

Alcohol rehabilitation program is designed to make an alcoholic free from the addiction. It involves programs that will teach people the various bad effects of consuming excess alcohol.

Figure 1-9: Alcohol Rehabilitation

viii. Medical Rehabilitation

Medical rehabilitation includes treatment programs that help a person perform better in all his daily physical and mental activities. Medical rehabilitation is a follow up treatment after any kind of treatment program.

Figure 1-10: Medical Rehabilitation

ix. Vestibular Rehabilitation

It helps in improving the ear deficit by working on the central nervous system. Also deals in improving eye and head coordination.

Figure 1-11: Vestibular

RehabilitationList of Clinic

Rehabilitation

a) Acquired Brain Injury Rehabilitation (Abi)
b) Advanced Pain Care Rehab (APCR)
c) Neuropathic Clinic
d) Hand Recon Surgery & Rehab
e) Spasticity Clinic
f) Acupuncture Clinic

g) Neuro Medical Rehabilitation

h) Cardiac Rehabilitation

i) Spinal Cord Injury Rehabilitation (Sci)
j) Amputee Rehabilitation
k) Wheelchair Seating
l) Pediatric Rehabilitation
m) Scoliosis

1.2 EPIDEMIOLOGY OF REHABILITATION

Epidemiology is the study and analysis of the patterns, causes, and effects of health and disease conditions in defined populations. Major areas of epidemiological study include:

a) Disease
b) Causation
c) Transmission (passing of a pathogen causing communicable disease from an infected)
d) outbreak investigation, (A sudden increase in occurrences of a disease in a particular time and place)
e) disease surveillance
f) forensic epidemiology
g) Occupational epidemiology
h) screening
i) biomonitoring
j) Comparisons of treatment effects such as in clinical trials

12.1 Epidemiology of Rehabilitation (Example)

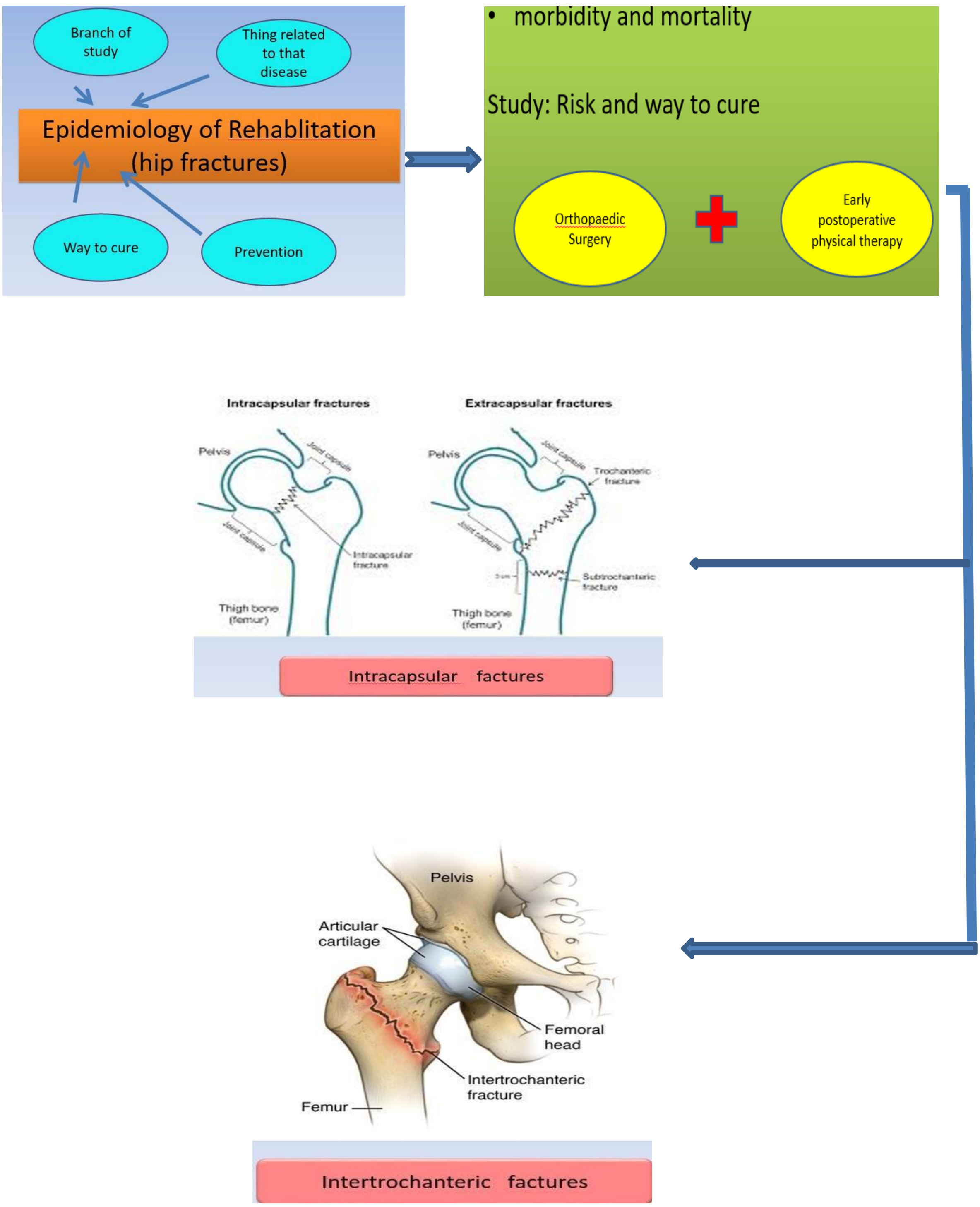


Figure 1-12 : Epidemiology of rehabilitation

1.3 DIAGNOSIS OF DISABILITY

What is diagnosis? Diagnosis is the formal process by which a learning disability – and indeed other disabilities or conditions.

a) Illnesses like cancer, heart attack or diabetes cause the majority of long-term disabilities. Back pain, injuries, and arthritis are also significant causes.

b) Most are not work-related, and therefore not covered by workers' compensation.

c) Lifestyle choices and personal behavior that lead to obesity are becoming major contributing factors.

d) Musculoskeletal disorders are the #1 cause of disabilities. Examples include arthritis, back pain, spine/joint disorders, fibromytis, etc.

e) Here is a chart of claim diagnosis categories in lay language to provide clear examples of common causes of disability.

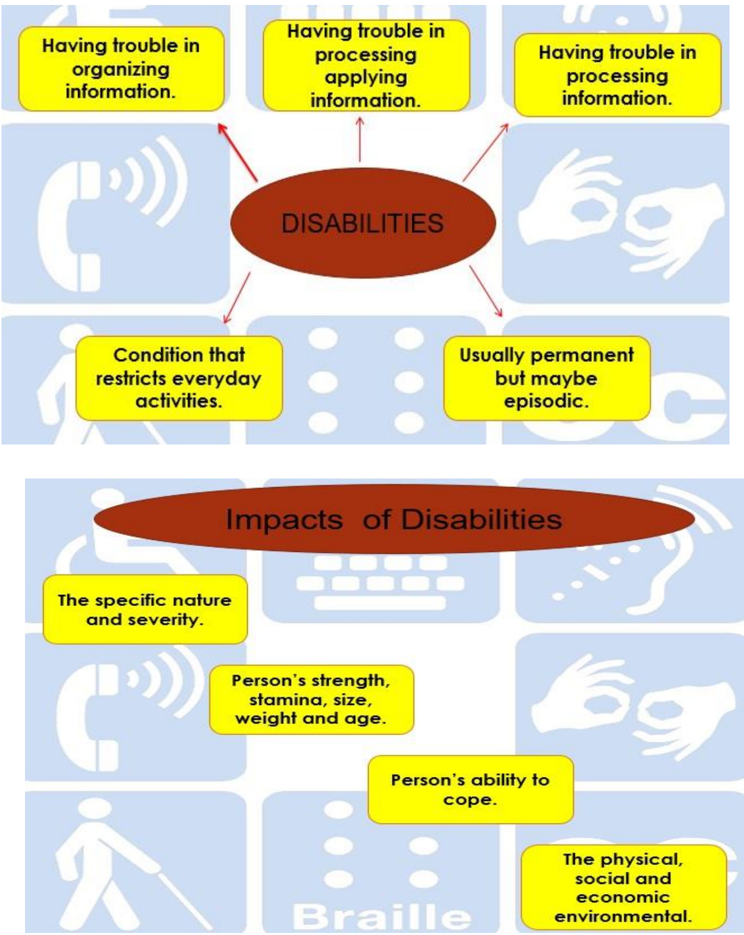


Figure 1-13: Diagnosis of Disability

1.4 FUNCTIONAL DIAGNOSIS

Functional diagnosis is a complex analytical and methodological approaches to the definition and evaluation of the functional state of organs and body systems. The Purpose is:

a) Determination of functional reserves
b) Determining the type and degree of functional disorders
c) Monitoring of the rate of disease progression
d) Evaluating the effectiveness of a course of treatment
e) Differential diagnosis
f) Expert evaluation for disability, military, sports, etc.

14.1 Types of Functional Diagnosis

a) Functional Electrical Stimulation (FES).

   Method of externally controlling muscles when signals from the brain can no longer control movement.

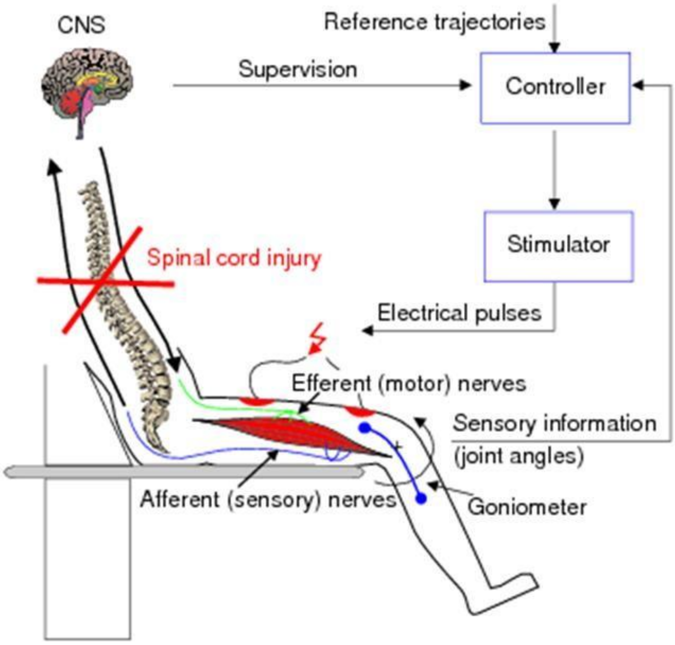


Figure 1-14: Functional Electrical Stimulation

Who is needed FES?

Spinal cord injury, stroke or neurological disease such as Multiple Sclerosis.


Figure 1-15: Spinal Cord Injury (SCI)

b) Functional Endoscopic Sinus (FESS).

Functional endoscopic sinus surgery (FESS) is a minimally invasive surgical treatment which uses nasal endoscopes to enlarge the nasal drainage pathways of the paranasal sinuses to improve sinus ventilation. This procedure is generally used to treat inflammatory and infectious sinus diseases, including chronic rhinosinusitis that doesn't respond to drugs, nasal polyps, some cancers, and decompression of eye sockets/optic nerve in Graves's ophthalmopathy.

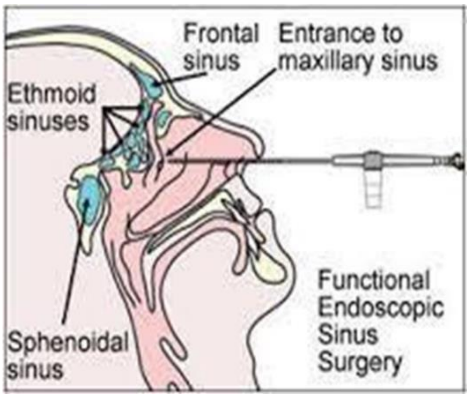



Figure 1-16: Functional Endoscopic Sinus Surgery (FESS)

c) Functional Neurological Symptoms (FNS)

A functional neurological disorder (FND) is a condition in which patients experience neurological symptoms such as weakness, movement disorders, sensory symptoms and blackouts. In the past, the brain of a patient with functional neurological symptom disorder was believed to be structurally normal, but functioning incorrectly. Patients with FND were marginalized for much of the 20th century, with limited clinical and neuroscientific interest. Functional neurological symptoms can be either motor or sensory in nature and include:

i. chronic pain
ii. speech problems
iii. functional weakness
iv. cognitive changes
v. visual changes
vi. non-epileptic attacks

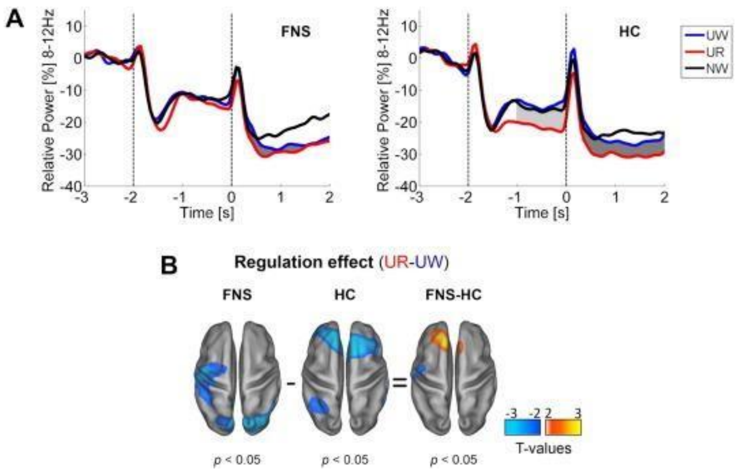


Figure 1-17: Functional Neurological Symptoms (FNS)

d) Functional Diagnostic Nutrition (FDN)

Functional Diagnostic Nutrition (FDN) is a certification course that trains alternative health practitioners such as personal trainers and health coaches how to utilize functional lab testing with their clients. This type of lab testing allows practitioners to see subtle patterns of dysfunction occurring in the body.

1.5 IMPORTANCE OF PHYSIATRY IN FUNCTIONAL DIAGNOSIS

A physician who has received specialized training in physical medicine and rehabilitation (PM&R). PM&R, or physiatry, is the branch of medicine emphasizing the prevention, diagnosis, treatment, and rehabilitation of disorders that produce temporary or permanent functional impairment. Physiatry is unique among medical fields in that its area of expertise addresses the function of the whole patient, as compared with a focus on an organ system or systems. Suffering an acute injury or living with chronic illness can affect the way people move and communicate, perceive themselves and their role in the home and workplace. Physiatry is about patient-centered care and maximizing independence and mobility with the goal of returning patients to their roles in society.

1.6 DIFFERENCES OF IMPAIRMENT, DISABILITY AND HANDICAP

The terms above to explain the differences:

a) Physical impairment pertains to a loss of an anatomical structure; for the benefit of this exercise, let's say the person lost a leg due to an accident. He can wear prosthetics as a replacement of the lost leg.
b) Physical disability now refers to the inability to walk. To be able to navigate the surroundings, the person can use a wheelchair.
c) Physical handicap now means that this person faces disadvantages that prevent him or her to perform a normal role in life, such as not being able to climb stairs anymore. Or run a marathon. Or be a basketball player. Here is where the environment plays a part. By providing wheelchair access or lift for the person with physical disability, he or she will have no problem going up to the next floors of a building. By providing multi-sport events for athletes with physical disabilities, such as Paralympics, the person will still able to participate in sports.

