Clinical application of Prosthesis and Orthosis

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Acknowledgments:

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توصيف مقرر دراسى

		1- بيانات المقرر
الفرقة /المستوى :	**اسم المقرر : Clinical application of Prosthetics and Orthotics**	**الرمز الكودى :**
عملى 2	**نظرى 3** **عدد الوحدات الدراسية :**	**التخصص :**

1. To provide a core body of scientific knowledge concerning the disorders commonly encountered by the prosthetist/orthotist with an emphasis on those in the fields of internal medicine, neurology and neuromuscular orthopedic disorders. 2. Acquire an appropriate functional background of examining orthopedic disorders. 3. Integrate basic knowledge with prosthetic and orthotic interventions to improve diagnostic skills. 4. Develop the basic scientific research background.	**2- هدف المقرر:**
	3- المستهدف من تدريس المقرر :
By the end of the course, students should be able to: 1. Recognize basic pathological processes that underlie different orthopedic diseases of spine, upper limbs and lower limbs. 2. Identify pathologies underlying myopathies, neuromuscular junction defects, peripheral neuropathies, plexopathies, radiculopathy, disorders of the spinal cord, basal ganglia, cerebellum, and cortex. 3. Discuss the pathophysiology of abnormalities present at birth. 4. Outline both medical and prosthetic/orthotic treatment of these conditions. 5. Describe and contrast the etiology and progression of diseases. 6. Identify early signs and symptoms of conditions commonly encountered by orthotists and prosthetists. 7. Understand basic surgical technique and post-surgical care.	**ا. المعلومات والمفاهيم :**
By the end of the course the candidate will be able to: 1- Describe the pathological processes that underlie different medical, neurological and orthopedic diseases. 2-Comprehend the pathophysiology of abnormalities present at birth. 3- Relate the early signs and symptoms of conditions commonly encountered by orthotists and prosthetists. 4- Design orthotic and prosthetic for different pathological cases 5-Formulate management plan for different insults in relation to prosthesis and orthosis	**ب- المهارات الذهنية :**
By the end of the course the candidate will be able to: 1- Apply knowledge of basic pathological processes to explain the aetiology, pathogenesis, structural and functional manifestations of diseases encountered in clinical practice. 2- Plan appropriate care and treatment options	**ج- المهارات المهنية الخاصة بالمقرر:**

3- Interpret clinical findings in relation to pathophysiological basis.	
By the end of the course the candidate will be able to: 1- Maintain honesty and integrity in all interactions with teachers, colleagues, patients and others with whom technicians must interact in their professional lives. 2- Recognize the scope and limits of their role as students as well as the necessity to seek and apply collaboration with other workers. 3- Be responsible towards work. 4- Maintain a professional image concerning behaviour, dress and speech. 5- Work in study group 6-Benefit from e-learning 7- Perform case presentations 8- Self-evaluation and learning 9- Uses various sources to acquire medical knowledge	د- المهارات العامة :
Course will include the following topics in relation to Prosthesis and Orthosis **1- the clinic team** **2- amputation surgery** **3- demyelination disorders** **4- skin disorders;** **5- foot disorders and chiropody** **6- upper motor neurone disorders** **7- lower motor neurone disorders** **8- abnormalities present at birth** **9- peripheral vascular disease** **10-age related disabilities** **11- spinal injuries** **12-fracture treatment** **13-joint and skeletal disorders** **14-patient handling and safe movement**	4- محتوى المقرر:

1- Lectures 2- Tutorials 3- Practical (in physical medicine clinic and workshops)	5- أساليب التعليم والتعلم
If we have to accept these students, students must be able to use his hands and have proper vision, and moderate IQ. If so the normal teaching methods could be used	6- أساليب التعليم والتعلم للطلاب ذوى القدرات المحدودة
	7- تقويم الطلاب :
a. Class work: 1. Quizzes 2. Midterm theoretical 3. Practical Quiz b. Final exam: Theoretical and practical	أ- الأساليب المستخدمة
a. Class work:	ب- التوقيت

1. Quizzes: Quiz I (4th week) Quiz II (11th week) 2. Midterm theoretical (7th week) b. Final exam Practical exam (13th week)	
Quizzes (7%), 10 marks Midterm theoretical (7%), 10 marks Final Practical exam (26%), 40 marks Final written theoretical exam (60%), 90 marks. Total percentage 100%	ج- توزيع الدرجات
	8- قائمة الكتب الدراسية والمراجع :
Lecture and practical notes for clinical application of prostheses and orthoses	أ- مذكرات

1- Joan Edelstein and Alex Moroz, Lower limb prosthetics and Orthotics Clinical concepts. 2010 1st edition, Slack incorporated 2- Michelle Lusardi, Orthotics and Prosthetics in Rehabilitation, 2006, Butterworth-Heinemann	ب- كتب ملزمة
1-Randall L. Braddom, Physical Medicine and Rehabiliation , 2010 4th edition, Saunders 2-John H. Bowker. Atlas of limb prosthetics: surgical, prosthetic, and rehabilitation principles. American Academy of orthopedic surgeons, Mosby Year book	ج- كتب مقترحة
https://www.oandp.org Journal of Prosthetics and Orthotics	د- دوريات علمية أو نشرات الخ ......

Contents

Course Description

5. This course will provide a core body of scientific knowledge concerning the disorders commonly encountered by the prosthetist/orthotist with an emphasis on those in the fields of internal medicine, neurology and neuromuscular orthopedic disorders. The student will acquire an appropriate functional background of examining various disorders.
The student Integrate basic knowledge with prosthetic and orthotic interventions to improve diagnostic skills.

Core Knowledge and Understanding

By the end of this course, students should be able to:

- Recognize basic pathological processes that underlie different orthopedic diseases of spine, upper limbs and lower limbs.
- Identify pathologies underlying common neuromuscular disorders
- Discuss the pathophysiology of abnormalities present at birth.
- Outline both medical and prosthetic/orthotic treatment of these conditions.
- Describe and contrast the etiology and progression of diseases.
- Identify early signs and symptoms of conditions commonly encountered by orthotists and prosthetists.
- Understand basic surgical technique and post-surgical care

Core Intellectual Skills

By the end of this course, students should be able to:

- Describe the pathological processes that underlie different medical, neurological and orthopedic diseases.
- Comprehend the pathophysiology of abnormalities present at birth.
- Relate the early signs and symptoms of conditions commonly encountered by orthotists and prosthetists.
- Design orthotic and prosthetic for different pathological cases
- Formulate management plan for different insults in relation to prosthesis and orthosis

Core Professional Skills

By the end of this course, students should be able to:

- Apply knowledge of basic pathological processes to explain the aetiology, pathogenesis, structural and functional manifestations of diseases encountered in clinical practice.
- Plan appropriate care and treatment options
- Interpret clinical findings in relation to pathophysiological basis.

General and transferable Skills

By the end of the course the candidate will be able to:

- Maintain honesty and integrity in all interactions with teachers, colleagues, patients and others with whom technicians must interact in their professional lives.
- Recognize the scope and limits of their role as students as well as the necessity to seek and apply collaboration with other workers.
- Be responsible towards work.
- Maintain a professional image concerning behaviour, dress and speech.
- Work in study group
- Benefit from e-learning
- Self-evaluation and learning
- Uses various sources to acquire knowledge

Course Overview

ID	Topics	*Methods of Teaching/Training with Number of Total Hours per Topic*				
		Interactive Lecture	workshop	Class Assignments	Research	Lab
1	Multidisciplinary team	3	3			
2	Amputation surgery and complications	3	3			
3	Neuromuscular disorders and orthoses	9	6			
4	**Foot disorders and chiropody**	6	3			
5	Abnormalities present at birth	6	3			
6	Spinal disorders	3	3			
7	Peripheral vascular disease (including diabetes)	6	3			
	TOTAL HOURS(60)	**36**	24			

Chapter 1

Prosthesis and Orthosis and the clinic team, and patient handling and safety

Objectives

- Introduction to idea of a multidisplinary team
- Recognizing importance of an orthotist and prosthetic as a member of team
- Different approaches addressed to help patients

Introduction

What is an Orthotist?

•Orthotists are autonomous registered practitioners who provide gait analysis and engineering solutions to patients with problems of the neuro, muscular and skeletal systems. They are extensively trained at undergraduate level in mechanics, biomechanics, and material science along with anatomy, physiology and pathophysiology. Their qualifications make them competent to design and provide orthoses that modify the structural or functional characteristics of the patients' neuro-muscular and skeletal systems enabling patients to mobilise, eliminate gait deviations, reduce falls, reduce pain, prevent and facilitate healing of ulcers.

•They treat patients with a wide range of conditions including Diabetes, Arthritis, Cerebral Palsy, Stroke, Spina Bifida, Scoliosis, MSK, sports injuries and trauma.

•Whilst they often work as autonomous practitioners they increasingly often form part of multidisciplinary teams such as within the diabetic foot team or neuro-rehabilitation team.

What is an Orthosis?

“An externally applied device used to modify the structural or functional characteristics of the neuro-muscular-skeletal system”

(International Standards Organisation, 1981)

An orthosis accomplishes its purpose by applying a force to a part of the body. The force may be required to help support weight or to maintain body parts in alignment. The forces applied may help to control the range and rate of the body components.

Functions of Orthoses:

•Limit Movement

•Correct Deformity

•Assist Movement

•Protection

Therefore…The Orthosis: –Protects a body part –Supports a body part –Alters the presentation of abnormal biomechanics

Benefits of Orthotics

•Orthotics services play an essential role in enabling quality of life for people with long term conditions, disabilities and limb loss

•Being able to access the right orthotics equipment, quickly, and with appropriate support, is of paramount importance

•"*Orthotic provision has the potential to achieve significant health, quality of life and economic benefits for the NHS if a comprehensive, integrated service can be provided,* *throughout the patient pathway. Service planning and contracting arrangements which emphasize the delivery of an integrated and comprehensive orthotic service are more likely to achieve the benefits to the NHS identified in the many reports."*

•*Early orthotic intervention improves lives and saves money*

•The provision of orthotics has a beneficial impact on a range of clinical conditions by relieving pain, increasing mobility, protecting tissues and promoting healing along with a whole host of other benefits including improved independence and self-image

•The range of clinical conditions benefiting from orthotics includes chronic diseases and trauma as well as neurological, musculoskeletal and congenital conditions. A number of these remain as policy priorities for the Government and the NHS, All-Party Associate Parliamentary Limb Loss Group, 2014: Patient Led Orthotic Services Patients Charter

•Commissioners and managers should be aware of the positive impact that orthotics services can have on commissioning priorities such as the reduction of hospital admissions, accident and emergency (A&E) attendances and prevention of complications from diabetes, peripheral vascular disease and cancer

•Appropriate orthotic management of patients with these conditions can delay and reduce the need for more expensive and complex treatment and the need for surgery

•In addition, there are also benefits to wider health and social care priorities including promoting well-being and supporting independence in the community, for example by reducing the probability of falls in frail, older patients and keeping them mobile and independent reducing the need for social care. All of which contribute to reducing inequity

What is a Prosthetist?

•Prosthetists are autonomous registered practitioners who provide gait analysis and engineering solutions to patients with limb loss.

•They are extensively trained at undergraduate level in mechanics, bio-mechanics, and material science along with anatomy, physiology and pathophysiology.

•Their qualifications make them competent to design and provide prostheses that replicate the structural or functional characteristics of the patients absent limb.

•They treat patients with congenital loss as well as loss due to diabetes, reduced vascularity, infection and trauma.

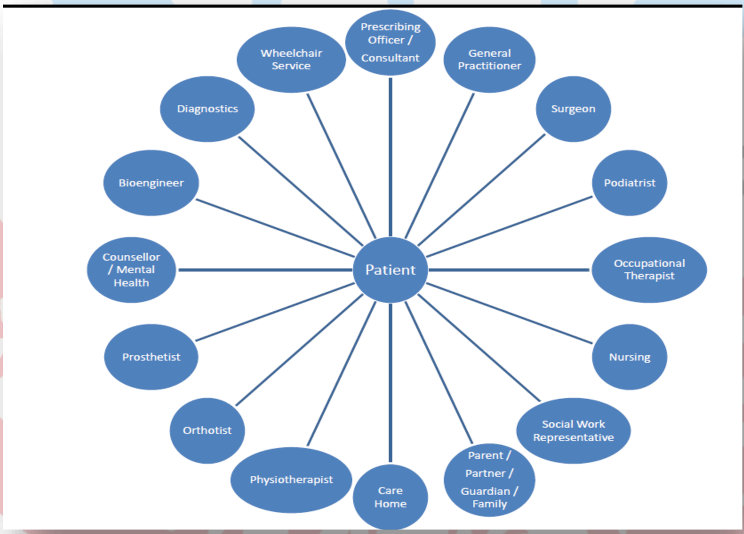
•Military personnel are forming an increasing part of their caseload. Whilst they are autonomous practitioners they usually work closely with physiotherapists and occupational therapists as part of multidisciplinary amputee rehabilitation teams.

Multi-Disciplinary Team

•Both Orthotists and Prosthetists are members of the Multi-Disciplinary Clinical Team, the collective responsibility of which is to effect the care and rehabilitation of the patient

•The team will ideally include all parties who have a direct input to the needs of the patient, which will vary from patient to patient

•An ideal clinical team consists of the following



Allied health professionals work in health care settings to meet the physical rehabilitation needs of diverse patient populations. Today's health care environment strives to be patient-centered and advocates the use of best practice models that maximize patient outcomes while containing costs. The use of evidence-based treatment approaches, clinical practice guidelines, and standardized outcome measures provides a foundation for evaluating and determining efficacy in health care across disciplines. The World Health Organization International Classification of Functioning, Disability, and Health (ICF) provides a disablement framework that enables health professionals to maximize patient/client participation and function while minimizing disability. In this complex environment, current and evolving patterns of health care delivery focus on a team approach to the total care of the patient.

For a health care team to function effectively, each member must develop a positive attitude toward interdisciplinary collaboration. The collaborating health professional must understand the functional roles of each health care discipline within the team and must respect and value each discipline's input in the decision-making process of the health team.

Rehabilitation, particularly when related to orthotics and prosthetics, lends itself well to interdisciplinary teams because the total care of patients with complex disorders requires a wide range of knowledge and skills.

The physician, prosthetist, orthotist, physical therapist, occupational therapist, nurse, and social worker are important participants in the rehabilitation team. Understanding the roles and professional responsibilities of each of these disciplines maximizes the ability of the rehabilitation team members to function effectively to provide comprehensive care for the patient.

Persons coping with illness, injury, disease, impairments, and disability often require special orthotic and prosthetic devices to help with mobility, stability, pain relief, and skin and joint protection. Appropriate prescription, fabrication, instruction, and application of the orthotic and prosthetic devices help persons to engage in activities of daily living as independently as possible.

Prosthetists and orthotists are allied health professionals who custom-fabricate and fit prostheses and orthoses. Along with other health care professionals, including nurses, physical therapists, and occupational therapists, prosthestists and orthotists are integral members of the rehabilitation teams responsible for returning patients to productive and meaningful lives.

Definitions of disability continue to evolve. Current definitions consider social, behavioral, and environmental factors that affect the person's ability to function in society..

Good Practice of Prosthetist and Orthotist:

•Pertinent fields of knowledge required by the Orthotist and Prosthetist include normal anatomy, pathological anatomy, physiology, joint orientation, cause and effect of distortion.

•Good orthotic and prosthetic practice includes the following;

1.Problem Identification

2.Accurate Prescription

3.Documentation

4.Orthotic/Prosthetic Design and Fabrication

5.Material science

6.Biomechanics/pathomechanics
7.Engineering
8.Accurate Fitting
9.Effective Evaluation
10.Effective Follow-up Procedures

Prosthetic and orthotic professional roles and responsibilities

Patient examination, evaluation, education, and treatment are now significant responsibilities of practitioners. Most technical tasks are completed by technicians who work in the office or in the laboratory, or at an increasing number of central fabrication facilities. The advent and availability of modifiable prefabrication systems have reduced the amount of time that the practitioner spends crafting new prostheses and orthoses. In order to address the rehabilitation needs of individuals who will benefit from the art and science of the fields of prosthetics and orthotics, physical therapists, orthotists, prosthetists, and other members of the health care team must have discreet knowledge and skills in the management of persons with a variety of health conditions across the lifespan. Working as a rehabilitation team, physicians, nurses, prosthetists, orthotists, physical therapists, occupational therapists, social workers, patients, and family members seek to maximize function and alleviate disease, injury, impairments, and disability.

Disablement frameworks

Historically, disability was described using a theoretical medical model of disease and pathology. Over time, various conceptual frameworks have been developed to organize information about the process and effects of disability. Disablement frameworks in the past have been used to understand the relationship of disease and pathology to human function and disability. The need to understand the impact that acute injury or illness and chronic health conditions have on the functioning of specific body systems, human performance in general, and on the typical activities of daily living from both the individual and a societal perspective has been central to the development of the disablement models. The biomedical model of pathology and dysfunction provided the conceptual framework for understanding human function, disability, and handicap as a consequence of pathological and disease processes.

The Nagi model was among the first to challenge the appropriateness of the traditional biomedical model of disability. Nagi developed a model that looked at the individual in relationship to the pathology, functional limitations, and the role that the environment and society or the social environment played. The four major elements of Nagi's theoretical formulation included active pathology (interference with normal processes at the level of the cell), impairment (anatomical, physiological, mental, or emotional abnormalities or loss at the level of body systems), functional limitation (limitation in performance at the level of the individual), and disability. Nagi defined disability as "an expression of physical or mental limitation in a social context." The Nagi model was the first theoretical construct on disability that considered the interaction between the individual and the environment from a sociological perspective rather than a purely biomedical perspective. Despite the innovation of the Nagi model in the 1960s, the biomedical model of disability persisted.

In 1980, the World Health Organization (WHO) developed the International Classification

of Impairments, Disabilities, and Handicaps (ICIDH) to provide a standardized means of classifying the consequences of disease and injury for the collection of data and the development of social policy. This document provided a framework for organizing information about the consequences of disease. However, it focused solely on the effects of pathological processes on the individual's activity level. Disability was viewed as a result of an impairment and considered a lack of ability to perform an activity in the normal manner. In 1993, the WHO began a revision of ICIDH disablement framework that gave rise to the concept that a person's handicap was less related to the health condition that created a disadvantage for completing the necessary life roles but rather to the level of participation that the person with the health condition was able to engage in within the environment. The concept of being handicapped was changed to be seen as a consequence of the level of participation for the person and the interaction within an environment.
The Institute of Medicine enlarged Nagi's original concept in 1991 to include the individual's social and physical environment. This revised model describes the environment as "including the natural environment, the built environment, the culture, the economic system, the political system, and psychological factors." In this model, disability is not viewed as a pathosis residing in a person but instead is a function of the interaction of the person with the envir