1.7 PRIMARY & SECONDARY DISABILITIES

Primary disabilities are characteristics or behaviors that reflect differences in brain structure and function, such as mental retardation, attention deficits and sensory integration dysfunction. Secondary disabilities are disabilities that the individual is not born with. These disabilities and behaviors develop over time because of a poor fit between the person and the environment. A secondary condition is an additional condition that presupposes the existence of a primary condition. It is distinguished from other health conditions by the lapse in time from the acquisition of the primary condition to the occurrence of the secondary condition. Examples include pressure ulcers, urinary tract infections, and depression. Secondary conditions can reduce functioning, lower the quality of life, increase health care costs, and lead to premature mortality. Many such conditions are preventable and can be anticipated from primary health condition.

CHAPTER TWO

ORTHOTIC DEVICES IN REHABILITATION ENGINEERING

2.1 GENERAL ORTHOTICS

Orthotics: ortho, "to straighten" or "align") is a specialty within the medical field concerned with the design, manufacture, and application of orthoses.An orthosis (plural: orthoses) is "an externally applied device used to modify thestructural and functional characteristics of the neuromuscular and skeletal system". Anorthosis is a type of brace or other wearable device that serves one or more of the following purposes:

a) Improvement of mobility
b) Immobilization of an injured body part to promote healing
c) Correction of biomechanical misalignments
d) Prevention of injuries
e) Reduction of weight bearing and pain

An orthotist is the primary medical clinician responsible for the prescription, manufacture and management of orthoses. An orthosis may be used to:

a) Control, guide, limit and/or immobilize an extremity, joint or body segment for a particular reason
b) To restrict movement in each direction
c) To assist movement generally
d) To reduce weight bearing forces for a particular purpose
e) To aid rehabilitation from fractures after the removal of a cast
f) To otherwise correct the shape and/or function of the body, to provide easier movement capability or reduce pain

The Orthotics combines knowledge of

a) Anatomy and physiology,
b) Pathophysiology,
c) Biomechanics
d) Engineering.

Orthotics are medical devices prescribed to help relieve foot and ankle discomfort. They are a conservative treatment approach to allow patients to go about normal activity by helping to control ones' walking and prevent future injury. An orthotic is not just an arch support can be purchased from a pharmacy or sneaker outlet, but rather a sophisticated corrective prosthetics, which are customized for the patient's foot structure and functional needs patients benefiting from an orthosis may have a condition such as spina bifida or cerebral palsy or have experienced a spinal cord injury or stroke. Equally, orthoses are sometimes used prophylactically or to optimize performance in sport.

2.2 CLASSIFICATION OF ORTHOTICS-FUNCTIONAL & REGIONAL

The International Standard terminology, orthoses are classified by an acronym describing the anatomical joints which they contain:

a) Upper-limb orthoses
b) Lower-limb orthoses
c) Neck and spinal cord orthoses
d) Compression care garments: These are worn by people with poor circulation or who must remain in one position for extended periods of time (for example, standing all day or sitting in a wheelchair all day). Compression wear can be used to treat deep vein thrombosis and to reduce swelling

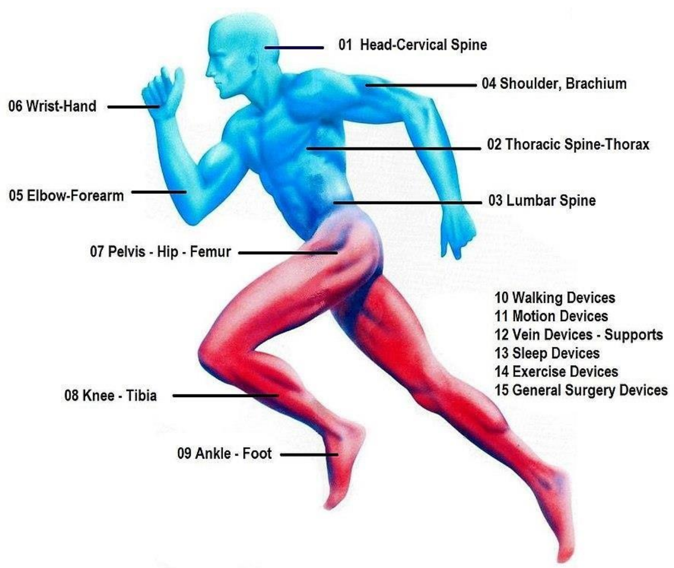


Figure 2-1: Part of orthotics

Upper-limb orthoses

Upper-limb (or upper extremity) orthoses are mechanical or electromechanical devices applied externally to the arm or segments thereof in order to restore or improve function, or structural characteristics of the arm segments encumbered by the device. Types of upper-limb orthoses is:

i. Upper-limb orthoses
   a. Clavicular and shoulder orthoses
   b. Arm orthoses
   c. Functional arm orthoses
   d. Elbow orthoses
ii. Forearm-wrist orthoses
iii. Forearm-wrist-thumb orthoses
iv. Forearm-wrist-hand orthoses
v. Hand orthoses
vi. Upper-extremity orthoses (with special functions)

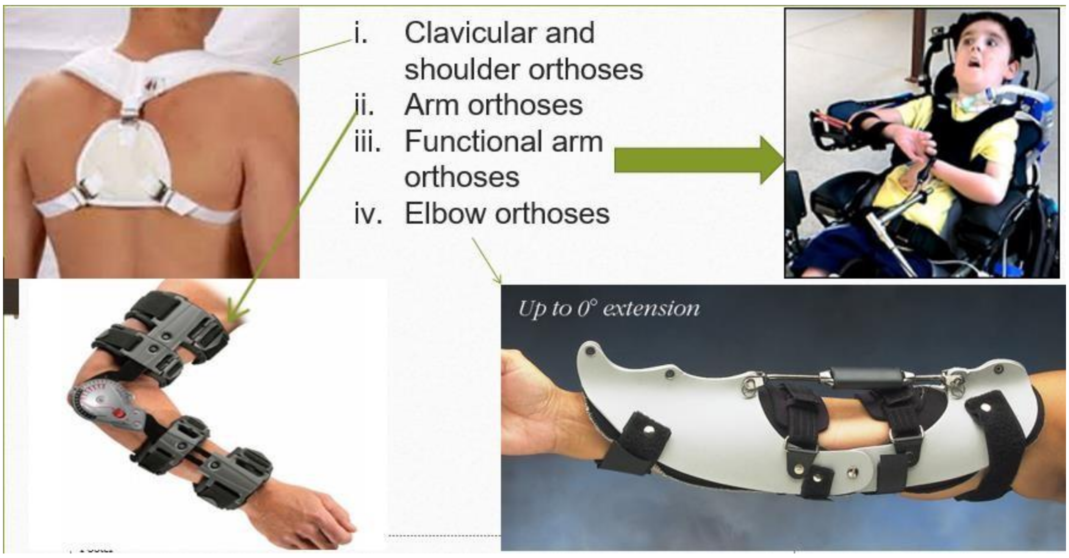


Figure 2-2: Upper-limb orthoses

Lower-limb orthoses

A lower-limb orthosis is an external device applied to a lower-body segment to improve function by controlling motion, providing support through stabilizing gait, reducing pain through transferring load to another area, correcting flexible deformities, and preventing progression of fixed deformities. Types of lower- limb orthoses is:

a) Foot Orthoses (FO)
b) Ankle-Foot Orthosis (AFO)
c) Knee-Ankle-Foot Orthosis (KAFO)
d) Knee Orthosis (KO)
e) Prophylactic, functional and rehabilitation braces.

Table 2-1: List of lower-limb orthoses

LL orthoses:			
FO	Foot orthosis	AFO	Ankle-Foot orthosis
KO	Knee orthosis	KAFO	Knee-Ankle-Foot orthosis
HO	Hip orthosis	HKAFO	Hip-Knee-Ankle-Foot orthosis
		RGO	Reciprocal Gait orthosis
Spinal orthoses			
CO	Cervical orthosis	CTO	Cervical-Thoracic orthosis
TO	Thoracic orthosis	CTLSO	CervicoThoracic lumbosacral orthosis
SO	Sacral orthosis		
SIO	Sacroiliac orthosis	TLSO	Thoracic-lumbosacral orthosis
		LSO	Lumbosacral orthosis

UL orthoses HdO WO EO SO	 Hand orthosis Wrist orthosis Elbow orthosis Shoulder orthosis	 WHO EWHO SEO SEWHO	 Wrist-Hand orthosis Elbow-Wrist-Hand orthosis Shoulder-Elbow orthosis Shoulder-Elbow-Wrist-Hand orthosis

x. Foot Orthoses (FO)

Foot orthoses (commonly called "orthotics") are devices inserted into shoes to provide support for the foot by redistributing ground reaction forces acting on the foot joints while standing, walking or running

Figure 2-3: Foot Orthoses

xi. Ankle Foot Orthoses (AFO)

A brace, usually made of plastic that is worn on the lower leg and foot to support the ankle, hold the foot and ankle in the correct position and correct foot drop. Abbreviated AFO. Also known as foot drop brace.

Figure 2-4: Ankle Foot Orthoses

xii. Knee Ankle Food Orthoses (KAFO)

A KAFO is a device that is used to control instabilities in the knee and lower limb by maintaining proper alignment and controlling motion. Instabilities can be caused by broken bones, arthritic joints, hyperextension of the knee, muscle weakness and/or paralysis. As there are many different reasons that a person may need to utilize a KAFO, there are many different designs for a KAFO based on necessity. A KAFO may be made with leather components or with plastic components. It also has a variety of knee joints (from drop locks to no locks) that is determined by a person's condition.

Figure 2-5: Knee Ankle Foot Orthoses

xiii. Knee Orthosis (KO)

Knee orthoses are used as a common intervention in orthopedic and physical therapy practice, not only for the treatment of knee impairments, but also for injury prevention. The clinical goals of using knee orthoses include pain reduction, joint protection, functional or recreational improvement, and injury prevention.

Figure 2-6: Knee Orthosis

2.3 GENERAL PRINCIPLES OF ORTHOSIS

A device that is applied externally to a part of the body. The word is derived from ortho, meaning straight. Orthoses are sometimes called orthotics Brace: is a device that corrects irregularities. Splint: usually used after surgery and does not allow for movement. The orthoptist is the person who designs, fabricates and repair the orthotic device.

Principles for orthoses:

a) Provide support and stability to the hip, knee and ankle joints.
b) Orthoses are designed to permit safe and effective ambulation by patients
c) Provide the needs and requirements of the patient to support or to mobilize
d) It should correlate to the findings of tests & measurements
e) It should correlate with patient's personality and the impact of device upon him.
f) They may also prevent the development of deformity and require modifications in design to accommodate spasticity and/or muscle imbalance.
g) To supply the best possible device for each patient is essential.
h) Introduction of materials that are light, sturdy, and resistant to wear.
i) The orthosis is only one component of the treatment and is not the whole treatment.
j) The orthoses should conserve the time and energy of the patient.

Design characteristics of an orthotic device. Most important features include the following:

a) Weight of the orthosis
b) Adjustability
c) Functional use
d) Cosmoses
e) Cost
f) Durability
g) Material
h) Ability to fit various sizes of patients

i) Ease of putting on (donning) and taking off (doffing)
j) Access to tracheostomy site, peg tube, or other drains
k) Access to surgical sites for wound care
l) Aeration to avoid skin maceration from moisture

Duration of orthotic use: It is determined by the individual situation. In situations where instability is not an issue, recommend use of an orthosis until the patient can tolerate discomfort without the brace. When used for stabilization after surgery or acute fractures, allow 6-12 weeks to permit ligaments and bones to heal.

Effects of the orthosis may lead to:

a) Decrease pain
b) Increase strength
c) Improve function
d) Increase proprioception
e) Improve posture
f) Correct of spinal curve deformity
g) Protect against spinal instability
h) Minimize complications
i) Assist healing of ligaments and bones

Role of physical therapist

a) Identify functional problems of the patient.
b) Determine orthotic needs.
c) Prescribe the orthoses according to each patient problems and requirements.
d) Evaluate orthotic adequacy.
e) Teach the patient to don and doff the orthoses.
f) Train the patient for proper use of the orthoses.

2.4 BIOMECHANICS OF ORTHOSIS

The biomechanical principles of orthotic design assist in promoting control, correction, stabilization, or dynamic movement. All orthotic designs are based on three relatively simple principles: (1) Pressure. (2) Equilibrium and (3) the lever arm principle. These considerations include and are not limited to:

a) the forces at the interface between the orthotic materials and the skin,
b) the degrees-of-freedom of each joint,
c) the number of joint segments,
d) the neuromuscular control of a segment, including strength and tone,
e) the material selected for orthotic fabrication,
f) The activity level of the client.

The pressure principle

It states that:

Pressure is equal to the total force per unit area.

Clinically, what this means is that the greater the area of a pad or the plastic shell of an orthosis, the less force will be placed on the skin. Therefore, any material that creates a force against the skin should be of a dimension to minimize the forces on the tissues.

$$P = \frac{\text{force}}{\text{Area of application}}$$

The equilibrium principle

It states that:

The sum of the forces and the bending moments created must be equal to zero.

The practical application is best explained by the most commonly used loading system in orthotics, the three-point pressure system (Fig. 1). The three-point pressure or loading system occurs when three forces are applied to a segment in such a way that a single primary force is applied between two additional counterforces with the sum of all three forces equaling zero. The primary force is of a magnitude and located at a point where movement is either inhibited or facilitated, depending on the functional design of the orthosis.

The lever arm principle

It states that:

The farther the point of force from the joint, the greater the moment arm and the smaller the magnitude of force required to produce a given torque at the joint.

This is why most orthoses are designed with long metal bars or plastic shells that are the length of an adjacent segment. The greater the length of the supporting orthotic structure, the greater the moment or torque that can be placed on the joint or unstable segment. Collectively, these three principles rarely, if ever, act independently of each other. Ideally, when designing or evaluating an orthotic appliance, the clinician should check that

a) There is adequate padding covering the greatest area possible for comfort.
b) The total forces acting on the involved segment is equal to zero or there is equal pressure throughout the orthosis and no areas of irritation to the skin.
c) The length of the orthosis is suitable to provide an adequate force to create the desired effect and to avoid increased transmission of shear forces against the anatomic tissues.

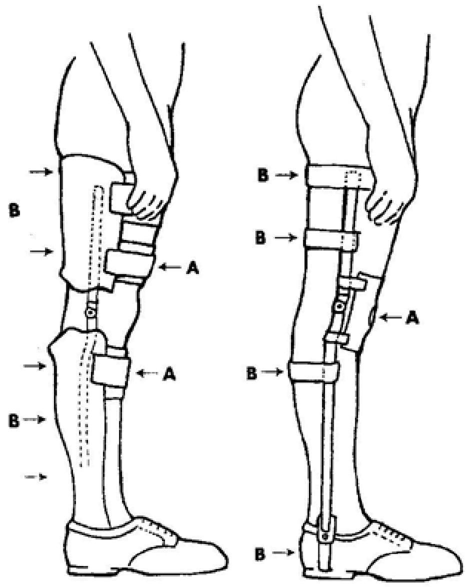


FIGURE
The three-point pressure system. **A,** The primary force. **B,** The counterforce application. The sum of all forces will equal zero.