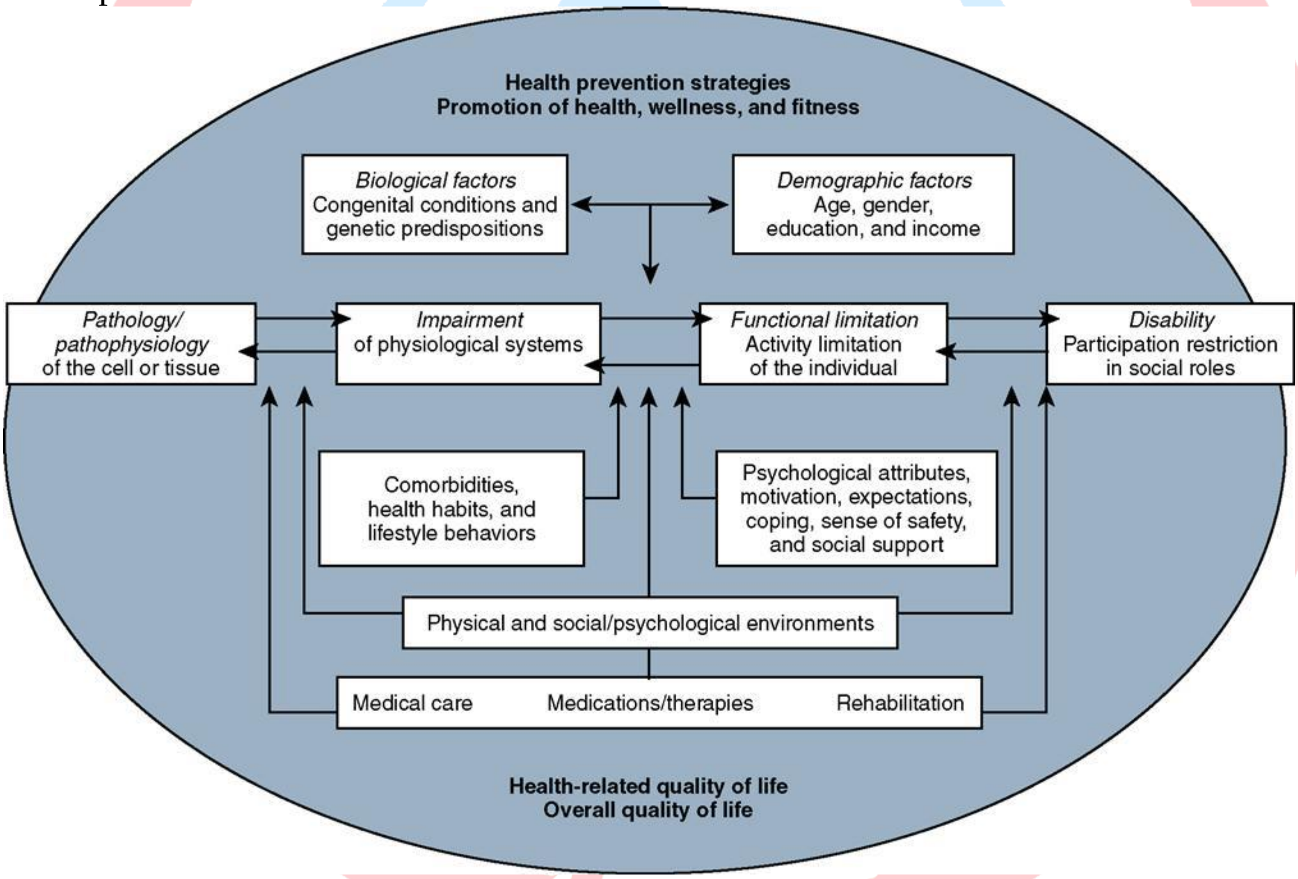


Fig 1 The revised Institute of Medicine/Nagi model of the disablement process considers the impact of pathological conditions and impairment as well as intraindividual and extraindividual factors that may influence functional limitation and disability affecting health-related and overall quality of life. (Modified from Guccione AA: Arthritis and the process of disablement. *Phys Ther* 1994;74[5]:410.)

In 2001, ICIDH was revised to ICIDH-2 and renamed "International Classification of Functioning, Disability and Health" and is commonly referred to as ICF.The ICF disablement framework includes individual function at the level of body/body part, whole person, and whole person within a social context. The model helps in the description of changes in body function and structure, what people with particular health conditions can do in standard environments (their level of capacity), as well as what they actually do in their usual environments (their level of performance). One of the major innovations of the ICF model is the presence of an environmental factor classification that considers the role of environmental barriers and facilitators in the performance of tasks of daily living.

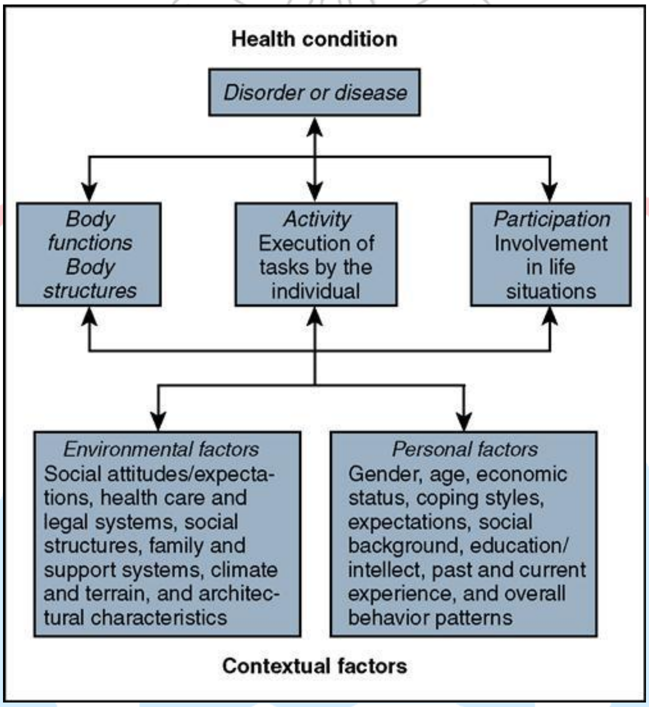


Fig 2 WHO uses a biopsychosocial model as the basis for its International Classification of Functioning, Disability and Health. (Modified from World Health Organization. *Towards a Common Language for Functioning, Disability and Health*. Geneva: World Health Organization, 2002. pp. 9-10.)

Chapter 2
Amputation Surgery and complications

Objectives

- Identifying preoperative considerations of amputation
- Complications encountered following amputation
- Skin disorders associated with amputation

Introduction

Planning for Optimal Function in Amputation Surgery

Although most surgeons consider amputation to be the ultimate surgical failure, a well-planned and executed amputation can remove a painful, dysfunctional limb and allow rehabilitation with a prosthetic limb to a functional, painless state.

Amputation surgeons must recognize the global problems associated with amputation surgery. In the United States, the most common reason for lower-limb amputation is peripheral vascular disease. Oftentimes, these patients have the same process in the contralateral limb, as well as coronary artery and cerebral vascular disease. Several series of dysvascular amputees in the 1960s and 1970s reported contralateral limb amputation rates of 15% to 28% within 3 years of the initial amputation and a 50% mortality rate during the same time period. Despite significant improvements in the care of the dysvascular amputee (diabetic management, nutrition, antibiotic management, vascular reconstructive procedures, etc.) the contralateral limb amputation rate and long-term survival rates have not significantly changed.

The role of the amputation surgeon involves much more than the actual surgical procedure. The initial, most basic decision is whether to proceed with amputation or to attempt limb salvage. Advances in trauma management such as arterial and venous repairs, bony stabilization, and free-tissue transfers have resulted in limb salvage in severely traumatized limbs that previously would have been amputated. Improvements in adjunctive chemotherapy and surgical technique have allowed en bloc resection of certain bony tumors and limb salvage with either custom prosthetic implants or allograft replacement.

Once an amputation is decided upon, preoperatively the most distal level of amputation compatible with wound healing and subsequent satisfactory prosthetic fitting should be determined by clinical evaluation and laboratory evaluation. The environment for wound healing should be maximized by evaluating the patient's nutritional status, control of diabetics' blood glucose, and the use of antibiotics in infected patients. Appropriate surgical technique should be utilized to produce an acceptable stump for subsequent prosthetic fitting. Postoperatively, appropriate judgment should determine prosthetic candidacy in elderly dysvascular amputees.

Modern amputee management involves a multidisci-plinary approach to address the global problems (medical, surgical, social, rehabilitative, and economic) involved in amputees. Planning for optimal function in amputation surgery should consist of preoperative, operative, and postoperative considerations.

PREOPERATIVE CONSIDERATIONS

Amputation vs. Limb Salvage

Trauma

Modern advances in trauma management such as fracture stabilization and free-tissue transfers have allowed salvage in limbs that previously would have been amputated. In addition, several series have shown that there is significant morbidity, increased economic cost, and psychological effects involved in limb salvage in severely traumatized limbs.

Peripheral Vascular Disease

The largest number of amputations done are for peripheral vascular disease. As the population ages, more patients will be evaluated for dysvascular disease in lower limbs. Oftentimes, early amputation at the most distal level possible and rehabilitation with a prosthesis offer the best solution for a painful, dysvascular limb. However, before undergoing amputation, many of these patients should be evaluated for consideration for vascular reconstructive procedures that may allow either limb salvage or a more distal amputation level.

Vascular reconstruction in limbs at risk for amputation may have some drawbacks. Arterial reconstructive surgery is expensive and may delay eventual definitive treatment,and the outcome is uncertain. However, several series have demonstrated no adverse effect of failed vascular reconstructive procedures on the ultimate level of amputation or clinical outcome.

The vast majority of lower-limb amputations for peripheral vascular disease occur in diabetics. Often diabetics with dysvascular disease are thought to have "small-vessel disease" not treatable with vascular reconstructive procedures. In addition, multiple series have demonstrated that when modern techniques of vascular reconstructive surgery are applied to diabetics, long-term limb salvage rates are comparable to nondia-betics treated in a similar manner.Therefore, diabetics should not be automatically excluded for consideration for vascular reconstructive procedures in limb-threatening conditions.

Tumors

The field of musculoskeletal oncology is rapidly evolving. In the 1960s and early 1970s, 5-year survival rates for patients with osteogenic sarcoma were in general less than 20%.The advent of more sophisticated radiographic preoperative staging and the use of preoperative and postoperative adjunctive chemotherapy have improved 3-year survival rates in osteogenic sarcoma to 60% to 85% in some studies.En bloc resection of osteosarcomas and limb salvage with either customized orthopedic implants or allograft implantation has been developed in the last decade.Several institutions report similar overall survival rates of patients who underwent primary amputation and of those who underwent segmental limb resection.Survival rates may actually be improved in those patients who undergo an en bloc resection because the patients selected for this treatment are likely to have more limited disease.

Site of Amputation

Before World War II, the majority of lower-limb amputations were transfemoral because such procedures yielded healing rates approaching 100% in ischemic limbs. In the 1960s and early

1970s, several factors combined to reverse the ratio of transfemoral to trans-tibial amputations. The use of a long posterior myofasciocutaneous flap in dysvascular patients, with its increased blood supply, improved the success rate in transtibial amputations. In addition, the development of preoperative objective criteria for amputation site viability allowed more distal amputations to be done.

Lower-limb amputations in the dysvascular patient should be performed at the most distal site compatible with wound healing to achieve the optimal potential for ambulation. Several well-documented studies have shown that energy expenditure with prosthetic ambulation is markedly increased in more proximal amputations. Waters and coworkersfound that energy expenditure during ambulation, as measured by oxygen consumption per kilogram of body weight per meter traveled, was significantly increased in transfemoral amputees vs. transtibial amputees. Reviews found that lower-limb amputees expend more energy (kilocal-ories per meter) in ambulation than do non-amputees and have a compensatory decrease in gait velocity. They also showed that oxygen consumption during ambulation was increased 9% in transtibial amputees, 49% in transfemoral amputees, and 280% in bilateral transfemoral amputees when compared with nonamputees.

Preservation of the knee joint has even more significance when the rate of contralateral limb amputation is considered. Ambulation ability in bilateral amputees is, of course, less than in unilateral amputees. For geriatric patients with bilateral transfemoral amputations, ambulation is probably not feasible in most cases, and wheelchair locomotion is indicated. In contrast to some older reports, recent studies have demonstrated the enhanced ambulation potential of patients with at least one knee joint preserved as compared with patients having bilateral trans-femoral amputations. However, in elderly debilitated patients with limited or no ambulatory potential, knee disarticulation or transfemoral amputation is preferable to transtibial amputation to prevent knee flexion contractures and subsequent breakdown of the stump.

Various methods have been developed to objectively determine the most distal level at which amputation is likely to be successful. Clinical parameters such as the lowest palpable pulse, skin temperature, and bleeding at surgery have been used with varying success to predict healing of amputation sites.The use of Doppler ultrasonography to measure arterial blood pressure at the proposed amputation site has been advocated as a predictor of amputation success.

However, there are inconsistencies with Doppler determinations of the amputation site. A calcified, non-compressible artery will give falsely elevated values. In addition, the pressure in a deep artery may not correlate with skin healing. Authors also suggest that the segmental arterial pressure in diabetics is not always helpful in preoperative determination of amputation levels.

Two methods use clearance of ^{133}Xe to measure dermal vascularity. In one method, cutaneous diastolic pressure is estimated by determining the applied pressure necessary to stop clearance of intradermally injected ^{133}Xe.

Measurement of transcutaneous Po_2 is another method of determining the amputation level. It is not invasive This method involves warming the skin to 44°C with a heated electrode, which then measures the oxygen emanating from the skin. This method is based on the fact that the oxygen tension measured over locally warmed skin reflects the metabolic and perfusion capabilities of the skin and hence its healing potential

Other preoperative methods of determining amputation level such as fluorescein angiography, skin temperature measurements, and pulse volume recordings have been used. Recently, laser Doppler velocimetry has been used to assess the viability of amputation levels.

Preoperative measurements to determine amputation level are more beneficial in predicting failure than in predicting success. Factors such as alteration in collateral circulation, decreased distal vascular runoff as a result of surgery, surgical technique, the nutritional status of the patient, infection, concomitant medical illnesses, and postoperative care cannot be assessed in the preoperative period. However, preoperative laboratory assessment of the amputation level does give an indication whether adequate circulation exists for a favorable outcome.

Nutrition

The significant incidence of malnutrition in hospitalized patients has been well documented. Patients undergoing lower-limb amputations are often elderly and debilitated. In addition, diabetics with dysvascular limbs often have open wounds and systemic sepsis causing increased metabolic demands.

Protein malnutrition has an adverse effect on morbidity and mortality in hospitalized patients.The cell-mediated and humoral immune systems are impaired with resultant decreased host resistance..

Trauma or infection increases energy requirements 30% to 55% from basal values. Patients undergoing a semielective lower-limb amputation should undergo at least a baseline nutritional assessment, including a serum albumin determination and total lymphocyte count. If the initial values are abnormal (serum albumin <3.4 g/dL or a total lymphocyte count of < 1,500 cells per cubic millimeter), then a more formal assessment should be done. There have been no prospective series to demonstrate decreased mortality or morbidity in malnourished patients treated with nutritional supplementation before amputation. However, if time permits, enteral or intravenous hyperalimentation should be considered in a malnourished patient being evaluated for amputation.

Antibiotics

The use of antibiotics as prophylaxis in orthopedic surgery, especially surgery involving implants, is well established. The use of antibiotics as prophylaxis in patients undergoing lower-limb amputation is less well defined. In cases of open, draining wounds or gas-forming infection, the use of antibiotics in the perioperative period is mandatory.

Most lower-limb amputations for dysvascular disease in the United States are in diabetic patients. In neurotrophic ulcers in diabetes mellitus, the infection is usually polymicrobial, including both anaerobic and aerobic species. Therefore, broad-spectrum antibiotics should be used initially until specific organisms are recovered in culture.

In cases of systemic sepsis or severely infected limbs, a preliminary guillotine amputation is done. Parenteral antibiotic therapy is continued until the sepsis is quiescent, at which time the definitive amputation is done. In cases of noninfected dysvascular amputations, prophylactic antibiotic therapy (usually a first-generation cephalosporin) is begun at the time of surgery and continued for 48 hours following the amputation.

Diabetes

Five out of six major lower-limb amputations are done in diabetics. Although previously it was believed that diabetics were doomed to an amputation in a dysvascular limb, several series have shown equivalent results with vascular reconstructive procedures in diabetics and nondiabetics. However, there are problems unique to diabetics that require consideration that will be discussed in a later chapter.

OPERATIVE CONSIDERATIONS

In order to enhance the potential for prosthetic ambulation following lower-limb amputation, the amputation surgeon must apply appropriate surgical technique to allow wound healing at the

most distal amputation site possible. This involves, especially in dysvascular patients, handling soft tissue in a nontraumatic manner. Therefore, tissue forceps should be avoided in handling the skin in these patients.
As already described, it is important to salvage the most distal amputation site feasible (transtibial vs. transfemoral amputations) in potential prosthetic ambulators. It has been defined the stump as being long if it is 50% of the length of the remaining contralateral leg, medium if 20% to 50% the length the contralateral leg, and short if less than or equal to 25% of the length of the contralateral limb. They found oxygen consumption during ambulation to be 10% higher in amputees with long stumps and 40% higher in amputees with short stumps when compared with nonampu-tees. Modern management of soft-tissue injuries such as free-muscle transfers and tissue expanders has allowed salvage of longer amputation stumps in trauma. Large skin defects can be covered by utilization of viable skin from amputated parts.
Grossly contaminated traumatic wounds and some infected dysvascular limbs with gangrene should not be closed primarily following amputation. In general, skin traction should not be used, especially in dysvascular amputees. Delayed primary closure, split-thickness skin grafting, or free-muscle transfer can be done when local sepsis is diminished.
In addition to the goal of obtaining the most distal amputation site possible, the stump should have sufficient soft-tissue coverage to resist the shear forces involved in prosthetic ambulation. Weight bearing occurs at the distal part of the stump in transfemoral amputations and knee disarticulations. Painful neuromas should be avoided at the site of weight bearing by sharply dividing nerves and allowing their retraction into sufficient soft-tissue cover.

POSTOPERATIVE CONSIDERATIONS

In the immediate postoperative period, amputation stumps should be splinted with well-padded rigid dressings to prevent joint contractures. The use of an immediate postoperative prosthesis (IPOP) has been advocated to allow early prosthetic ambulation, decrease stump edema, and diminish postamputation depression. However, others have found significant wound problems with IPOP. In general, IPOP should probably be reserved for young, traumatic amputees.
The most basic decision following wound healing in amputees is determination of appropriate candidacy for prosthetic ambulation. The presence of coronary artery disease in transfemoral amputees precluded prosthetic ambulation, presumably because of insufficient cardiac reserve for the increased energy demands of prosthetic ambulation.
An overall assessment of the lower-limb amputee should be done prior to prosthetic fitting. The patient's social situation should be evaluated. Such factors as impaired vision from diabetic retinopathy, poor balance from concomitant cerebral vascular accidents, significant psychological problems, or additional musculoskeletal problems such as rheumatoid arthritis should be considered prior to prosthetic fitting. In an elderly, dysvascular lower-limb amputee with significant coronary artery disease, optimum planning in amputation surgery may involve wheelchair locomotion, which has been shown to be equivalent in energy expenditure to normal bipedal gait.
The amputee rehabilitation program should ideally be designed to cover the wide spectrum of care from pre-amputation to reintegration into the community.

Energy expenditure and functional level:

Energy cost and speed of ambulation among lower extremity amputees compared to normal subjects :

As seen in Table 1 energy expenditure should be considered when prescribing a prosthesis according to patient's physical condition

Table 1

Walking parameter	TT	TT+TT	TF+crutch	TF	TT+TF	TF+TF
% increase in Ee/unit distance	23	41	92	99	118	186
% decrease in CWS	20	20	51	51	56	60

TT- transtibial, TF- Trans femoral, Ee/unit distance- energy expenditure per unit distance, CWS- comfortable walking speed= 80m/min *Ganzalez et al, 2001*

To determine the patients potential for using lower limb prosthesis careful assessment of functional level should be carried out using the Medicare prosthetic K levels. When determining functional level we can determine type and components of prosthesis to use.

Table 2: Lower limb extremity prosthesis Medicare Functional Classification Levels (K levels)

Level 0:	Does not have the ability or potential to ambulate or transfer safely with or without assistance and a prosthesis does not enhance their quality of life or mobility
Level 1:	Has the ability or potential to use a prosthesis for transfers or ambulation on level surfaces at fixed cadence. Typical of the limited and unlimited household ambulator.
Level 2:	Has the ability or potential for ambulation with the ability to traverse low level environmental barriers such as curbs, stairs, or uneven surfaces. Typical of the limited community ambulator.
Level 3:	Has the ability or potential for ambulation with variable cadence. Typical of the community ambulator who has the ability to traverse most environmental barriers and may have vocational, therapeutic, or exercise activity that demands prosthetic utilization beyond simple locomotion.
Level 4:	Has the ability or potential for prosthetic ambulation that exceeds basic ambulation skills, exhibiting high impact, stress, or energy levels. Typical of the prosthetic demands of the child, active adult, or athlete.

Complications following amputation:

As with any surgery, having an amputation carries a risk of complications. Surgeons will aim to reconstruct the limb to the best of their ability, taking into account soft tissue viability, bone length and other anatomical considerations. However, underlying disease state and post-operative management can result in complications, the most common of which are:

1-**Oedema**

Stump oedema occurs as a result of trauma and the mishandling of tissues during surgery. After the amputation, there is an imbalance between fluid transfer across the capillary membranes and lymphatic reabsorption. This, in combination with reduced muscle tone and inactivity, can lead to stump oedema. The complications that can arise from stump oedema include wound breakdown, pain, reduced mobility and difficulties with prosthetic fitting .

Numerous interventions are used to manage and prevent post-operative stump oedema, including compression socks, rigid removable dressings, exercise, wheelchair stump boards. The use of rigid removable dressings where expertise, time and resources alloware essential. Stump boards, and compression socks have some evidence for oedema control but it is not their main function.