Figure 2-7: Level Arm Principle

Fitting a knee orthosis is particularly challenging because of the complexity of the joint's coordinated movement. The function of the individual parts was unclear, perhaps because the knee joint differs in its basic mechanical structure from other joints, such as the hip and shoulder. To understand the knee joint, the complicated mechanics must be reduced to their simplest forms. The working and contact areas of the knee's two joint surfaces are relatively small and are connected to one another by muscles, ligaments and other structures that influence movement. The peculiar form of the two differently shaped femoral condyles also affects movement. Rarely do we find that our left and right sides are symmetrical. This is equally so for our feet and legs. The examination has two parts:

a) Static Assessment: Non-weight bearing anatomical examination, muscle testing, weight bearing lower limb posture assessment.
b) Dynamic Assessment: Video gait analysis and/or Pressure plate analysis.

2.5 MERITS & DEMERITS OF ORTHOTICS

An orthotic (orthoses) is a device that can be placed directly into shoes to correct any dysfunction in the feet and ankles. Foot orthotics can help reduce foot pain caused by medical conditions such as arthritis, bunions, plantar fasciitis, flat feet, and diabetes. These foot devices can offset stress levels as pressure is exerted on them allowing your feet to function properly. Some of the benefits of custom orthotics are as follows:

a. Custom orthotics can help provide superior comfort allowing you to stand, walk, and run comfortably.
b. Assist in fighting off pain in the foot, ankle and leg.
c. Improve balance by allowing your feet the necessary support to maintain a functionally correct position.
d. Help absorb shock and redirect pressure away from painful areas in the foot and ankle.
e. Enhances athletic performance. Lowers the risk of injury.

Unlike shoe inserts that can be bought over-the-counter at numerous drug stores, custom-mold-orthotics are personalized to match your unique foot structure. They provide the necessary comfort and support to your feet. If your feet and ankles are aching on a daily basis, you may have plantar fasciitis or struggling with flat feet. The best way to address any foot pain is to have a podiatrist examine your feet properly to determine whether you need orthotics.

At Foot and Ankle Associates, a variety of foot and ankle conditions and can provide you with custom-fitted orthotics to help you reduce your foot pain and thus adjust your movement patterns to reduce the overall strain through your body. Schedule an appointment with our expert foot doctors today for a thorough examination of your foot and ankle to make sure your orthotics work well for you.

Merits

Figure 2-8: Merits Orthotics

Demerits

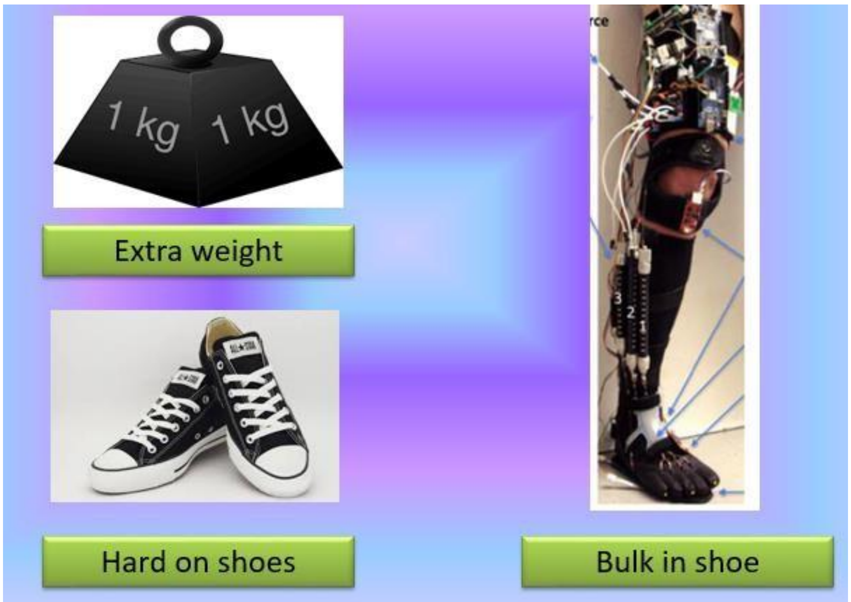


Figure 2-9: Demerit orthotic

2.6 MATERIAL DESIGN CONSIDERATION IN ORTHOTICS

Materials used are a very important aspect of orthotic prescription that is often overlooked.

Types of material

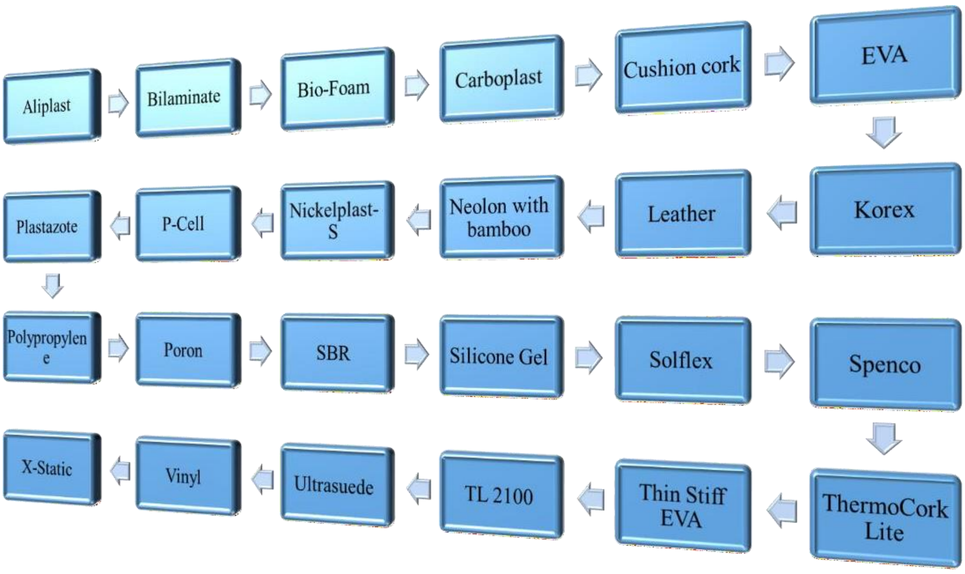
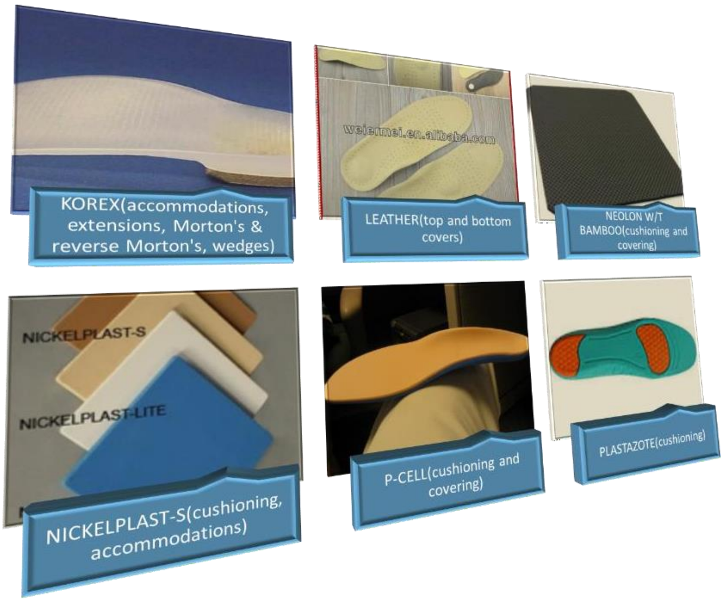


Figure 2-10: Types of Material


ALIPLAST(cushioning)
(BILAMINATE(cushioning, covering, diabetic top covers)
BIO-FOAM
IMPRESSION FOAM SYSTEM
BIO-FOAM(foot impressions)
CARBOPLAST(orthotic shells)
CUSHION CORK(heel lifts)
EVA(top & bottom covers, cushioning, accommodations, wedges, filler, shell material for soft orthotics)


KOREX(accommodations, extensions, Morton's & reverse Morton's, wedges)
weiermei.en.alibaba.com
LEATHER(top and bottom covers)
NEOLON W/T BAMBOO(cushioning and covering)
NICKELPLAST-S
NICKELPLAST-LITE
NICKELPLAST-S(cushioning, accommodations)
P-CELL(cushioning and covering)
PLASTAZOTE(cushioning)

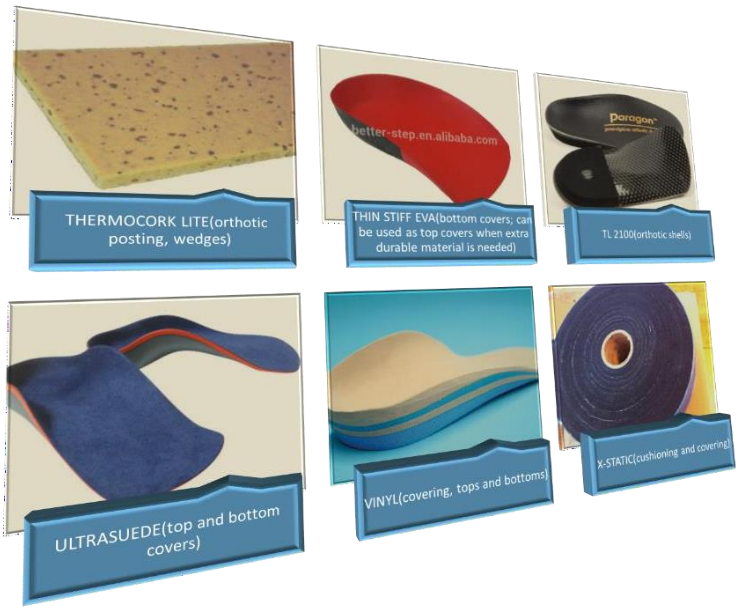


Figure 2-11: Type of product

Important characteristics of orthotics material

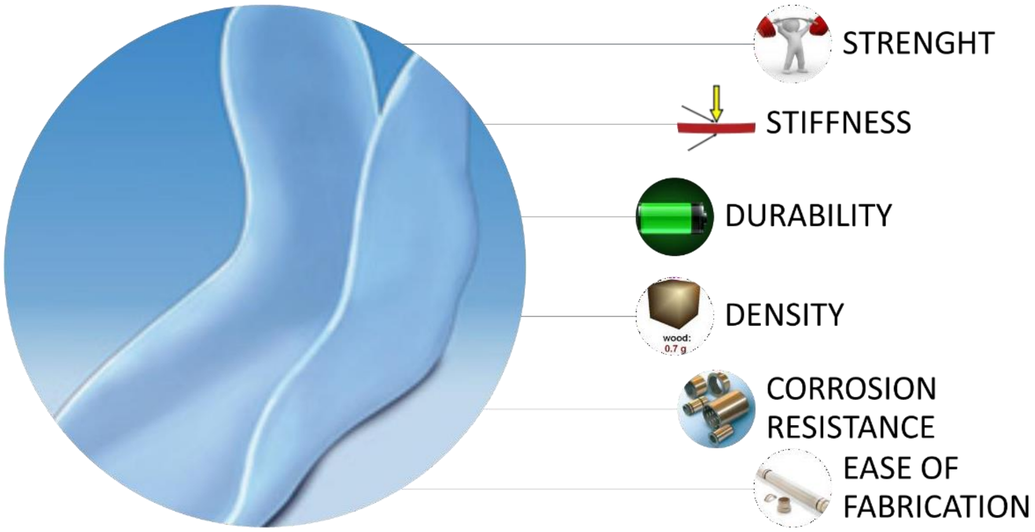


Figure 2-12 Characteristics of orthotic

Strength: the maximum external load that can be sustained by a material.

Stiffness: the amount of bending or compression that occurs under stress. e.g. when greater support is required, a stiffer material is used; when a more dynamic orthosis is desired, a more flexible material is used.

Durability (fatigue resistance): the ability of a material to withstand repeated cycles of loading and unloading. (Selection of a material for orthotic appliances is based on the ability of the material to withstand the day-to-day stresses of each individual client

Density: the greater the volume or thicker a material the more rigid and more durable. (This usually increases the overall weight of the orthosis.

Corrosion resistance: the material may be affected by chemical degradation. Most materials will exhibit corrosion over time, metal will rust and plastics become brittle. Contact with human perspiration and environments such as dirt, temperatures and water accelerate the wearing effect on the materials. Knowing the client‘s daily environment can assist in material selection.

Ease of fabrication: the equipment needed for fabrication of orthosis

CHAPTER THREE

AMPUTATION

3.1 LEVELS OF AMPUTATION – SURGICAL PROCESS

What is amputation?

Amputation is the removal of a limb by trauma, medical illness, or surgery, or to cut off a part of the body.

Types of amputation

a) Leg
b) Arm
c) Others
d) Self-amputation

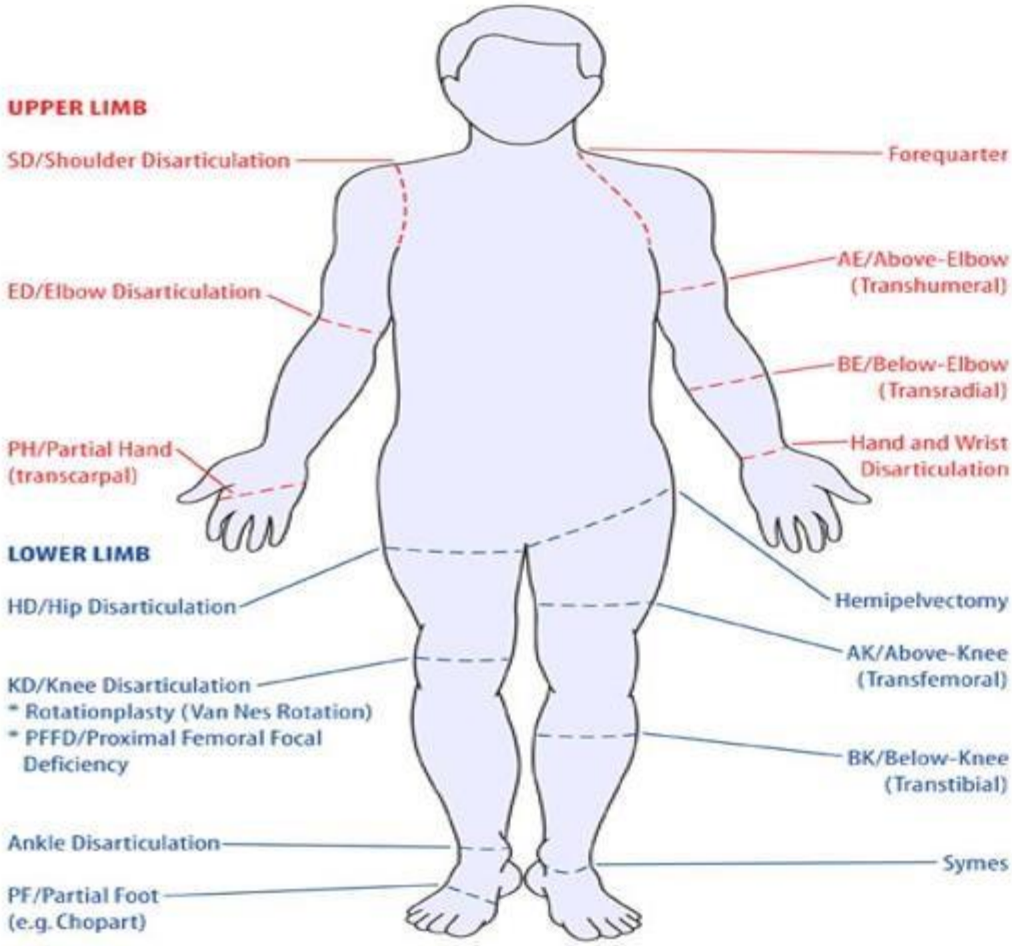


Figure 3-1: Part of amputation

xiv. Leg

Lower limb amputations can be divided into two broad categories: minor and major amputations. Minor amputations generally refer to the amputation of digits. Major amputations are commonly below-knee- or above-knee amputations Common partial foot amputations include the Chopart, Lisfranc, and ray amputations. Common forms of ankle disarticulations include Pyrogoff, Boyd, and Syme amputations. Types of amputations include:

i. **Partial foot amputation** : amputation of the lower limb distal to the ankle joint
ii. **Ankle disarticulation** : amputation of the lower limb at the ankle joint
iii. **Trans-tibial amputation** : amputation of the lower limb between the knee joint and the ankle joint, commonly referred to as a below-knee amputation
iv. **Knee disarticulation** : amputation of the lower limb at the knee joint
v. **Trans-femoral amputation** : amputation of the lower limb between the hip joint and the knee joint, commonly referred to an above-knee amputation
vi. **Hip disarticulation** : amputation of the lower limb at the hip joint
vii. **Trans-pelvic disarticulation** : amputation of the whole lower limb together with all or part of the pelvis, also known as a hemipelvectomy or hindquarter amputation