2-Wounds and Infection

Surgical site infection after amputation is common and as well as increasing patient morbidity, can have negative effects on healing, phantom pain and time to prosthetic fitting. Risk factors for a stump infection include diabetes mellitus, old age and smoking, which are all common denominators amongst the amputee population. The decision to insert a drain and use clips instead of sutures is also associated with an increased infection risk.

The potential consequences of infection include vac therapy, wound debridement and revision surgery. This can increase hospital length of stay and the risk of secondary morbidities such as pneumonia or reduced function. Wounds should be inspected regularly so that any signs of infection can be detected.

The wound may also open up along the surgical line (dehiscence). This happens when the wound is not strong enough to resist the forces placed on it and could result in muscle and bone being exposed. These forces include a direct fall (most common), trauma, or shearing. Other causes may include removing the sutures too soon or swelling of the residual limb. Surgical intervention is usually indicated with total dehiscence.

The following types of wounds may be encountered:

3-Tissue Necrosis

Poor tissue perfusion leads to ischaemia and necrosis. Dusky skin changes, mottled discolouration and slough can be observed. This can lead to subsequent wound breakdown and dehiscence . Depending on the extent of non viable tissue, wound debridement or revision surgery is often necessary.

Fig 4

4-Skin Blisters

Wound oedema, reduced elasticity or tight stump dressings, and adhesive dressings applied with tension can all increase friction of the epidermis and cause blistering of the skin. Blisters can also be formed due to infection, traction, and an allergic reaction.

Fig 5

5-Sinus/Osteomyelitis

A deep, infected sinus can often mask osteomyelitis and delay healing. The sinus can extend from the skin to the subcutaneous tissues and management often includes aggressive antibiotic therapy. Sometimes, surgery is an option, however, this can impact on the shape of the stump and rehabilitation outcomes

Fig 6

6-Pain

Pain is an inevitable consequence of amputation. There are several types of sensations following an amputation that should be discussed when referring to pain following amputation. Some of them are extremely painful and terribly unpleasant; some are simply weird or disconcerting. In one form or another they are experienced by most people following an amputation.

Post amputation pain can be isolated to the residual limb or can occur as phantom pain. For many, pain will not just result from the trauma of the surgery, but will also include a neuropathic presentation known as phantom limb pain (PLP). When amputation has resulted from a traumatic incident, such as in a disaster setting, this can be complicated by co-existing injury to the same limb or other parts of the body. For the physiotherapists involved in the early and post acute stages of rehabilitation, the challenge is determining the nociceptive and neuropathic causes which require attention in order to manage the patient and so enable effective rehabilitation to occur.

1. **Post-Amputation Pain**: Post-amputation pain at the wound site should be distinguished from pain in the residual limb and the phantom limb. After amputation, all three may occur together
2. **Residual Limb Pain (RLP)**: Patients can often feel pain or sensations in the areas

adjacent to the amputated body part. This is known as residual limb (RLP) or stump pain. It is often confused with and its intensity is often positively correlated with PLP.

3. **Phantom Limb Sensation**: This is a normal experience for the majority of amputees, but it is **not** a noxious sensation, which might be described by the patient as unpleasant. Often it can be described as a light tingling sensation, or in such cases re-assurance is the key.
4. **Phantom Limb Pain (PLP)**: Classified as neuropathic pain, whereas RLP and post-amputation pain are classified as nociceptive pain. PLP is often more intense in the distal portion of the phantom limb and can be exacerbated or elicited by physical factors (pressure on the residual limb, time of day, weather) and psychological factors, such as emotional stress. Commonly used descriptors include sharp, cramping, burning, electric, jumping, crushing and cramping.

In addition to these 4 pain types that can be experienced following amputation, clinicians should also be aware of pain that may be caused by co-existing pathology:

1. **Vascular pain** - such as exercise induced claudication or pain caused by vascular disease
2. **Musculoskeletal pain** - pain from other injuries suffered during a traumatic amputation, musculoskeletal pain caused by abnormal gait patterns, pain caused by normal ageing processes, or excessive wear and tear on the joints and soft tissue of the residual limb.
3. **Neuromas** - localized pain, sharp/shooting/paraesthesia reproduced by local palpation and Tinel's sign, relieved by LA injection.

Prosthetic pain is also a concern and may be caused by:

1. Ill-fitting socket - lack of distal contact, insufficient bony relief, too tight, too loose, pistoning causing friction / blisters
2. Incorrect alignment and pressure distribution
3. Incorrectly donned prosthesis, including the number / thickness of socks
4. Excessive sweating / skin breakdown Verrucous hyperplasia

Treatments

A large variety of medical/surgical and non-medical methods exist for the treatment of post-amputation pain:

- Adequate post-op analgesia
- Patient education
- Limit oedema
- Prevent contractures
- Address musculoskeletal weakness and imbalances
- Desensitization - massage/bandaging
- Get patient moving, distraction helps
- Early prosthetic training

7-Muscle weakness, muscle contractures and joint instability

After amputation, it is not uncommon for patients to experience pain, muscle weakness or instability in structures not directly associated with the amputation. These compensatory

structures are the muscles and joints that are required to perform additional functions post amputation, often resulting in stiffness, spasm or pain.
The effects of bed rest and reduced mobility are also well documented. Deconditioning results in diminished muscle mass, sarcomere shortening, reduced muscle strength and changes in cartilaginous structures. It is therefore, crucial, that amputee patients undertake functional rehabilitation and personalised exercise programmes from as early as day 1 post surgery. Hip flexion contractures and knee flexion contractures are common complications post amputation and can impact significantly on prosthetic rehabilitation.
ROM exercises should be incorporated to avoid contractures, as well as prone lying to prevent hip flexion contractures, a sandbag could be placed next to the residuum to prevent a hip abduction contracture. A sandbag could also be placed on the lower part of a transtibial residuum when the patient is prone, to prevent hip flexion contractures.
Physiotherapy regimes should consist of the following elements:

- Range of movement exercises
- Strengthening exercises
- Stretches
- Core stability exercises
- Early mobility practice
- Transfer practice
- Balance exercises
- PPAM aiding and gait re-education

8-Autonomic Dysfunction

Complex regional pain syndromes (CRPS) are neuropathic pain disorders developing as a disproportionate consequence of trauma affecting the limbs . Symptoms include distal pain, allodynia and autonomic and motor dysfunction. The residual limb can appear hot, swollen and trophic due to altered control of the sympathetic nervous system.
Due to the lack of understanding about the pathophysiological abnormalities underlying CRPS, treatment should be multi-disciplinary and comprise of neurologists, physiotherapists and psychologists to name but a few. Anti-depressants are proven to be beneficial in reducing neuropathic pain alongside nerve blocks, TENS, graded exercise and mobilization.

9-Osseointegration Specific Complications in Trans Femoral Patients

Rare major complications

- Mechanical: fractures of the abutment screws, abutments, fixtures, loosening of the implant

Common minor complications:

- Most frequent is superficial infection and soft tissue complications

Chapter 3
Neurological disorders and Orthotics

Objectives

- Knowledge of different stages of management of amputation

Introduction

Movement impairment in neurological and neurneuromuscular pathology

Pathologies of the neuromuscular system manifest in a sometimes confusing array of clinical signs and symptoms. To select the most appropriate therapeutic intervention, be it exercise to promote neuroplasticity and recovery, functional training, or the use of various orthoses and assistive devices to accommodate for impairment of a body system or structure, the clinician must develop a strategy to “classify” the movement disorder that has produced the observed impairments and functional limitations. The clinician must understand the medical prognosis and potential progression of the disease process, as well as the lifestyles and risk factors that might contribute to secondary impairments that limit function over time (even if the disease is “nonprogressive”) and their impact on the individual’s growth and development.

Health professionals use a number of organizational strategies as frameworks for decision making during rehabilitation of individuals with pathologies leading to neuromuscular dysfunction. Many neurologists use a medical differential diagnosis process to locate the lesion as being within the central nervous system (CNS) or involving structures of the peripheral nervous system (PNS) or the muscle itself. They do this by triangulating evidence gathered by examining tone and deep tendon reflexes, observing patterns of movement and postural control, and looking for specific types of involuntary movement. They may also interpret results of special tests such as nerve conduction studies, electromyography (EMG), computed tomography (CT), and magnetic resonance imaging (MRI). These tests might pinpoint areas of denervation, ischemia, or demyelinization and help the health professionals arrive at a medical diagnosis.

Rehabilitation professionals are most interested in the functional consequences associated with the various neuromotor conditions. They examine the ways in which abnormal tone (hypertonicity—excessive tone; hypotonicity—insufficient tone; or flaccidity—absence of tone) affects mobility and locomotion, postural control, motor planning and motor control during movement, coordination (error control), and muscle performance during functional activities. Rehabilitation professionals are not only concerned about function at the present time but also consider the long-term impact of neuromotor impairment on the person’s joints and posture, especially in children who are growing with abnormal tone and postures.

Differential Diagnosis: Where Is the Problem?

Most neurological and neuromuscular diseases affect either the CNS or the PNS; only a few diseases, such as amyotrophic lateral sclerosis, affect both CNS and PNS. Diseases of the CNS and of the PNS may contribute to motor or sensory impairment; however, there are patterns and characteristics of dysfunction that are unique to each. Selection of the appropriate orthosis, seating/wheelchair system, or assistive devices is facilitated when the therapist, orthotist, members of the rehabilitation team, patient, and patient's family understand the normal function and consequences of the disease process of the neurological subsystem that is affected.

The Central Nervous System

The CNS is a complex of dynamic and interactive subsystems that mediates purposeful movement and postural control, vital autonomic vegetative and physiological functions, and learning of all types. Some diseases affect a single CNS system or center and other pathologies disrupt function across several systems: a thromboembolic stroke in the proximal left middle cerebral artery may disrupt volitional movement and sensation of the right side of the body, as well as communication and vision. It can be challenging but imperative to sort through the various types of impairments that may result in order to select the most appropriate therapeutic or orthotic intervention for the individual.

Pyramidal System

The *pyramidal system* is responsible for initiation of volitional movement and plays a major role in the development of skilled and manipulative activities. The motor cortex in the left cerebral hemisphere influences primarily the right side of the body (face, trunk, and extremities); the right cortex influences the left body. A lesion at any point in the pyramidal system has the potential to disrupt volitional movement. The degree of disruption varies with the extent and functional salience of the structures that are damaged, manifest on a continuum from mild weakness (paresis) to the inability to voluntarily initiate and direct movement (paralysis).

Immediately following insult or injury of the pyramidal system, during a period of neurogenic shock, there may be substantially diminished muscle tone and sluggish or absent deep tendon reflexes. As inflammation from the initial insult subsides, severely damaged neurons degenerate and are resorbed, while minimally damaged neurons may repair themselves and resume function.1The more neurons that are destroyed, the greater the likelihood that hypertonicity will develop over time due to the altered balance of descending input of pyramidal and extrapyramidal systems. As the recovery period continues, individuals may begin to move in abnormal synergy patterns whenever volitional movement is attempted. When the damage to the system is less extensive, individuals may eventually recover some or all volitional motor control; the more extensive the damage to the system, the more likely there will be residual motor impairment.

Extrapyramidal System

The extrapyramidal system is made up of several subcortical subsystems that influence muscle tone, organize patterns of movement from among the many possible movement strategies, and make both feedforward adjustments (in anticipation of movement) and refining feedback adjustments (in response to sensations generated as movement occurs) during performance of functional tasks. Damage to the premotor and accessory motor cortex leads to apraxia, the inability to effectively sequence components of a functional task and to understand the nature of a task and the way to use a tool in performance of the task. If there is damage to the caudate and putamen underlying muscle tone may fluctuate unpredictably (athetosis) and involuntary dancelike movements (chorea) are likely to occur. Damage to the subthalamic nuclei can lead to forceful, often disruptive, involuntary movement of the extremities (ballism) that interrupts purposeful activity. Damage to the substantia nigra characteristically leads to resting tremor, rigidity of axial and appendicular musculature (hypertonicity in all directions), and bradykinesia (difficulty initiating movement, slow movement with limited excursion during functional tasks), which are most commonly seen in persons with Parkinson's disease.

Extrapyramidal structures influence muscle tone and readiness to move via a network of interconnections among motor centers in the brainstem. They play a major role in balancing the stiffness required for antigravity position and the flexibility necessary for movement of the limbs through space during functional activity and are likely the effectors for tonic hindbrain reflexes.

Coordination Systems

The error control, or coordination subsystem, has several interactive components. The cerebellum judges how "in sync" these various types of information are (essentially asking the questions, "Did the movement occur as planned? Was the outcome of the movement as intended?" and suggests refinements for more precise and coordinated movement by various interconnections through the brain

Somatosensory and Perceptual Systems

The somatosensory system is composed of a set of ascending pathways, each carrying a specific sensory modality from the spinal cord and brainstem to the thalamus and postcentral gyrus of the cerebral cortex, reticular formation, or cerebellum. The anterolateral (spinothalamic) system carries exteroceptive information from mechanoreceptors that monitor protective senses (e.g., pain, temperature, irritation to skin and soft tissue). A lesion such as an **M**ultiple Sclerosis plaque in one of the ascending pathways may result in a discrete area of loss of exteroception or of conscious proprioception in one area of the body; a lesion on the somatosensory cortex can lead to a more profound, multimodality impairment on the opposite side of the body.

Visual and Visual-Perceptual Systems

The visual system begins with processing of information gathered by the rods and cones in the multiple layers of specialized neurons in the retina, located in the posterior chamber of the eye then moves through pathways through optic nerve to the visual cortex in occipital lobe. Damage to the retina or optic nerve results in loss of vision from that eye. Damage to the optic chiasm typically leads to a narrowing of the peripheral visual field (bitemporal hemianopsia); a lesion of one of the optic tracts or radiations leads to loss of part or all of the opposite visual field (homonymous hemianopsia). Damage to the visual cortex can result in cortical blindness, in which visual reflexes may be intact but vision is impaired.

Executive Function and Motivation

The ability to problem solve, consider alternatives, plan and organize, understand conceptual relationships, multitask, set priorities, and delay gratification, as well as the initial components of learning are functions of the frontal association areas of the forebrain. These dimensions of cognitive function are often described by the phrase *higher executive function*. Quantitative and other analytical skills are thought to be primarily housed in the frontal association areas of the left hemisphere, while intuitive understanding and creativity may be more concentrated in the right hemisphere.

Peripheral Nervous System

The PNS serves two primary functions: to collect information about the body and the environment and to activate muscles during functional activities. Afferent neurons collect data from the various sensory receptors distributed throughout the body and transport this information to the spinal cord and brainstem (sensory cranial nerves) for initial interpretation and distribution to CNS centers and structures that use sensory information in the performance of their various specialized roles. . Efferent neurons (also described as lower motor neurons or, more specifically, α and γ motor neurons) carry signals from the pyramidal (voluntary motor) and extrapyramidal (supportive motor) systems to extrafusal/striated and intrafusal (within muscle spindle) muscle fibers that direct functional movement by enacting the CNS's motor plan.

Pathologies of the PNS can be classified by considering two factors: the modalities affected (only sensory, only motor, or a combination of both) and the anatomical location of the problem (at the level of the sensory receptor, along the neuron itself, in the dorsal root ganglion, in the anterior horn, at the neuromuscular junction, or in the muscle itself). Poliomyelitis is the classic example of an anterior horn cell disease; Guillain-Barré syndrome is a demyelinating infectious-autoimmune neuropathy that impairs transmission of electrical impulses over the length of motor and sensory nerves. The polyneuropathy of diabetes (affecting motor, sensory, and autonomic fibers) is the classic example of a metabolic neuropathy. Radiculopathies (e.g., sciatica) result from compression or irritation at the level of the nerve root, while entrapment syndromes (e.g., carpal tunnel) are examples of compression neuropathies over the more distal peripheral nerve. Myasthenia gravis, tetanus, and botulism alter function at the level of the neuromuscular junction. Myopathies and muscular dystrophies are examples of primary muscle diseases.

Determinants of effective movement

Regardless of the underlying neurological or neuromuscular disease, rehabilitation professionals seek to understand the impact of the condition on an individual's underlying muscle tone and motor control (ability to initiate, guide, sustain, and terminate movement), muscle performance (strength, power, endurance, speed, accuracy, fluidity), and postural control and balance (ability to stay upright, to anticipate how to make postural adjustment during movement, and to respond to unexpected perturbations) in order to move effectively during goal-directed, functional movement necessary for daily life.

Muscle Tone and Muscle Performance

Effectiveness of movement is determined by the interaction of underlying muscle tone and muscle performance.

Muscle tone can be conceptualized as the interplay of compliance and stiffness of muscle, as influenced by the CNS. Ideally the CNS can set the neuromotor system to be stiff enough to align and support the body in functional antigravity positions (e.g., provide sufficient baseline postural tone) but compliant enough in the limbs and trunk to carry out smooth and coordinated functional movement and effectively respond to changing environmental conditions or demands as daily tasks are carried out .At the center of the tone continuum, the interplay of stiffness and compliance is optimal, such that motor performance is well supported . At the low-tone end of the continuum, where there is low stiffness and high compliance, individuals are challenged by inadequate postural control and inability to support antigravity movement. At the high tone end of the continuum, where there is high stiffness and low compliance, freedom and flexibility of movement are compromised.

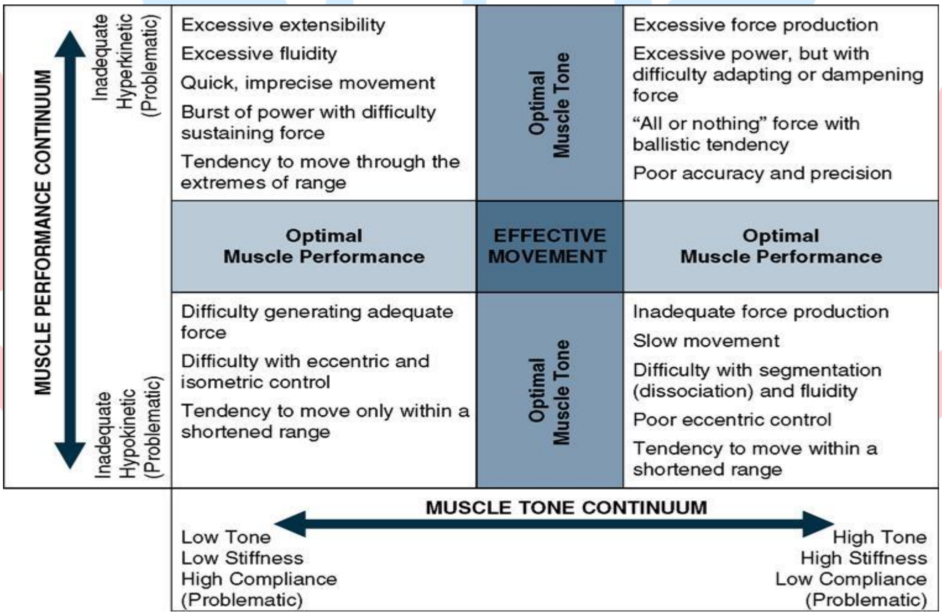


Fig 1 A conceptual model of the interrelationship of muscle tone and muscle performance as they interact to influence functional abilities. The muscle tone ranges from excessively compliant (easily extensible on passive movement) to excessively stiff (resistant to passive movement). The muscle performance continuum ranges from hypokinetic (exhibiting minimal movement during task activity) to hyperkinetic (exhibiting excessive and poorly controlled movement during task activity). Movement is most effective at the intersection of optimal muscle tone and optimal muscle performance.

Effective movement occurs when *muscle performance* meets the demands of the task. The components of muscle performance are the ability to

(1) generate sufficient force (strength)

(2) at the rate of contraction required for the task at hand (speed and power)

(3) to sustain the concentric, holding/isometric, or eccentric contraction necessary to meet task demands (muscle endurance)

(4) to ramp up or dampen force production in response to task demands (accuracy);

(5) coordinate mobility and stability of body segments to complete the task (fluidity).

While muscle tone and muscle performance are distinct contributors to movement, they are certainly interactive. Movement is most effective and efficient if an individual's resources fall at the center of each continuum. A problem with muscle tone, or with muscle performance, or a combination of both leads to abnormal and less efficient movement.