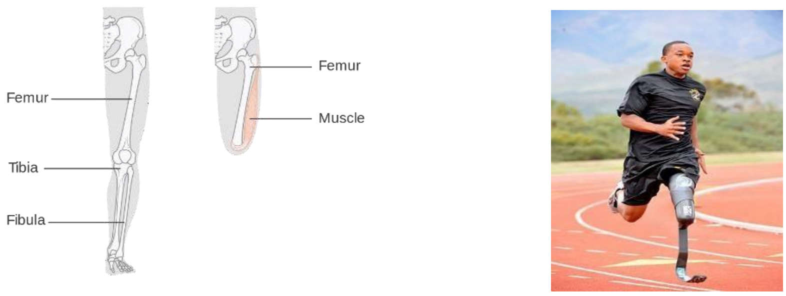


Figure 3-2: Part of leg

xv. Arm

Types of upper extremity amputations include:

i. partial hand amputation
ii. wrist disarticulation
iii. trans-radial amputation, commonly referred to as below-elbow or forearm amputation
iv. elbow disarticulation
v. trans-humeral amputation, commonly referred to as above-elbow amputation
vi. shoulder disarticulation
vii. forequarter amputation

Figure 3-3 Partial finger

xvi. Other

i. Facial amputations include but are not limited to:
   a. amputation of the ears
   b. amputation of the nose (rhinotomy)
   c. amputation of the tongue (glossectomy).
   d. amputation of the eyes (enucleation).
   e. amputation of the teeth. Removal of teeth, mainly incisors, is or was practiced by some cultures for ritual purposes (for instance in the Iberomaurusian culture of Neolithic North Africa).
ii. Breasts:
   a. amputation of the breasts (mastectomy).
iii. Genitals:
   a. amputation of the testicles (castration).
   b. amputation of the penis (penectomy).
   c. amputation of the foreskin (circumcision).

d. amputation of the clitoris (clitoridectomy).

iv. Hemicorporectomy, or amputation at the waist, and decapitation, or amputation at the neck, are the most radical amputations.

v. Genital modification and mutilation may involve amputating tissue, although not necessarily as a result of injury or disease

xvii. Self-amputation

In some rare cases when a person has become trapped in a deserted place, with no means of communication or hope of rescue, the victim has amputated his or her own limb. The most notable case of this is Aron Ralston, a hiker who amputated his own right forearm after it was pinned by a boulder in a hiking accident and he was unable to free himself for over five days. Body integrity identity disorder is a psychological condition in which an individual feels compelled to remove one or more of their body parts, usually a limb. In some cases, that individual may take drastic measures to remove the offending appendages, either by causing irreparable damage to the limb so that medical intervention cannot save the limb, or by causing the limb to be severed.

i) Causes of Amputation

a) Circulatory disorders

The circulatory system is your heart and blood vessels, and it's essential to keeping your body functioning. This finely tuned system carries oxygen, nutrients, electrolytes, and hormones throughout your body. Interruptions, blockage, or diseases that affect how your heart or blood vessels pump blood can cause complications such as heart disease or stroke.

b) Peripheral Vascular Disease

Figure 3.4: PVD

c) Neo Plasm

A new and abnormal growth of tissue in a part of the body, especially as a characteristic of cancer.

Figure 3-5: Neo Plasm

d) Trauma

Figure 3-6: Trauma

e) Congenital anomalies

Figure 3-7: Congenital Anomalies

f) Infection

Figure 3-9: Infection

g) Frostbite

Figure 3-10: Frostbite

ii) Levels of Amputation

a) Transhumoral amputation (AE): an amputation performed at the above the elbow.
b) Transfemoral amputation (AK): an amputation performed at the level above the knee.
c) Transtibial amputation (BK): an amputation performed at the level below the knee.
d) Partial foot amputation: an amputation performed at the level of the foot.
e) Wrist disarticulation (WD): an amputation performed at the level of the wrist.

f) Symes amputation: an amputation performed at the level of the ankle joint that retains the fatty heel pad portion intended to preserve weight bearing function.

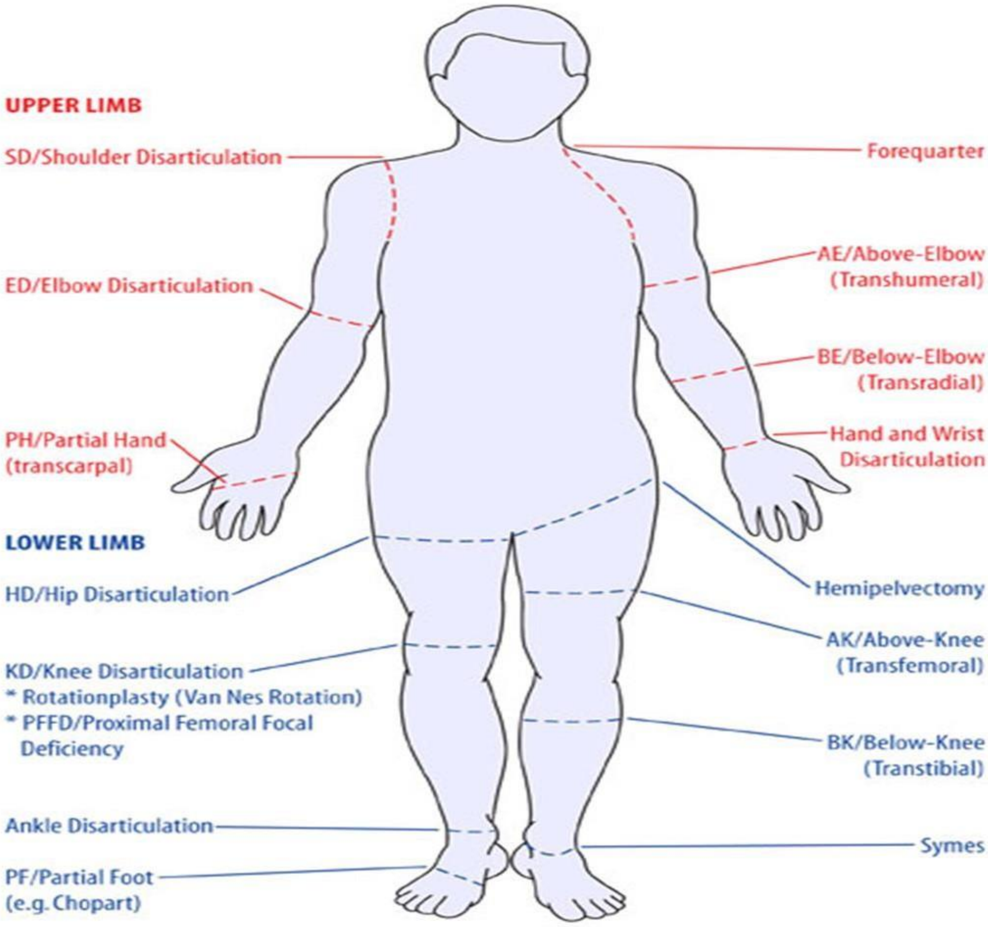
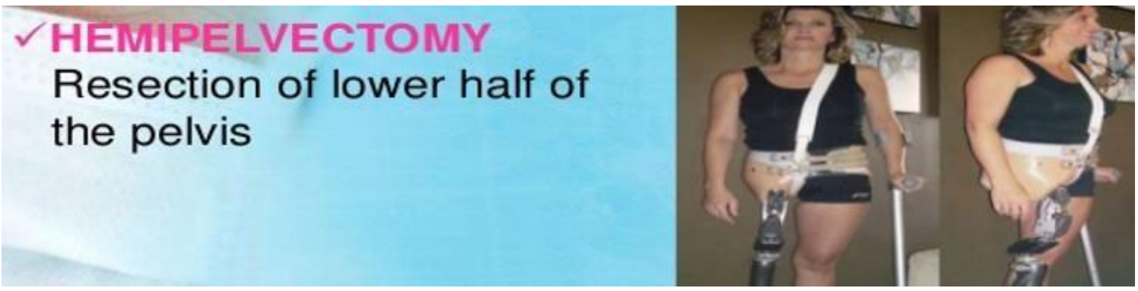
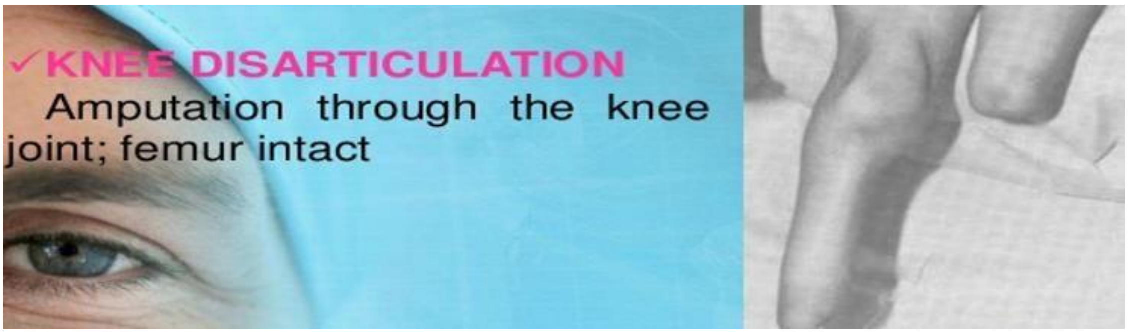


Figure 3-11: Level of Amputation (Front)

Figure 3-12: Level of amputation (Side)




✓KNEE DISARTICULATION
Amputation through the knee joint; femur intact


✓SHORT TIBIAL(below knee)
Less than 20% tibial length


✓TRANSFEMORAL(above knee)
Between 35% & 60% femoral length
✓ LONG TRANSFEMORAL(above knee)
More than 60% femoral length


✓SYME'S AMPUTATION
Ankle disarticulation with attachment of heel pad to distal end of tibia. Many include removal of malleoli & distal tibia/ fibular flares
✓TRANSMETATARSAL
Amputation through mid section of all metatarsals


✓PARTIAL FOOT/ RAY RESECTION
Resection of the 3rd, 4th , 5th metatarsals and digits
✓TOE DISARTICULATION
Disarticulation at the metatarsal phalangeal joint .
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✓PARTIAL TOE
Excision of any part of one or more toes

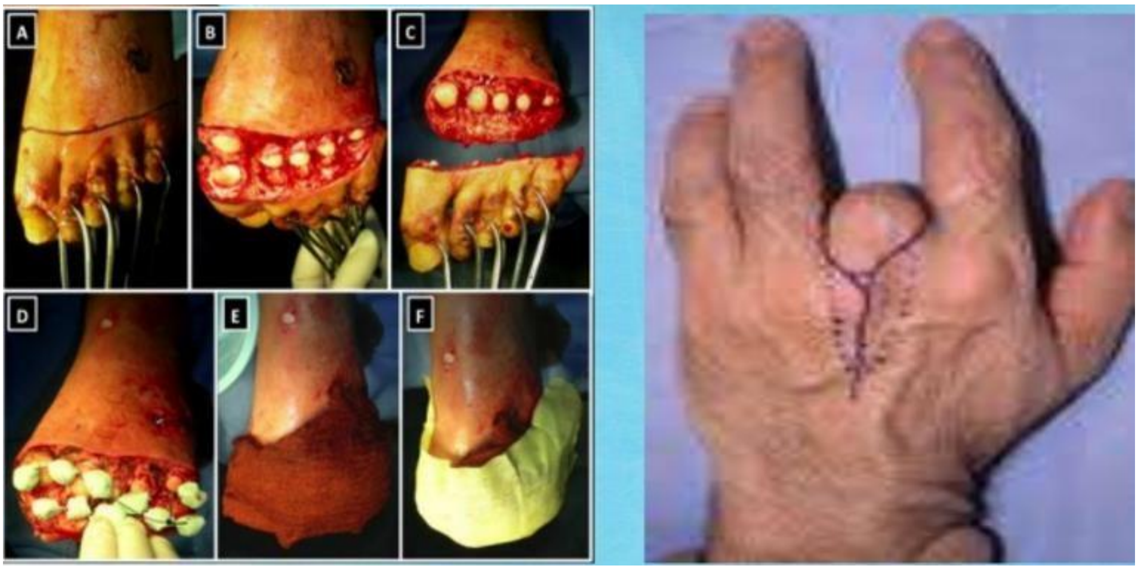


Figure 3-13: Part of amputation

3.2 EXPECTED OUTCOMES, POST OPERATIVE DRESSINGS – RIGID DRESSINGS

Figure 3-14: POD

With the advent of "immediate postoperative fitting procedures," considerable emphasis was placed on the application of a rigid plaster-of-Paris cast immediately after amputation. This cast, carefully applied to provide "total contact" or "total tissue support," was considered to have two prime functions: The limitation of fluid accumulation (stump edema) with consequent reduction in pain and accelerated wound healing; and The provision of a foundation on which, either immediately or soon, the patient could stand and bear at least part of his weight, or even ambulate, by means of a simple pylon prosthesis attached to the cast. In this way fitting of the definitive prosthesis could be expedited.

The report of a survey published in the April 1975 issue of Newsletter. Amputee Clinics indicates that the use of the rigid dressing is still viewed quite positively in regard to the first of these functions, even when the second is not utilized. Details concerning various methods of applying rigid postoperative casts may be found in the references.

According to some users, rigid dressings can present difficulties as well as benefits. A summary of the pros and cons advanced by various practitioners might read as follows:

Advantages

The dimensions of the plaster cast will be the limiting factor in any increase in tissue volume. Stump movements, and changes in pressure across the interface associated with standing and walking, will promote beneficial reductions in stump volume. These pressure changes may improve blood circulation in the tissues, thus expediting wound healing. Psychological benefits accrue to patients through the achievement of early walking.

Disadvantages

The correct application of the postoperative cast requires specific skills, particularly if felt pads or other modifying materials are incorporated. If the cast is not applied correctly or if there are subsequent changes in stump dimensions, localized high-pressure areas may develop. Some surgeons find unacceptable the lack of easy access to the stump for inspection. Moreover, once the cast has set, changes in the environment to meet changing tissue conditions can usually only be effected by replacement of the entire cast. Some surgeons are inadequately trained or do not wish to take the time to apply the postoperative cast themselves in the operating room, their assistants lack the skill, and prosthetists are unwelcome or unavailable.