Traditionally, an individual's muscle tone has been described clinically as hypertonic or spastic, rigid, hypotonic or low, flaccid, or fluctuating

Hypertonus

Hypertonus is a term used to describe muscles that are influenced to be too stiff or are excessively biased toward supporting antigravity function. Spasticity is a type of hypertonus that typically occurs when there is damage to one or more CNS structures of the pyramidal motor system and is encountered as a component of many neuromuscular pathologies. "Stroke" The upper extremity is typically biased toward flexion, such that the limb can be easily moved into flexion but not into extension (decreased compliance of flexors). The lower extremity is biased toward extension, such that the impaired compliance of extensors makes movement into flexion difficult. There is an increase of muscle stiffness and resistance to passive elongation (impaired compliance) in one group of muscles (agonists) with relatively normal functioning of opposing muscle groups (antagonists).

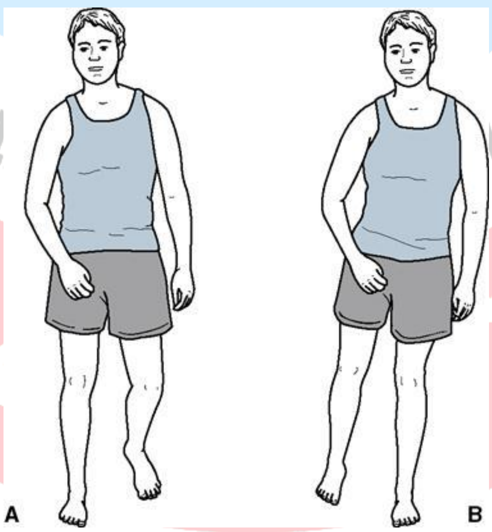


Fig 2 Decorticate pattern hypertonicity following cerebrovascular accident. **A,** The affected upper extremity is held in a flexed posture, while the extensor bias in the lower extremity provides stability at midstance and permits swing limb advancement of the less-involved extremity. **B,** The extensor pattern hypertonus in the affected lower extremity precludes swing-limb shortening normally accomplished by hip and knee flexion; instead, the individual uses an abnormal strategy such as pelvic retraction and hip hiking to advance the involved limb.

Given the unidirectional nature of severe hypertonus, it is common for persons with severe hypertonus to develop chronic abnormal postures.

Hypertonicity is also associated with deficits in muscle performance, most notably diminished strength, diminished ability to produce power (generate force quickly), diminished ability to effectively isolate limb and body segments, diminished excursions of movements within joints (i.e., moving within a limited range of motion [ROM]), and inefficiency with altering force production or timing of contractions to meet changing (fluid) demands of tasks.

Rigidity

Individuals with Parkinson's disease and related neurological disorders often demonstrate varying levels of rigidity: a bidirectional, co-contracting hypertonicity in which there is resistance to passive movement of both agonistic and antagonistic muscle groups. Co-contraction of flexor and extensor muscles of the limbs and trunk creates a bidirectional stiffness that interferes with functional movement. Rigidity is often accompanied by slowness in initiating movement (bradykinesia), decreased excursion of active ROM, and altered resting postures of the limbs and trunk. Because rigidity creates a situation of excessive stability of the trunk and limbs, orthoses are not typically a component in the plan of care for persons with Parkinson's disease.

Fig 3 Typical standing posture in individuals with Parkinson's disease, with a forward head, kyphotic and forward flexed trunk, and flexion at hip and knees. Upper extremities are often held in protracted and flexed position.

Hypotonus

Hypotonus (low muscle tone) describes a reduced stiffness of muscle that does not effectively support upright posture against gravity or to generate force during contraction; as a result, hypotonic muscles are more compliant than they are stiff. In children, hypotonia can arise from abnormal function within the CNS (approximately 75%) or from problems with peripheral structures (peripheral nerve and motor units, neuromuscular junction, the muscle itself, or unknown etiology). Hypotonia can be congenital (seen as "floppy" infants), transient (e.g., in preterm infants), part of the clinical presentation of CP, Down syndrome and other genetic disorders, as well as Autism spectrum disorders.

Fig 4 Postural control is often inefficient in children (and adults) with hypotonicity or low tone.

Postural Control

Postural control has three key dimensions:

(1) *Static postural control* is defined as the ability to hold antigravity postures at rest;

(2) *dynamic anticipatory postural control* is the ability to sustain a posture during movement tasks that shift (internally perturb) the center of mass;

(3) *dynamic reactionary postural control* is the ability to be able to withstand or recover from externally derived perturbations without loss of balance.

One has functional postural control if the center of mass (COM) can be maintained within one's base of support (BOS) under a wide range of task demands and environmental conditions. This requires some level of ability across the triad of static, anticipatory, and reactionary control.

The key interactive CNS systems involved in postural control include extrapyramidal and pyramidal motor systems, visual and visual-perceptual systems, conscious (dorsal column/medial lemniscal) and unconscious (spinocerebellar) somatosensory systems, the vestibular system, and the cerebellar feedback/feedforward systems. Clinical measures used to assess efficacy of static postural control include timing of sitting or standing activities and measures of center of pressure excursion in quiet standing.

Many individuals with neuromuscular disorders demonstrate inefficiency or disruption of one or more of the CNS subsystems necessary for effective postural control and balance. An individual with mild to moderate hypertonicity or spasticity often has difficulty with anticipatory and reactionary postural control, especially in high task demand situations within a complex or unpredictable open environment.

Persons with hypotonicity, on the other hand, often have difficulty with sustaining effective postural alignment in antigravity positions such as sitting and standing. They are likely to demonstrate patterns of postural malalignment such as excessive lumbar lordosis and thoracic kyphosis.

Movement and Coordination

Many functional activities require us to move or transport the entire body (e.g., mobility or locomotion) or a segment of the body (e.g., using one's upper extremity to bring a cup toward the mouth to take a drink) through space. The locomotion task that receives much attention in rehabilitation settings is bipedal ambulation–the ability to walk. For full functional ability, individuals must be able to manage a variety of additional locomotion tasks: running, skipping, jumping, and hopping.

To fully understand an individual's functional ability, therapists and orthotists must also consider the environmental context in which ambulation is occurring:

- What are the physical characteristics of the surface on which the individual needs to be able to walk or traverse?
- Is it level, unpredictably uneven, slippery or frictional, or structurally unstable?
- Is the ambulation task occurring where lighting is adequate for visual data collection about environmental conditions?
- Does it involve manipulation of some type of object (e.g., an ambulatory assistive device, a school backpack, shopping bags, suitcases)?
- Is it occurring in a familiar and predictable environment (e.g., at home) or in a more unpredictable and challenging open environment such as a busy school, supermarket, mall, or other public space?

The task demands of locomotion in complex and challenging environments create more demand on the CNS structures involved in motor control (perceptual-motor function, motor planning, cerebellar error control), as well as on the musculoskeletal effectors (muscles and tendons, joints, ligaments, and bones) that enact the motor plan necessary for successful completion of the task that relies on body transport. Individuals with neurological and neuromuscular system problems related to muscle tone, muscle performance, and postural control are typically less efficient, less adaptable, and more prone to fall when walking, especially if there are competing task demands and the environment is complex and challenging.

For individuals with neurological and neuromuscular system dysfunction, the ability to safely and efficiently perform complex mobility tasks is often compromised due to abnormal muscle tone, impaired muscle performance, and poor postural control. Coordination can be examined by considering the individual’s ability to initiate movement, sustain movement during the task or activity, and terminate movement according to task demands.

For movement and coordination to be functional, one must have muscle performance that is flexible/adaptable to varying demands. Mobility or transport tasks cannot be performed independently (safely) unless the individual is able to

(1) transition into and out of precursor positions (e.g., getting up from the floor into a standing position, rising from a chair)

(2) initiate or begin the activity (e.g., take the first step)

(3) sustain the activity (control forward progression with repeated steps)

(4) change direction as environmental conditions demand (e.g., step over or avoid an obstacle)

(5) modulate speed as environmental conditions demand (e.g., increase gait speed when crossing the street),

(6) safely and effectively stop or terminate the motion, returning to a precursor condition or position (quiet standing, return to sitting).

Examples of Neuromuscular disorders that need orthosis:

1-Stroke

Also known as brain attack or cerebrovascular insult
Causes: Thrombus or embolism of cerebral artery due to hypertension, hypercholesterolemia, diabetes and metabolic syndrome, overweight and obesity, smoking, sedentary lifestyle, or artrial fibrillation or

hemorrhage

Prognosis: ischemic: severity depends on site of occlusion within arterial tree and the size of the area that is without blood flow

Muscle tone: Initial hypotonus (sometimes appearing to be flaccid) due to neurogenic shock. Some individuals remain hypotonic, most develop various levels of hypertonus in weeks/months following event. Hyperactive deep tendon reflexes evolve over time.

Muscle Performance: Upper extremity often biased toward flexion, with lower extremity biased toward extension. Impaired force production, speed and power, eccentric/isometric control, accuracy, and fluidity.

Mobility and coordination: Asymmetry in ability to use trunk, limbs during functional activity; tendency to move in abnormal "synergy" (flexion UE, extension LE).

Frequently require AFO and ambulatory device.

Cerebral Palsy:

Causes: Diminished fetal oxygenation

Types:

- Spastic (85%-93%): Quadriplegia/tetraplegia: global impact on both gray and white matter structures in forebrain. Some individuals have concomitant cognitive impairment and seizure disorders.Diplegia: usually due to damage of white matter of internal capsule/corona radiate, impacting on motor and sensory systems more than perceptual.Hemiplegia: may be due to intracerebral hemorrhage or ischemia affecting one hemisphere.

- Dyskinetic (5%-10%)(choreoathetoid): May be related to perinatal damage of basal ganglia Unpredictably fluctuating tone of head/neck, trunk, and extremities; may be associated with perinatal bilirubin toxicity

- Ataxic/cerebellar (5%): May be related to perinatal damage of cerebellar cortex, nuclei, or peduncles

Prognosis: Static event occurring at or around the time of birth. Signs and symptoms become apparent over first 2 years of life as motor developmental delay. High risk of secondary musculoskeletal deformity due to impact of abnormal tone during periods of growth and repetitive impact of muscle imbalance on movement. Level of disability often becomes more pronounced as child moves into middle childhood, adolescence, and young adulthood due to increasing body size and weight.

Muscle tone:

-spastic: May be hypokinetic (small excursion of movement) or hyperkinetic (large excursion of movement) with difficulty modulating force; force production can be great (strong forceful unrelenting contraction) or small (inability to sustain contraction for functional movements); difficulty with eccentric and isometric control, poor accuracy and precision of movement.