Plaster casts provide limited protection against bacterial infection and little or no control of temperature and relative humidity in the immediate environment of the stump. Post amputation management is an important determinant of recovery from amputation. Dressings can include simple soft gauze dressings, thigh-high rigid cast dressings, shorter removable rigid dressings, and prefabricated pneumatic dressings. Postoperative prosthetic attachments can be added to all but simple soft dressings. These dressings address the need to cleanly cover a fresh surgical wound, but not all postoperative dressings are designed to facilitate the strategic goals of preventing knee contractures, reducing edema, protecting from external trauma, or facilitating early weight bearing.

The type of dressing and management strategy often overlap and are certainly interrelated. Current protocols and decisions are based on local practice, skill, and intuition. The current available literature is challenging, and difficulties include variations in healing potential, in comorbidity, in surgical-level selection, in techniques and skill, in experience with postoperative strategies, and with poorly defined outcome criteria

A sterile non-adherent dressing such as an Adaptic bandage, is applied to any open or draining areas of the wound only for the first 3-4 days post-surgery.

A Soft Sock (a two ply, two way stretch sock) is applied snugly over the limb (Sock #1).

A shrinker is applied to the residual limb (Sock #2). It is pulled on to the thigh above the knee cap by 3-4 inches and marked with a line at the end of the residual limb. It is then twisted snugly about 90 degrees and reflected back up towards the knee cap. It should end just below the knee cap.

Figure 3-15: Dressing

When reapplying the rigid cast, inspect its fit for looseness. If loose, then remove the cast and apply additional filler socks until it fits snugly. It is important that socks be applied one at a time and that no wrinkles occur.

3.3 SEMI RIGID DRESSINGS

In attempts to obtain the benefits of rigid dressings without the attendant difficulties, a number of wound-encasement substitutes for postoperative procedures have been tried recently. It is these substitutes that we are referring to as "semirigid" dressings. Two lines of approach are discernible, Unna paste and the air splint

Figure 3-16: Semi Rigid Dressings

3.4 SOFT DRESSINGS

In traditional amputation management the dressing typically applied to the freshsurgical wound has been "soft," i.e., comprised essentially of gauze pads and a gauze bandage. Again typically, this type of dressing has been maintained, with changes, untilthe wound has healed. Subsequent management might include exercise and other modalities for the residual limb, and the application of a "shrinker" sock, "Ace"bandage, or other elastic materials to prepare the stump for prosthetics fitting.

Thus the use of a "soft" dressing is ordinarily associated with "delayed" prosthetics fitting and, in the ischemic patient, with above-knee amputation. However, this is not necessarily so a high level of healing success (80-plus percent) in a series of below-knee amputations in which "soft" dressings were used in conjunction with long posterior flaps. Soft dressings are used on the residual limb and a prosthesis is fitted only after healing and maturation of the residual limb. The soft dressing strategy usually consists of a nonadherent dressing over the suture line, sterile 4 × 4 pieces of gauze, absorbent fluffed gauze applied anteriorly and distally, and gauze roll over-wrap.

Typically, but not always, an elastic bandage is used to secure the soft gauze and control edema. Weight bearing and gait training are delayed for many weeks until healing is achieved. Physical therapy commonly starts soon after surgery and includes range of motion, muscle strength training, and personal self-care. However, protocols are not standardized.

Advantages of the soft gauze dressing claimed in descriptive studies include ease of application, low cost, and accessibility to the wound. Disadvantages of soft dressings, based on descriptions from case series or other reports and descriptive studies, include—

a. Application of the elastic wrap can generate high local or proximal pressures that impair skin survival and healing.
b. A tendency for the gauze wrappings to loosen and fall off.
c. An increased likelihood of knee flexion contracture.
d. Prolonged bedrest or limited mobilization may be required for pain control, which could increase hospital stays and heighten the risk of pulmonary complications, strokes, and pneumonia.
e. Higher health care costs because of extended hospital stays. Data from controlled trials found that for soft dressing strategies, frequency of uncomplicated healing rates, postoperative pain, eventual use of a

prosthesis, and mortality were not significantly different when compared with other types of dressings.

Management of the postoperative amputee with simple soft dressings is commonly viewed as the least expensive and time-consuming strategy. However, when a cost benefit analysis is considered, the initial savings in cost must be balanced with complications that many believe are potentially preventable.

For example, because of the short mechanical lever that remains after TTA, knee flexion contractures do occur. The patient who develops a severe contracture often cannot be fitted with a prosthesis. When soft dressings are used, knee contractures might be minimized with prompt physical therapy and the use of a knee immobilizer. The effectiveness of these strategies is not well documented in the current literature. Years of experience have also shown that attention to correct wrapping technique is vitally important to prevent the complications of residual-limb pressure damage, overaggressive proximal compression, and tissue strangulation.

Figure 3-17 : Soft Dressing

3.5 EXAMINATION- RANGE OF MOTION

Figure 3-17: Examination

Range of motion (ROM) is the measurement of the amount of movement around a specific joint or body part. It is commonly measured during a physical therapy evaluation or during a course of treatment. Other impairments that your physical therapist may measure include strength, gait, flexibility, or balance.

Range of motion is measured by your physical therapist using a device calleda goniometer. A goniometer is a metal or plastic handheld device with two arms. Numbers representing angular distance are on the device, much like a protractor. Yourphysical therapist lines up the arms along your body, and then he or she can move yourbody in specific directions and measure the amount of motion that occurs. Measuring ROM is usually a painless procedure. There are some instances after surgery or injury where measuring the ROM may be painful, but the pain is usually short-lived and onlyoccurs during the measurement. In general, there are three types of ROM that are measured. They are:

a) Passive (PROM)

Passive ROM occurs around a joint if you are not using your muscles to move. Someone else, like your physical therapist, manually moves your body while you relax. A machine may also be used to provide passive ROM. For example, after knee replacement surgery, you may not be able to use your muscles to move the knee. Your physical therapist may bend and straighten your knee for you, passively moving your leg. Occasionally, a device called continuous passive motion (CPM) is used to provide passive ROM.

b) Active-assistive (AAROM)

Active-assistive ROM occurs when you are able to move your injured body part, but you may require some help to move to ensure further injury or damage does not occur. The assistance that helps move your body can come from you or from another person. It may also come from a mechanical device or machine. An example of AAROM is after shoulder rotator cuff surgery. You may be allowed to move your arm, but another person may assist your arm during the motion to help limit the amount of stress that may occur. Active-assistive ROM is typically used after injury or surgery when some healing has occurred and your muscle can contract, but protection is still required to prevent damage to your healing body part

c) Active (AROM)

Active ROM occurs when you use your muscles to help move your body part. This requires no other person or device to help you move. Active ROM is used when you are able to start moving independently after injury or surgery, and little or no protection from further injury is needed. Strengthening exercises are a form of active ROM. Be sure to speak with your physical therapist or doctor to understand what type of ROM is necessary if you are injured or have had surgery. Understanding what range of motion is and how it is used in physical therapy can help you become better informed about your course of physical therapy and have a positive physical therapy experience. Working towards normal ROM can help ensure a safe and rapid return to optimum functional mobility.

3.6 MUSCLE STRENGTH

Muscular strength is defined as the maximum amount of force that a muscle can exert against some form of resistance in a single effort. In the gym, a single repetition at a given weight is an example of muscular strength. Activities that build muscular endurance include long-distance running, cycling, or swimming, along with circuit training and bodyweight exercises. You can improve muscular strength and endurance by doing repetitive movements until the point of exhaustion. Muscular strength and endurance are important for many reasons: Increase your ability to do activities like opening doors, lifting boxes or chopping wood without getting tired. Reduce the risk of injury. Lead to healthier, stronger muscles and bones.

Muscle strength can be measured by estimating a person's one repetition maximum (1RM) - a measurement of the greatest load (in kg) that can be fully moved (lifted, pushed, or pulled) once without failure or injury. Strength is the ability to carry out work against a resistance. Each strength test is specific to the action and muscle groups being tested. Muscular strength endurance is the ability to repeat a series of muscle contractions without fatiguing

Figure 3-18: Muscle

3.7 STATUS OF RESIDUAL LIMB

Historically, the limb that had been amputated in people had been called a "stump." Unfortunately, this term is not the most attractive term to use. Many people who have had an amputation feel that this term is insensitive. There is a more appropriate term: residual limb. The term residual limb refers to the part of the body that remains after an amputation has been performed. For example, if you have had a lower extremity amputation above the knee, the part of your thigh that remains after the amputation is called the residual limb.

The rehabilitation process after an amputation involves proper care of your residual limb. First and foremost, you must ensure that the surgical incision heals properly. You must be on the lookout for signs of infection and your doctor must be alerted if you suspect infection in your residual limb.Shaping of your residual limb is important after an amputation as well. Ensuring the proper shape of your residual limb will make fitting a prosthesis a lot easier. Your physical therapist can teach you wrapping techniques to help your limb maintain the proper shape after a lower extremity amputation. Occasionally after an amputation, your limb may be highly sensitive.

This is caused by altered nerve signals at the end of your residual limb. Desensitization techniques can help you ensure that your limb is not too sensitive after an amputation.

This will make using your prosthesis easier. Phantom limb pain is a complex and confusing phenomenon that may occur after you have had an amputation. Be sure to work with your doctor, physical therapist, and rehabilitation team to help you manage phantom limb pain if you are experiencing it. Most importantly, exercise for your residual limb (and your entire body) is essential after an amputation. You will need good strength in the muscles that remain intact after an amputation for proper walking and functional mobility.

Figure 3-19: Residual Limb

3.8 STATUS OF THE UN INVOLVED LIMB

Standard Functional Tests (SFTs) have been developed as a more accurate measure of patient ability and readiness to return to play. Multiple tests exist in this category, all of which combine complex kinetic chain motions to better simulate sport-related demands and evaluate neuromuscular control. The single-leg hop test has been evaluated extensively and is capable of detecting functional limitations up to 54 weeks postoperatively, with good test-retest reliability. Other investigators have recommended a 4-test battery consisting of a single leg hop, a crossover triple hop, a single-leg triple hop and timed hop. Strength testing also has a role in rehabilitation assessment, as well as other functional tests such as single-leg squat and retro step-up. No universally accepted protocol of functional testing exists, and multiple groups have developed unique functional test batteries for assessment.

During rehabilitation, the injured limb's SFT performance is typically compared with that of the uninjured limb as a reference, yielding a measure known as the Limb Symmetry Index (LSI). This is preferable to the use of arbitrary single-limb performance levels, both because patients inherently differ in ability and because in biomechanical testing, limb symmetry is associated with better rates of return to play and lower rates of reinjury. Physical therapy programs focus on the injured limb, yet many exercises involve the uninjured side as well—for instance, double leg jumps and Russian hamstring raises. In addition, the patient undergoes motor learning during each assessment, since both limbs are tested. Therefore, uninvolved limb ability may increase over subsequent SFTs.

Previous research on this theory is inconclusive, with one study showing no significant change in uninvolved limb ability in hop test–subjects who underwent multiple assessments in a 5-day period. A subsequent study, however, showed increased uninvolved limb performance with repeat testing in all 4 hop tests, which the authors attributed to motor learning. Other functional tests in wide use, such as the single-leg squat and the retro step-up, have not been studied in this regard. Some studies that involved strength testing even suggested that the uninvolved limb's performance worsens during rehabilitation. This is conceivable since the postsurgical period likely involves an overall lower level of activity, especially for an athlete. While limb symmetry in the SFT is a clearly beneficial goal, if this is achieved due to deterioration in the uninvolved limb, it could diminish the legitimacy of LSI measurements in functional testing. Therefore, it is especially vital to exclude the possibility that the uninvolved limb's SFT performance may worsen with rehabilitation

CHAPTER FOUR

PROSTHETIC DEVICES IN REHABILITATION TECHNOLOGY

4.1 INTRODUCTION, PARTIAL FOOT PROSTHESES- FOOT-ANKLE ASSEMBLY

a) Definition

Prosthetic Devices: the making and fitting of artificial body parts the design by fabricating and fitting of custom-made. An artificial extension that replaces a missing body part. Prostheses are typically used to replace parts lost by injury (traumatic) or missing from birth (congenital) or to supplement defective body parts. Prosthetic devices are artificial components designed to replace a part of the human body that is missing, either due to accident or a birth defect. Example: artificial arms and legs, dentures (artificial of teeth). Aimed - quality of life

i) providing function

ii) Did not bear much resemblance to the body part they replaced

iii) Focused more on appearance and less on function.

iv) Provide assistance

A person's prosthesis should be designed and assembled according to the patient's appearance and functional needs.

Types of prosthesis (transradial prosthesis)

i. an aesthetic functional device,

ii. a myo electric device

iii. a body-powered device

iv. an activity specific device

Figure 4-1: Prosthetics Devices

b) Types of prosthetics

i. **Upper-extremity prostheses**

Used at varying levels of amputation: forequarter, shoulder disarticulation, transhumeral prosthesis, elbow disarticulation, transradial prosthesis, wrist disarticulation, full hand, partial hand, finger, partial finger. A transradial prosthesis is an artificial limb that replaces an arm missing below the elbow.

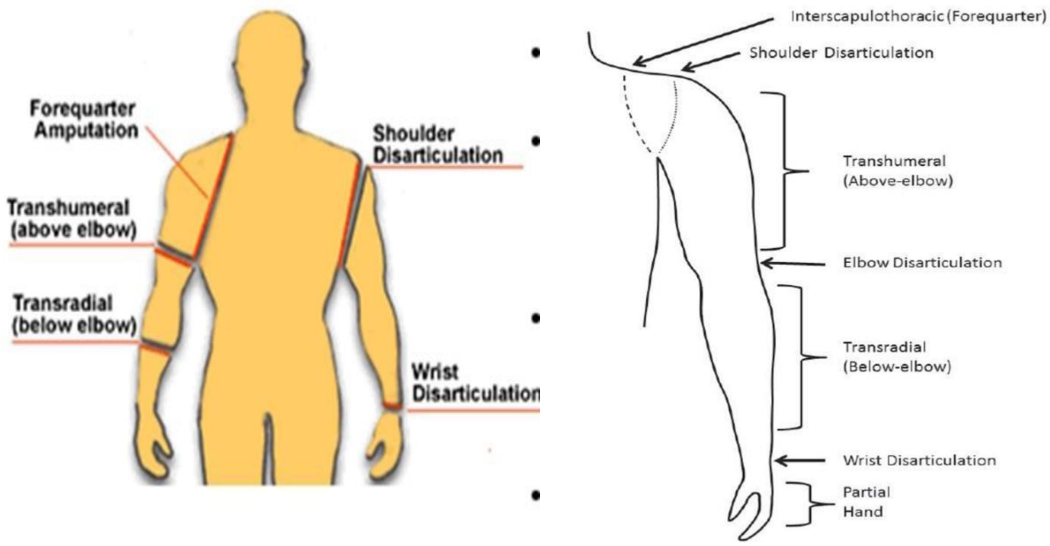


Figure 4-2: Upper prosthetic

Used at varying levels of amputation:

a) Forequarter,
b) Shoulder Disarticulation,
c) Transhumeral Prosthesis,
d) Elbow Disarticulation,
e) Transradial Prosthesis,
f) Wrist Disarticulation,
g) Full Hand,
h) Partial Hand,
i) Finger,
j) Partial Finger.

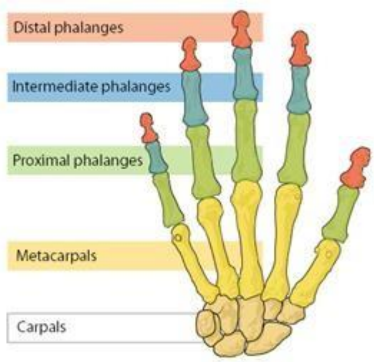


Figure 4.3: levels of amputation

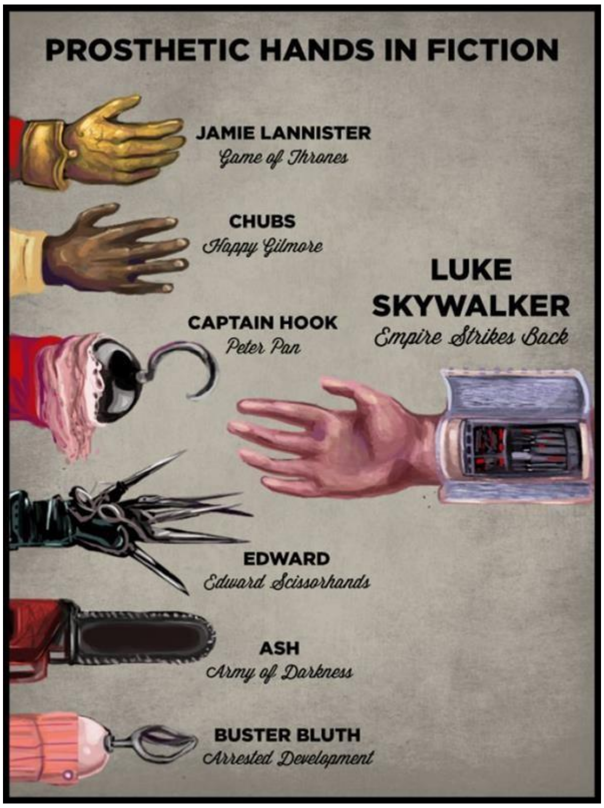


Figure 4.4: Prostatic hand in fiction

ii) Lower-extremity prostheses

Provide replacements at varying levels of amputation. These include hip disarticulation, transfemoral prosthesis, knee disarticulation, transtibial prosthesis, Syme's amputation, foot, partial foot, and toe. The two main subcategories of lower extremity prosthetic devices are trans-tibial (any amputation transecting the tibia bone or a congenital anomaly resulting in a tibial deficiency) and trans-femoral (any amputation transecting the femur bone or a congenital anomaly resulting in a femoral deficiency).

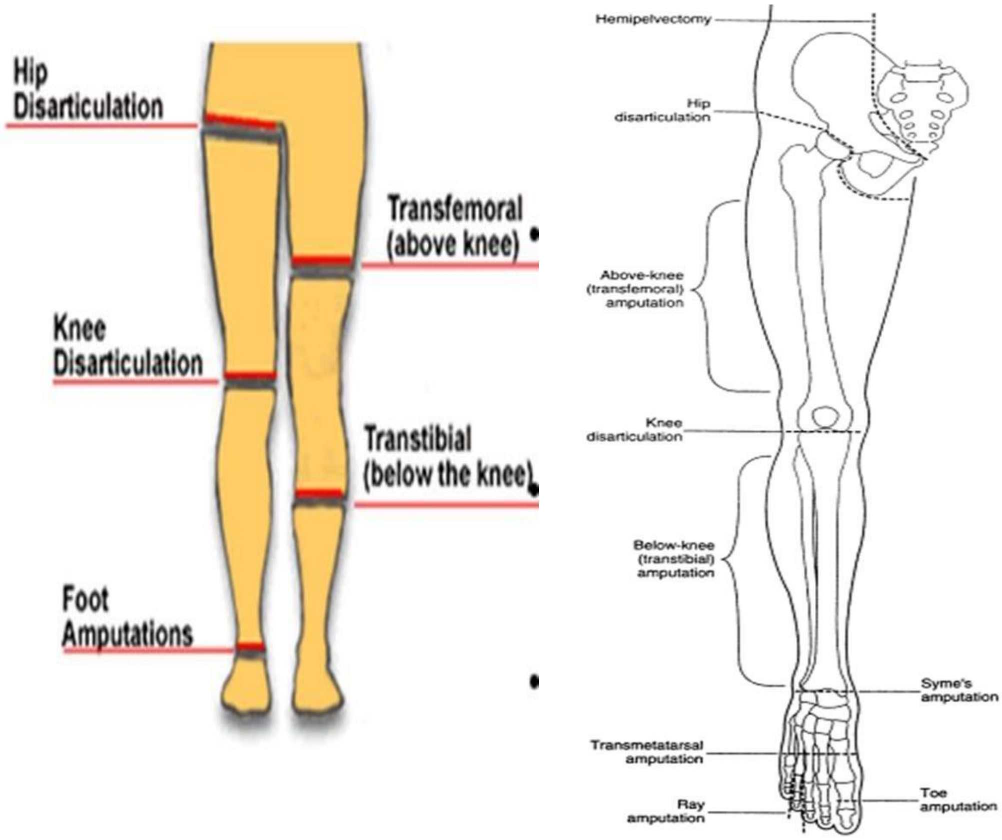


Figure 4-5: Lower prosthetic

Lower-extremity prostheses provide replacements at varying levels of amputation. These include:

a) hip disarticulation,
b) transfemoral prosthesis,
c) knee disarticulation,
d) transtibial prosthesis,
e) Syme's amputation,
f) foot,
g) partial foot,
h) Toe.

The two main subcategories of lower extremity prosthetic devices are trans-tibial (any amputation transecting the tibia bone or a congenital anomaly resulting in a tibial deficiency) and trans-femoral (any amputation transecting the femur bone or a congenital anomaly resulting in a femoral deficiency).

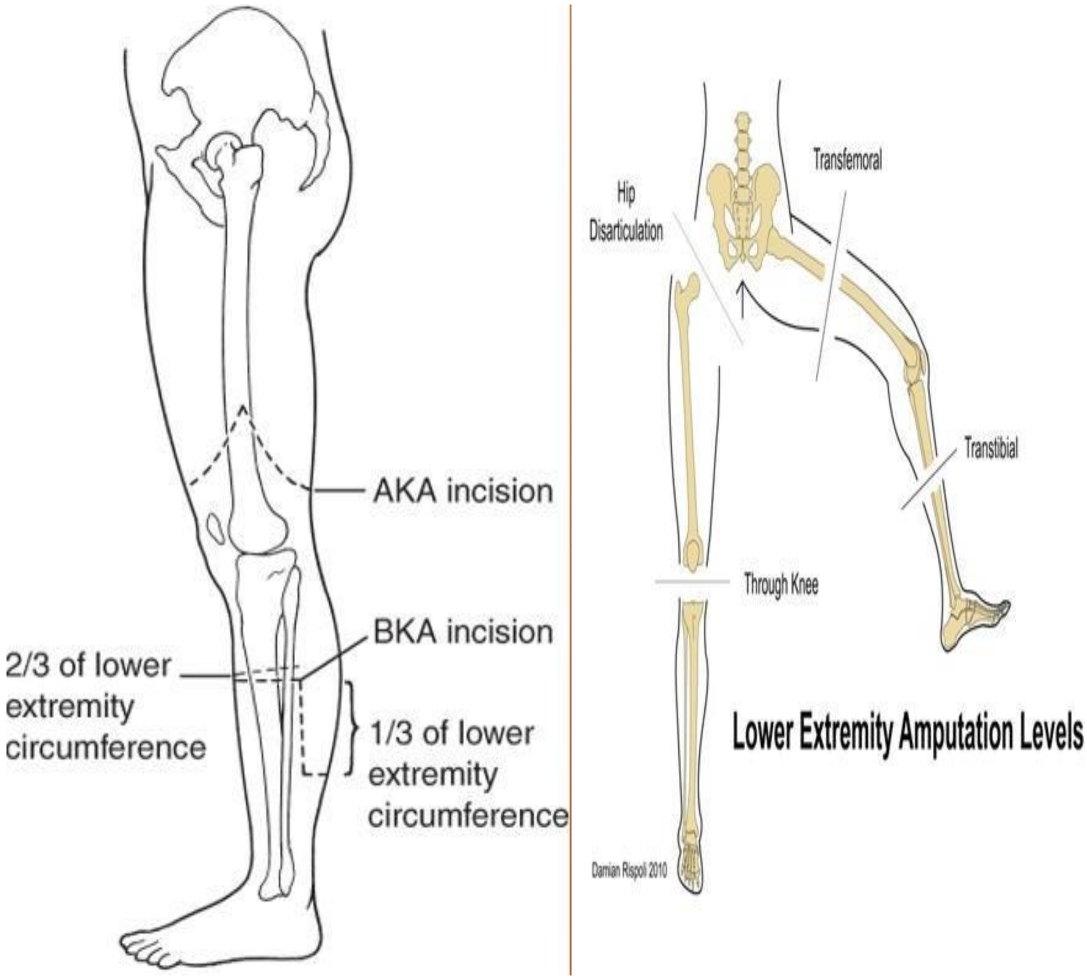


Figure 4.6: Lower-extremity prostheses

4.2 TRANS FEMORAL PROSTHESES – KNEE UNIT

In medicine, prosthetics are designed to help individuals with missing body parts attain a normal life. Artificial legs assist patients to boost their self-esteem and confidence levels. A trans-femoral prosthesis is an artificial limb that replaces any amputated limb above the knee. The prosthesis is made from a high-quality raw material known as polypropylene. It has several components which fit together to construct the final piece. According to the International Committee of the Red Cross, the following nine components make up the trans-femoral prosthesis:

a) Solid ankle cushion heel
b) Hexagonal-head bolt and lock washer
c) Convex ankle
d) Concave cylinder and pin

e) Set of washers with a nut and bolt
f) Convex disc
g) Conical cup
h) Trans-femoral cup
i) Knee shell

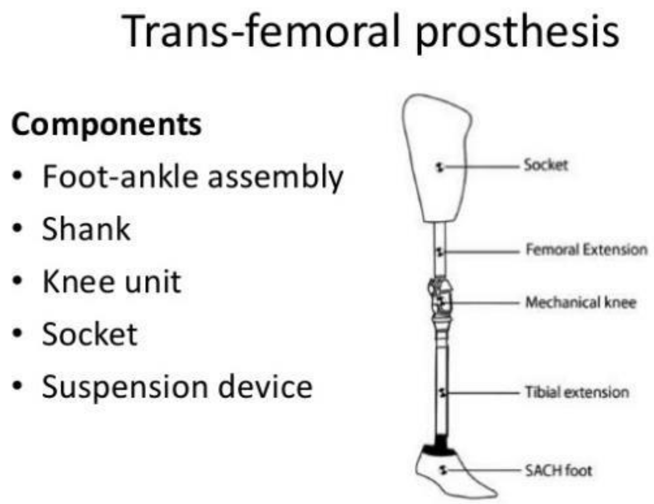


Figure 4.7: Trans-femoral prosthesis

ii. Components

a) Foot-ankle assembly

Over the past decade, technology and research have greatly expanded the functionality and aesthetics of prosthetic feet. Today, amputees have a wide array of feet from which to choose. Various models are designed for activities ranging from walking, dancing and running to cycling, golfing, swimming and even snow skiing. Heavier wood and steel materials have been replaced over the years by lightweight plastics, metal alloys and carbon-fiber composites. Much like the human foot, many of today's prosthetic feet can store and return some of the energy generated during walking. Other key attributes included toe and heel springs that allow more natural movement at the ankle, shock absorption, multi-axial rotation, adjustable heel heights, and waterproof materials.

A number of factors must be considered when selecting the right foot/feet for your lifestyle. These factors include your amputation level, age, weight, foot size, activity level, goals and occupational needs. Structurally, prosthetic feet can be divided into two groups: those with a rigid connection to the prosthetic shank (non-articulated) and those with a hinged ankle mechanism (articulated). In terms of function, prosthetic feet can be categorized into the following groups:

i. Solid Ankle Cushioned Heel (SACH)
ii. Elastic (flexible) Keel Foot
iii. Single-Axis Foot
iv. Multi-Axis Foot
v. Dynamic-Response Foot
vi. Microprocessor Foot.

Although not all are discussed in this Fact Sheet, the following are definitions of terms you may hear when discussing various types of prostheses, fitting needs and activity requirements with your prosthetist and physician. This knowledge may help you choose which type of prosthesis is the most appropriate for you and your daily activities and needs. Never hesitate to ask for clarification from your prosthetist or physician if you do not understand something they say. You are an important part of your medical team.

1) ***Internal and External Rotation***: Internal rotation refers to movement of a joint or body part toward the center of the body, while external rotation refers to the opposite rotation of a joint away from the body.
2) ***Dorsiflexion and Plantarflexion***: The upward (dorsi) and downward (plantar) movements of the ankle and toes. These movements alternately enable the leg to move forward over the foot, pushing the forefoot to the ground as one takes a step.
3) ***Inversion and Eversion***: The inward and outward, or side-to-side, motions of the ankle

i) SACH and Elastic Keel Foot

The most basic prosthetic feet come in two types: Solid Ankle Cushioned Heel (SACH) and Elastic Keel configurations. These designs consist of crepe neoprene or urethane foam molded over an inner keel and shaped to resemble a human foot. Because they have no hinged parts, these basic feet are relatively inexpensive, durable, and virtually maintenance-free. These feet offer cushioning and energy absorption but do not store and return the same amount of energy as dynamic-response feet. SACH and elastic keel feet are generally prescribed for amputees who do a limited amount of walking with little variation in speed.

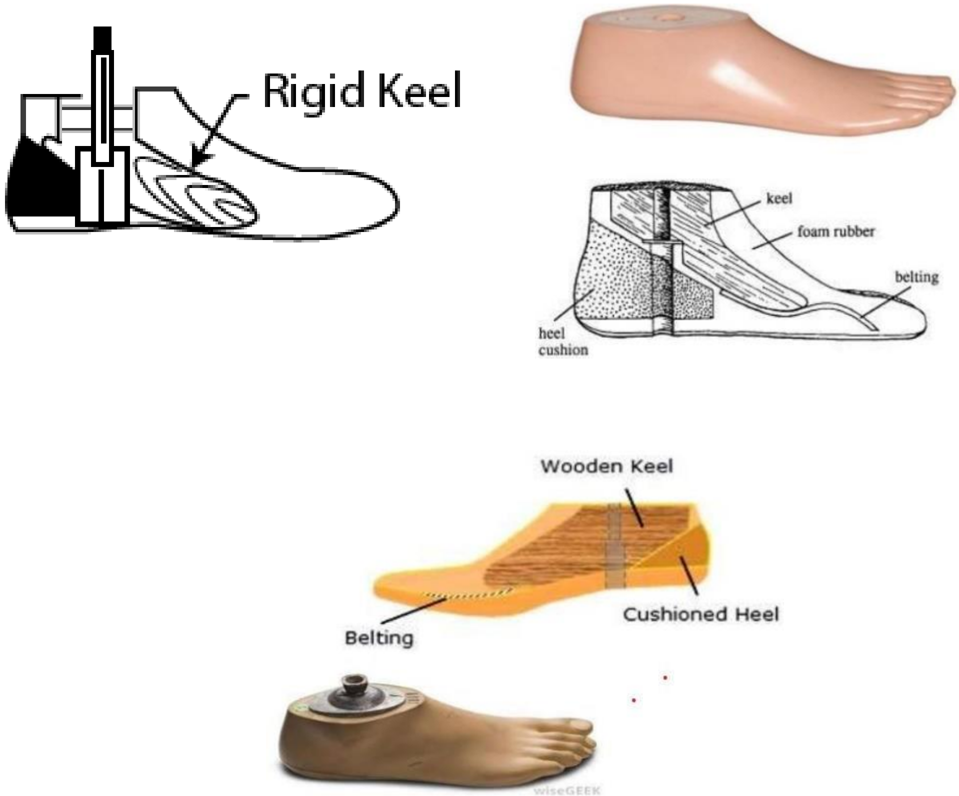


Figure 4.8: Solid Ankle Cushioned Heel (SACH)

SACH Foot: SACH Foot: The SACH is the simplest type of non-articulated foot. The name refers to a somewhat soft rubber heel wedge that mimics ankle action by compressing under load during the early part of the stance phase of walking. The keel is rigid, which provides midstance stability but little lateral movement. The SACH foot is available in various heel heights to match individual shoes with different heel heights.

Elastic (flexible) Keel Foot: This prosthetic foot allows motion similar to that of SACH feet. In addition, the forefoot is able to conform to uneven terrain but remains supportive and stable during standing and walking.

ii) Single-Axis Foot and Multi-Axis Foot

Articulated prosthetic feet may be single-axis or multi-axis in their design. “Axis” refers to motion in one or more of three different planes, similar to the movement of the natural foot. Prosthetic feet that have movement in two or three axes provide increased mobility at the ankle, which helps stabilize the user while navigating on uneven surfaces.

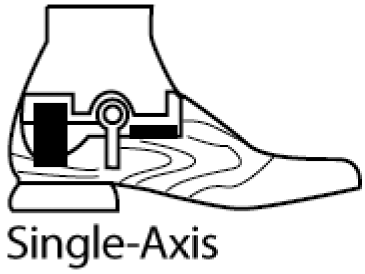


Figure 4.9: Single -Axis

Single-Axis Foot: The articulated single axis foot contains an ankle joint that allows the foot to move up and down, enhancing knee stability. The more quickly the full sole of the foot is in contact with the ground, the more stable the prosthesis becomes. This is beneficial for users with higher levels of amputation (an amputation anywhere between the knee and hip). The wearer must actively control the prosthesis to prevent the knee from buckling, and the single-axis ankle/foot mechanism reduces the effort required to do so. Unfortunately, the single-axis ankle adds weight to the prosthesis, requires periodic servicing, and is slightly more expensive than the more basic SACH foot. A single-axis foot may be more appropriate for individuals where stability is a concern.

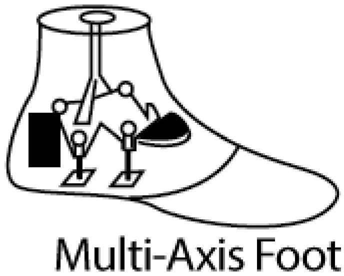


Figure 4.10: Multi-Axis Foot

Multi-Axis Foot: Although similar to the single-axis foot in terms of weight, durability and cost, the multi-axis foot conforms better to uneven surfaces. In addition to the up and down mobility of the single-axis foot, a multi-axis foot can also move from side to side. Since the added ankle motion absorbs some of the stresses of walking, this helps protect both the skin and the prosthesis from wear and tear.

iii) Dynamic-Response Foot

Prosthetic Feet 05People with more active lifestyles typically prefer a more responsive foot. A dynamic-response foot is ideal for those individuals who can vary walking speed, change directions quickly or walk long distances. Dynamic-response feet store and release energy during the walking cycle by absorbing energy in the keel during the “roll-over” phase and then springing back to provide a subjective sense of push-off for the wearer. Additionally, they provide a more normal range of motion and a more symmetric gait. Some dynamic-response feet feature a split-toe design that further increases stability by mimicking the inversion/eversion movements of the human ankle and foot.

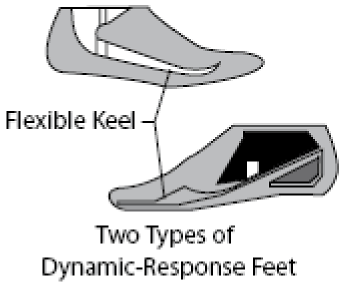


Figure 4-10: Dynamic Response foot

The comfort and responsiveness of a dynamic-response foot can also encourage an individual to advance from a more moderate activity level to a higher activity level, given the more natural feel of walking with this type of prosthetic foot. Further, some dynamic-response feet have been shown to reduce impact forces and stress upon the sound side foot and leg.

iv) Microprocessor Foot

Microprocessor-controlled (MPC) feet are a fairly new category of prosthetic components. These foot/ankle components have small computer-controlled sensors that process information from both the individual’s limb and the surrounding environment to adjust to various needs. Based on information from input signals, these processors apply an algorithm, or set of rules, to make decisions about how the ankle or foot should respond in any given situation. The microprocessor provides instructions to various parts of the prosthesis to produce the desired function of the foot. Current MPC ankles use a variety of sensors, including ankle angle sensors, accelerometers, gyroscopes, and torque sensors. The microprocessors in these systems then take the input signals and make decisions as to how to position the ankle, how to set the damping resistance in the ankle, and how to drive an ankle motor during stance phase (1).

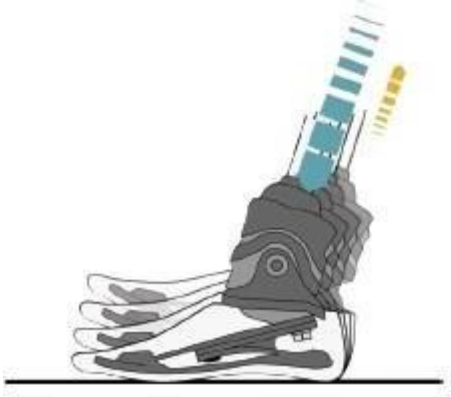


Figure 4-11: Microprocessor Foot

The largest potential benefit of an MPC ankle/foot system over other prosthetic feet is the enhanced ability to react to varying environmental situations by providing different mechanical properties or alignments to improve the user’s balance and mobility. For example, non-MPC prosthetic feet work nicely on smooth, level terrain; however, they have a more limited ability to alter their mechanical properties or alignment when walking on slopes or other uneven surfaces. Powered feet provide propulsion during ambulation to enhance walking capabilities in real-time. Some specific models include software as well as options for connectivity to mobile devices through smart phone or computer apps. This allows the prosthetist and user to match the performance of the ankle/foot to various activities, allow for adjustments to the input gains and timing, and turn on or off certain features. All of these functions provide a more individualized experience by the user.

The ultimate goal of this class of prosthetic feet is to mimic the functions of the human foot. However, devices differ in their ability to accommodate for all environments and thus to the extent in which that accommodation can be achieved (2). Although these types of feet can coordinate the movements of the foot and ankle automatically, they do not directly communicate with the body. Microprocessor or powered prosthetic feet require batteries to power the chip, sensors, motors and actuators. Additionally, electronic parts associated with microprocessor systems make them more delicate than their passive counterparts. Many should not be used in water or in highly dusty or dirty environments. Due to the extra parts required by the addition of the microprocessor, they often weigh more than other prosthetic feet. Users may notice the mechanical clicks and sounds coming from the prosthesis as the microprocessor extrapolates information and adjusts various aspects of the ankle or foot. Finally, the higher level of technology and more intricate design of this class of prosthetic feet mean they may likely be the more expensive options on the market.

b) Shank

This part creates distance and support between the knee-joint and the foot (in case of an upper-leg prosthesis) or between the socket and the foot. The type of connectors that are used between the shank and the knee/foot determines whether the prosthesis is modular or not. Modular means that the angle and the displacement of the foot in respect to the socket can be changed after fitting. In developing countries prosthesis mostly are non-modular, in order to reduce cost. When considering children modularity of angle and height is important because of their average growth of 1.9 cm annually

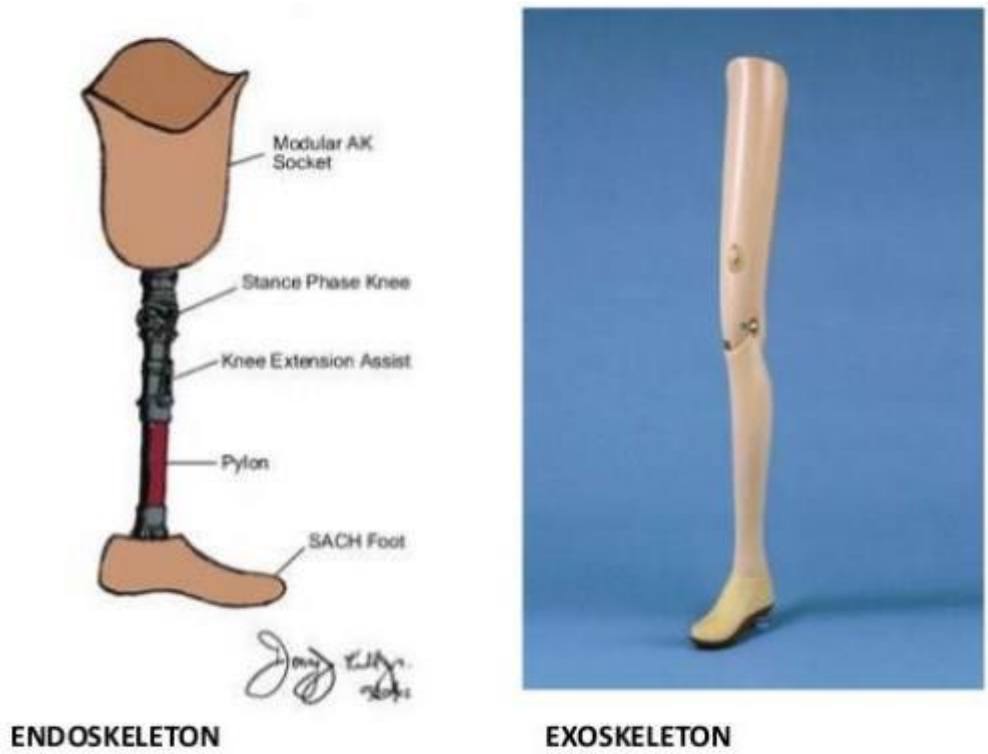


Figure 4-12 shank

c) Knee unit

A prosthetic **knee unit** is integral to every trans femoral (above knee) prosthesis.

d) Socket

The socket serves as an interface between the residuum and the prosthesis, ideally allowing comfortable weight-bearing, movement control and proprioception. Socket issues, such as discomfort and skin breakdown, are rated among the most important issues faced by lower-limb amputees.

iii. Benefits of Trans-Femoral Prosthesis

For those with amputated limbs, it's often a challenge to live a normal life. The impaired ability to perform certain day-to-day tasks can be inhibiting. Over many years, prosthetics in Memphis, TN, have helped many people obtain access to high quality prostheses through the use of advanced technology. It can be reasoned that the decision to invest in artificial limbs can be a tough one, but there are many benefits.

a) Mobility

Prosthetics provide impaired patients with the ability to move around easier when fitted properly. Although many areas are wheelchair accessible, there are some public areas and buildings that are not accessible. For many patients, wearing prosthetics allows them to feel independent and provide greater mobility.

b) Energy

A study conducted by the National Institute for the Orthopedically Handicapped suggests that the energy expenditure an amputee expends is far greater when walking with fitting crutches versus walking with a prosthetic. The data on energy cost indicates that all below knee amputee groups walk with less effort by using a prosthesis. A prosthesis, therefore, allows one to be able to move around efficiently and comfortably.

c) Psychological Lift

Wheelchair-bound amputees often feel a sense of helplessness when they ask others for assistance. Amputees often lose the sense of normalcy they once had. Access to prosthetics helps people blend in better with the rest of the population and return to their normal lives. Day-to-day activities are made less challenging, and amputees experience less frustration when they have access to artificial limbs. In addition, wearing artificial limbs help self-conscious individuals gain their self-esteem and self-confidence. Our company can assist you in making the best decision when it comes to choosing the right prosthetic for your needs. Our prosthetics office in Memphis, TN, has skilled prosthetists that specialize in the use of advanced technology solutions tailored to the needs of our patients. Our company will work with you and your family to make the most educated decision to choose the most fitting prosthetic.

4.3 AXIS SYSTEM

The type of knee used on an above knee prosthesis depends on the patient's activity level, the patient's weight, the patient's strength and ability to control the knee, residual limb length, funding, and patient preference. Friction is used in the knees in order to control the knee joint during walking. Friction controls how far and how fast the knee bends and straightens during gait. Some knees have mechanical friction while others have hydraulic resistance. Computerized knees are also available that control the knee speed based on the person's gait. Mechanical knees provide constant friction where the hydraulic knees and computerized knees change the knee speed depending on how fast the person is walking.

a) Manual Locking Knee

The manual locking knee is the most stable knee used in prosthetics. The knee is locked during gait and the patient releases the lock mechanism in order to sit down. Manual locking knees are primarily used with patients who have very short residual limbs and/or poor hip strength and are unable to control the knee.

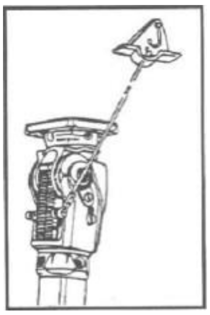


Figure 4-13: Manual locking Knee

b) Single Axis Constant Friction Knee

Single axis knees are basic knees that bend freely. The amputee must rely on his own muscle control for stability. The single axis constant friction knee is generally used by children who have a lower center of gravity or for patients with excellent musculature control that walk at a single speed. Friction in the knee can be adjusted by tightening a bolt. For exoskeletal knees, an extension strap made of elastic may be added to the front of the prosthesis to aid the knee in kicking forward. This knee is very durable and is easy to maintain and repair.

Figure 4-14: Single Axis Constant Friction Knee

Single axis knees can be exoskeletal (hard plastic) or endoskeleton (metal components). Oftentimes, hydraulic or pneumatic controls are added to single axis knees to allow for variable speed walking. Stance control may also be added to improve stability.

c) Weight Activated Stance Control Knee

The weight activated stance control knee is one of the most widely used knees in prosthetics. This knee is a single axis constant friction knee with a braking mechanism. When weight is put on the knee during gait, a braking mechanism is applied, and the knee will not buckle. Using this knee, the patient must unload or take weight off the prosthesis in order for the knee to bend. The wearer will need to unload the knee to sit or to initiate the swing phase of gait. This knee is sometimes referred to as the “safety” knee.

Otto Bock Weight Activated Stance Control Knee 3R49

Figure 4-15: Weight Activated Stance Control Knee

d) Polycentric Knees

The polycentric knee has a variable center of rotation allowing for stability at all phases of gait. The 4 bar linkage also allows the knee to collapse better during the swing phase of gait, essentially shortening the shin and allowing the foot to clear the ground easier. This collapsing feature also allows the knee to bend easier for sitting and is the ideal knee for knee disarticulation or long above knee amputees. The swing phase control can be either mechanical friction or hydraulic resistance. There are many manufacturers of polycentric knees.

Medipro OP2

Otto Bock 3R46

Figure 4-16: Polycentric Knees

e) Hydraulic and Pneumatic Knees

Hydraulic and pneumatic knees allow adjustment of walking speed by the use of hydraulics (either liquid or air) within the knee. As a person's walking speed increases or decreases, the hydraulics adjust to control the speed at which the shin of the prosthesis swings forward and bends backwards. This type of knee is often used for more active patients who vary their walking speeds and do not need assistive walking devices. Hydraulics can be used with single axis or polycentric knees. The following knees are just a few of the various hydraulic knees that are now available.

Figure 4-17: Hydraulic and Pneumatic Knees

f) Mauch SNS Knee (Ossur)

The Mauch SNS (swing and stance) knee was the first hydraulic knee to offer swing and stance phase control. This allows "stumble recovery" or a braking mechanism to prevent buckling of the knee when weight is on the knee. This feature can be turned off at the flip of a switch so that hydraulics are used only for the swing phase. The knee also has the ability to be locked so that it will not bend. This may be used if someone is standing for long periods of time.

Figure 4-18: Mauch SNS Knee (Ossur)

g) Medipro OP4 Knee

The OP4 is a single-axis pneumatic weight-activated locking knee. It provides pneumatic swing phase control in a single-axis design with the added attribute of weight activated stance control. The OP4 is a lightweight knee that can handle body weights up to 220#.

Figure 4-19: Medipro OP4 Knee

h) Programmable / Computerized Knees

The following knees are just a few of the various computerized knees that are now available.

Otto Bock C-Leg

Ossur Rheo

Freedom Plie®

4.4 EXTENSION AID

Excessive friction at the prosthetic knee. Too tight an extension aid. Fear and insecurity. The amputee walks with little or no knee flexion. Manual knee lock**.**

4.5 DISARTICULATION PROSTHESES-KNEE

Knee disarticulation **allows for end bearing (weight transmission) through the end of the stump (in a prosthesis)**. Compared with a transfemoral amputation, it maintains a long active lever arm for control of the prosthesis, with excellent muscle attachments.

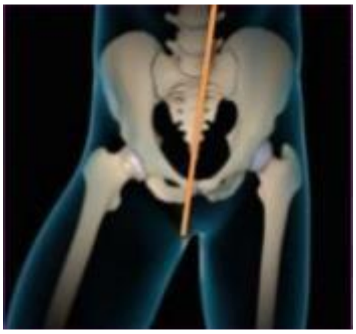
4.6 HIP DISARTICULATION PROSTHESES

Hip disarticulation is the surgical removal of the lower limn through the hip joint. 2% of all amputations are at the hip disarticulation level. Level of amputation in hip disarticulation is:

a) Above the lesser trochanter

b) True hip disarticulation

c) Hemipelvectomy



CHAPTER FIVE
MOBILITY AIDS

5.1 MOBILITY AIDS

When it comes to rehabilitation it’s slow and in some cases it’s for life. That is why at Alpha care we assist our customers to be as comfortable as possible. One thing we have learnt is that all our customers need time to come to terms with their situation and help diagnose their individual needs.

a) **Consultation**

   Caring and listening is at the core of all we do. Only after extensive. Consultation will we begin to formulate a rehabilitation solution to suit your client.

b) **Trial & Assessment**

   After a full consultation we want to make sure that the right equipment is suited to the individual. We allow a trial period with the product and the chance to assess whether it’s the best possible option.

c) **Expertise**

   Our staff are highly trained in all the rehabilitation equipment, having worked in our workshop or on the shop floor. They have confidence to match the right equipment to suit your client’s needs.

d) **Range**

   With one of the widest ranges of rehabilitation equipment, we are seen by many in the industry as a one stop shop for all your rehabilitation products.

5.1 WALKING FRAMES

Walking frames are mobility aids that provide an additional level of balance and support while walking and getting about your day. Types of walking freames:

a) Walking Frame - Coopers Folding

Height adjustable, Folds for easy storage and transportation, contoured plastic handgrips, Available with or without fixed front wheels, Lightweight aluminum, Tip size 25mm, Max user weight 125kg.

b) Walking Frame - Heavy Duty

Wide frame to suit the bariatric user, Height adjustable, Folds flat for easy storage and transportation, Front fixed wheels for added maneuverability, Push down brake system, Mounded plastic handles for additional support, Durable chromed steel construction.

5.2 PARALLEL BARS

A floor apparatus consisting of two wooden bars slightly over 11 feet (340 cm) long and positioned at roughly hand height. Parallel bars are used in artistic gymnastics and also for physical therapy and home exercise.

a) Clinton Folding Parallel Bars

Clinton Folding Parallel Bars feature one piece stainless steel handrails with end bumpers. Heavy duty, square telescoping steel uprights can handle up to 500 pounds load capacity under normal physical therapy use. Choose from seven or ten foot lengths. Width adjustable floor folding parallel bars with double stiffening rails, 1-1/2" one-piece, stainless steel handrails and easy height adjustment with spring loaded plungers and numbered height strip. Second height knob removes side to side play

b) Adjustable Folding Parallel Bars

Adjustable Folding Parallel Bars are easy to use and easy to move. Adjustable Folding Parallel Bars are adjustable from 22 to 36 inches in height and 16 to 24 inches in width. Available in a 7 foot length with 1½ inches diameter handrails, the lower posts and bases are black powder coated and very sturdy.

5.3 QUADRIPODS

A mobility device that aids walking and mobility

a) Centre Quad Stick

Adjustable height, Reflector on handle, Lightweight aluminium stem and steel base

b) Low Base Quad Stick

Adjustable height, Foam handgrip, Handle and stem rotate for left or right hand use
Low profile offset base, Lightweight, aluminium stem and steel base, Tip size 13mm

5.4 TRIPODS

Tripod cane is designed for patients with reduced mobility who need stable support and help while walking. It is also recommended to the elderly as an aid in keeping balance. Three legs provide greater stability than regular canes. Product characteristics: soft foamed handgrip, aluminium-steel leg, chromed and ergonomic height adjustable handle base with three legs and rubber tips

5.5 WALKING STICK

A walking stick is a device used to facilitate walking, for fashion, or for defensive reasons.

a) Walking Stick - Coopers

Lightweight aluminum, Adjustable height, Plastic handle

b) Timber Walking Stick - Crook Handle

Quality timber walking stick, Can be cut to individual requirements

5.6 CRUTCHES

A cane, or a walker can help keep your weight off your injured or weak leg, assist with balance, and enable you to perform your daily activities.

a) Elbow Crutches - Coopers ‘Cumfy’ Handle

Adjustable cuff and leg height, unique contoured plastic handle evenly distributes pressure across the palm of the hand, Lightweight aluminum

b) Elbow Crutches - Coopers Permanent User

Extra-long length to be cut down to suit individual requirements, Ideal for the heavier user or for those who use crutches for long periods of time, Moulded plastic handgrip Double thickness reinforced aluminium tubing for added strength.

5.7 WHEEL CHAIRS

A wheelchair is a chair with wheels, used when walking is difficult or impossible due to illness, injury, old age related problems, or disability. They may include specialized seating adaptions, individualized controls, and may be specific to particular activities, as seen with sports wheelchairs and beach wheelchairs. Types of wheelchairs:

a) Standard wheelchairs
b) Transit wheelchairs
c) Lightweight wheelchairs
d) Customer lightweight wheelchairs
e) Tilt recline wheelchairs
f) Amputee wheelchairs
g) Heavy duty wheelchairs
h) Pediatric wheelchairs
i) Hemiplegic wheelchairs

a) Standard-Combi Wheelchair

Supplied with swing away removable leg rests, calf strap and removable armrests, Folding frame for easy storage and transportation, Vinyl upholstery, Rear backrest upholstery storage pocket, Solid rear tires, Quality chromed steel construction, Complies to Australian Standards.

b) Concorde Wheelchair

Swingaway removable legrests and wingback arms, Breathable padded upholstery overlay, Folding backrest and adjustable seat height, Rear backrest storage pocket, Padded removable calf support, Double cross-over for added durability, Anti tip bars and rollers help prevent tipping, Lightweight aluminum folding frame and quick release rear wheels for easy storage and transportation, Solid tyres, Metallic burgundy or titanium paint finish.

c) Avant-garde Wheelchair

Custom made lightweight wheelchair is scripted to individual user requirements, Extensive range of options and accessories available, Modern European design and technology, High quality aluminium alloys are used for the folding frame, Double cross brace for added strength and durability, Made in Germany.

d) Serene Wheelchair

Full tilt & recline functions including elevating legrest (with separate leg function), Fully adjustable footrests, Push handle with adjustment handles, Anti tip bars, 2 way stretch, fire retardant fabric, Low resilient pressure care foam, Swingaway/removable legrests function, Height adjustable/removable armrests Height adjustable side wings.

e) Rainbow Amputee Wheelchair

Swingaway removable legrests and swingback armrests, Backrest height, armrest height and backrest upholstery tension are all adjustable to suit individual requirements, Breathable padded nylon upholstery and removable seat cushion, Heel loops, Anti tip bars, Adjustable rear axle plate for amputee setting, Quick release wheels for easy storage and transportation, Lightweight aluminium folding frame, Metallic red finish.

f) Heavy Duty Wheelchair [Rubix Wheelchair]

Reinforced frame to suit the bariatric client, Swingaway removable legrests and swingback removable armrests, Push handles, seat depth, seat height and footplate angle are adjustable to suit individual client requirements, Breathable padded nylon upholstery, Tension adjustable backrest, Seat to back connecting flap, Swingaway stabiliser bar prevents backrest sag, Heel straps' Transport tie down points' Anti tip bars and rollers help prevent tipping, Quick release rear wheels for easy storage and transportation' Solid tyres, Lightweight aluminium folding frame, Blue powder coat paint finish.

g) Glide G2 Leisure Child Wheelchair

Custom made child's wheelchair is scripted to suit individual user requirements, Lightweight aluminium folding frame for easy storage and transportation, Reinforced frame for long term use, Swingaway detachable armrests and legrests, Durable Sailcloth upholstery, Adjustable axle mounting plate, Wide range of accessories and options available, Available in a range of colours,

h) Hemiplegic Wheelchairs

Swingaway removable legrests, calf strap and removable armrests, Dual pushrims (on left or right side) allow one armed propulsion of the wheelchair, Durable vinyl upholstery, Quality stainless steel folding frame for long term use.

CHAPTER 6

ADVANCE APPLICATION IN REHABILITATION TECHNOLOGY

6.1 INTERFACES IN COMPENSATION FOR VISUAL PERCEPTION

Visual perception is the ability to perceive our surroundings through the light that enters our eyes. The visual perception of colors, patterns, and structures has been of particular interest in relation to graphical user interfaces (GUIs) because these are perceived *exclusively* through vision. An understanding of visual perception therefore enables designers to create more effective user interfaces.

6.2 IMPROVEMENT OF ORIENTATION AND MOBILITY

a) preventing, recognizing, and medical complications;
b) training for maximum independence;
c) facilitating maximum psychosocial coping and adaptation by patient and family;
d) preventing secondary disability by promoting community reintegration, including resumption of home, family, recreational, and vocational activities;
e) enhancing quality of life in view of residual disability; and
f) preventing recurrent stroke and other vascular conditions such as myocardial infarction that occur with increased frequency in patients with stroke

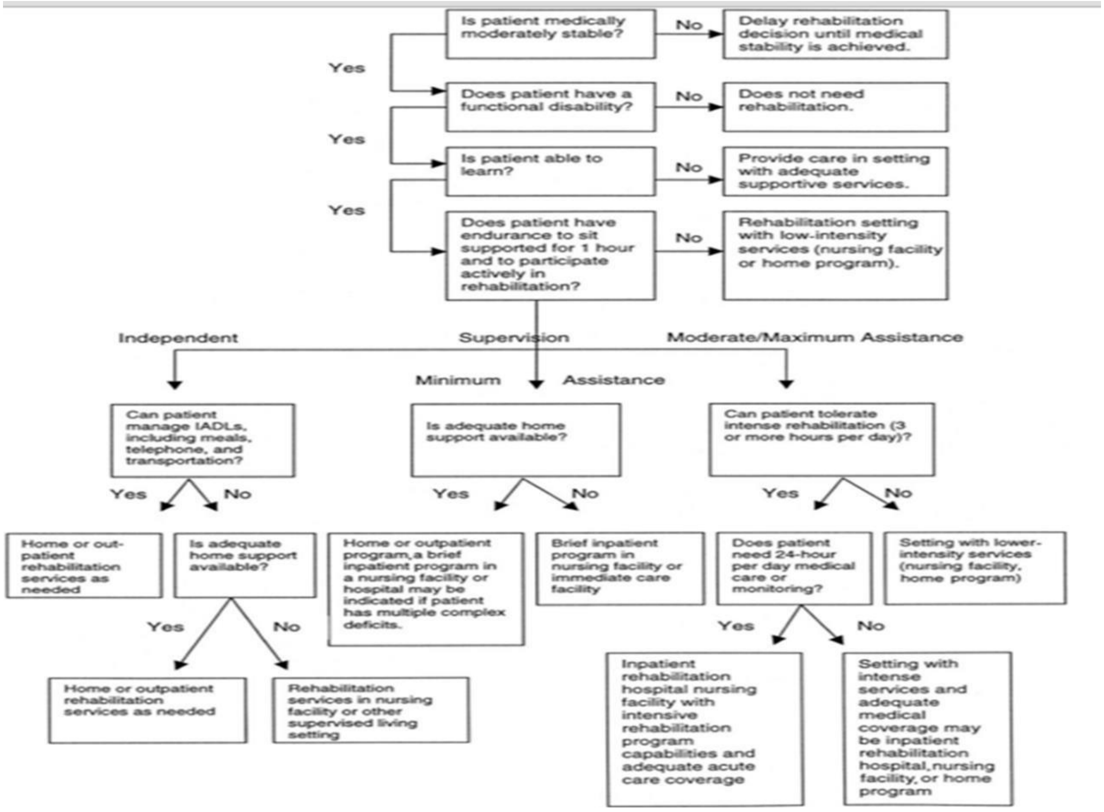


Figure 6.1: Block diagram improvement of orientation and mobility

6.3 REHABILITATION AIDS FOR MENTALLY IMPAIRED

Figure 6.2: Mentally impaired

6.4 SLEEPING AIDS

Figure 6.3: sleeping aids

6.5 SEATING

Figure 6.4: chair mobile

a) Head: Wider contoured headrest providing greater lateral support.

b) Trunk: Contoured shoulder pad increases back height by 75mm. Back height adjustment knob changed to ratchet handle. Improved tray locking mechanism. Padded grab rail can be used instead of tray in buggies.

c) Pelvis: Pelvic harness attachment points and webbing reinforced to cater for kids with strong extensor patterns. More width adjustment on hip laterals +40mm (260mm max).

d) Legs and Feet: Additional lateral padding at knees, up to 30mm both sides. Helps prevent low tone kids' legs from abducting – accessory only. Minimum on seat to footplate height reduced to 122.5mm (from 160mm).

e) Chassis: 10 degrees extra tilt-in-space on Hi-low chassis, giving 30º recline.

Figure 6.5: types of seating

6.6 WALKING AND POSTURAL AIDS

As a child grows out of the popular Squiggles Stander, their standing therapy can continue with the Mygo Stander as it encourages a natural standing posture with improved function.

Figure 6.6: walking

A seat option that can be used as needed and won't drop down as the child moves forward. Kids and parents like it because it's sporty and fun. Therapists like it because of its endless options for adjustment.

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