-Dyskinetic- May be hypokinetic (slow and minimal movement) or hyperkinetic (movements can be random and/or repetitive with minimal purpose); force production, speed, and timing of contractions do not match task demands; poor accuracy.

Ataxic: May be hypokinetic or hyperkinetic; tasks demanding greater accuracy lead to faster and greater excursions, with worsening accuracy; tasks demanding less accuracy lead to slower and lesser excursions with some accuracy. Timing of agonist and antagonist sequencing is impaired.

Postural control: impaired

Mobility and Coordination: Frequently employ movement strategies based on atypical and less variable patterns/synergies; over time may develop rotational deformity of lower extremity as well as joint contracture due to combination of preferred abnormal positions/patterns of movement and hypertonus.

Often require ankle-foot-orthosis, assistive devices, or wheelchair for locomotion. Those with significant trunk and upper extremity involvement may require adaptive equipment for feeding, communication, and activities of daily living.

Orthoses or resting splints may be used as a means of managing abnormal tone, minimizing risk of musculoskeletal deformity, or after orthopedic surgery to correct deformity.

Table 1 Treatment of principal limb deformities in cerebral palsy and stroke

DEFORMITY	ORTHOTIC INTERVENTION
Foot flaccid equinus	Spring loaded dorsiflexion
Foot spastic equinovarus	Limiting orthosis to eversion and dorsiflexion
Knee flexion	Knee–ankle–foot orthosis
Hip adduction	Seating Adaptation
Shoulder adduction	Positioning pillow
Elbow flexion	Night orthosis
Wrist flexion	Wrist Orthosis
Finger flexion	Night Orthosis

The muscular dystrophies

These are a group of hereditary disorders of the skeletal muscle that produce progressive degeneration of the skeletal muscle and associated weakness. The X linked dystrophies such as Duchenne's and Becker's muscular dystrophy (DMD and BMD) are the most common dystrophies encountered in clinical practice. Patients with muscular dystrophy should be treated using the standard rehabilitation principles.

There is a fairly well recognised orthopaedic and orthotic protocol in the management of DMD because of its relatively predictable prognosis and the compensations patients adopt to maintain stability. Patients also have respiratory insufficiency and cardiac abnormalities; these problems should be screened in parallel. Patients with DMD should have an echocardiogram and ECG at diagnosis, before any surgery, every 2 years up to the age of 10 years and annually after the age of 10 years. Female DMD and BMD carriers require similar but less frequent screening.

Patients develop progressive weakness of proximal upper and lower limb muscles and develop in ability to stand from sitting position and develop back and abdominal weakness causing gradual postoural defects and scoliosis.

Treatment:

The major goal of early treatment is to maintain functional ambulation as long as possible. Patients with DMD are susceptible to the development of contractures and scoliosis.

Stretching exercises and nightly bracing can help to prevent the contractures from becoming severe.

At the age of 8–15 years, children with DMD have a sensation of locking of the knees. It is easier to keep children with DMD walking than to induce walking once they have stopped, therefore, contractures should be treated early to maintain ambulation, because, if it is maintained even for 1–2 years, it considerably benefits these children and delays the inevitable development of scoliosis and kyphosi

Orthoses will be necessary to support back as well may need HKAFO if necessary. Assistive devices like wheel chairs will gradually be used.

Peripheral Nerve Injuries:

This is a lower motor neuron lesion and presented with weakness in muscles supplied by the nerve or complete loss of fuction. Muscles are usually hypotonic and wasted

Injuries of peripheral nerve can be cause by:

1- Traumatic: usually to median ulnar or radial nerves or combined. For pediatric during delivery brachial plexopathy ; Erb's Palsy

2- Peripheral neuropathy most commonly diabetes and affects the lower limbs first most commonly The Common Peroneal nerve

3- Entrapment neuropathies: which occurs at areas of entrapment like the carpal tunnel, and tarsal tunnel syndrome most commonly

Assessment:

Assessment is necessary to evaluate function of limb and treat according. We must evaluate:

Range of motion of joint: This should be done objectively with a goniometer. Both active and passive movement should be done

Strength of muscles: That can be done with a dynamometer or manual muscle testing

Sensation: to determine protective sensation, superficial sensory loss for crude touch or pin prick, and sympathetic loss.

Coordination, Dexterity, and Work Tolerance: Standardized hand function tests that measure a wide range of hand coordination and dexterity levels are currently available for assessing the functional repercussions of peripheral nerve injury.

Activities of Daily Living: Testing for activities that require fine bilateral coordination, such as shoe tying, or those that require dexterous use of the injured extremity alone, such as buttoning a cuff button, are frequently problematic. These may be quickly identified and simple adaptations taught that allow the patient to perform independently.

Median Nerve injury:

Low lesion. A laceration of the median nerve at the wrist produces low median palsy, a devastating injury. The median nerve innervates the majority of the thenar muscles and provides sensibility to the radial three and one half digits. Motor loss is present in only the radial portion of the hand

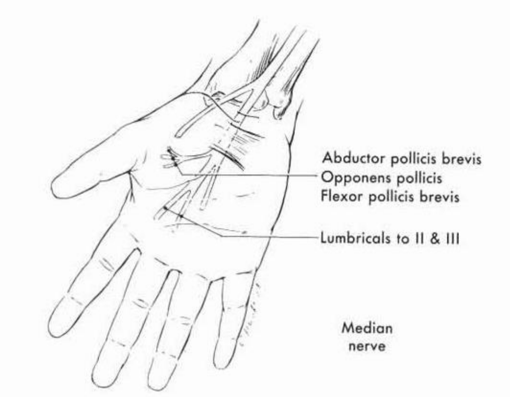


Fig 5 Low median palsy involves the intrinsic muscles of the thumb and index and long fingers.

Loss of the OP and APB renders it impossible to pull the thumb away from the palm. The thumb is carried across the palm in an adducted position "Ape hand".

Adduction contractures of the thumb are the most com- mon deformity following a low lesion of the median nerve. To provide a balance to the unopposed adductor pollicis, some means of holding the first metacarpal abducted from the second metacarpal is necessary (Fig. 6) Thumb abduction splinting prevents the OP and APB from resting in a stretched position and reinforces early return of their action. Abduction splinting also maintains the soft tissue length of the first web space. Much of the functional abduction of the thumb requires the elongation of the soft tissue of the entire first web.

Fig 6 An adduction contracture of the thumb in median palsy is caused by an unopposed adductor pollicis muscle.

Orthotic Intervention

A web spacer or C bar static hand orthosis is enough to prevent contracture at the thumb Fig 7

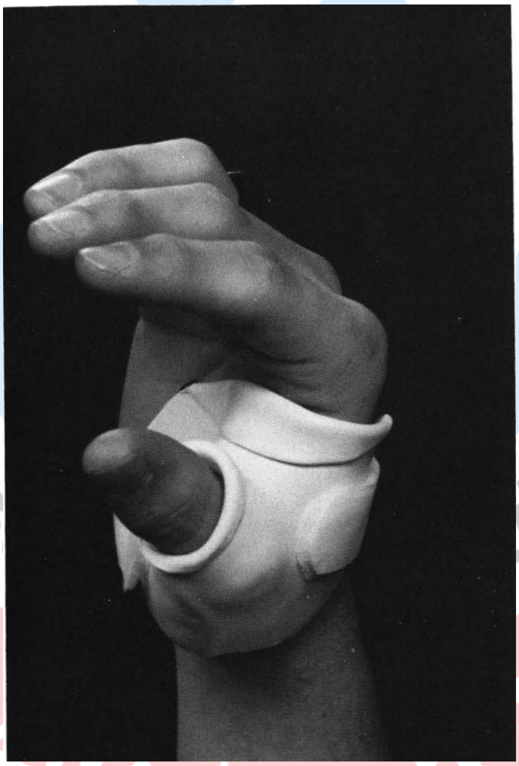


Fig 7 A simple web spacer splint worn at night is often sufficient to maintain thumb carpometacarpal motion in a low median nerve injury.

Ulnar Nerve Injury:

Low lesion. Laceration of the ulnar nerve at the wrist (low ulnar palsy) results in denervation of the majority of the intrinsic muscles of the hand (Fig.8).The ulnar nerve innervates all of the hypothenar muscles: abductor digiti minimi, flexor digiti minimi, and the opponens digiti minimi. The ulnar border of the transverse metacarpal arch is lost. Absence of the dorsal and volar interossei muscles creates the inability to abduct and adduct the fingers, causing loss of the fine manipulative power of the hand. In addition to the loss of the interossei, the ring and little fingers also lose function of the lumbricales, removing any intrinsic muscle balancing force in these two digits. The extrinsic muscles dominate. Fig 9

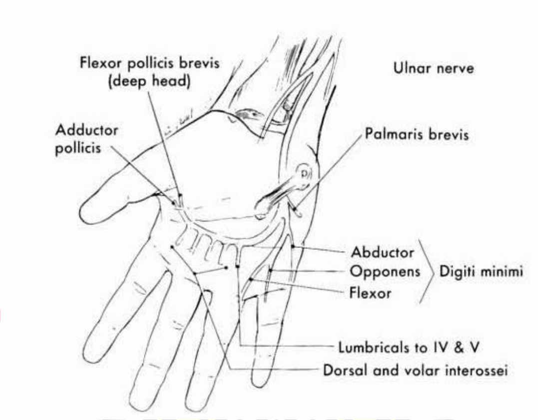


Fig 8: Innervated muscles by ulnar nerve

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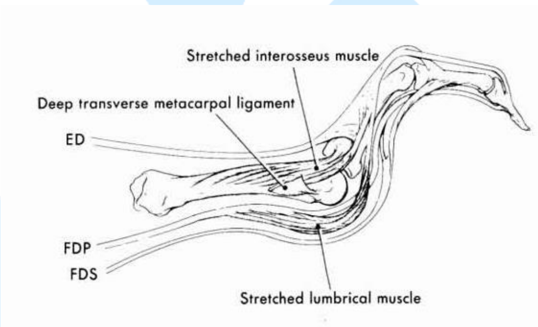


Fig 9 In ulnar palsy, the loss of intrinsic muscle control in the ring and little fingers allows the metacarpophalangeal joints to hyperextend. The denervated muscles are stretched in this claw position.***ED* ,**Extensordigitorumcornmunis; ***FDR*** flexordigitorum profundi; ***FDS,***flexor digitorum superf

The resulting deformity is clawing of the ring and little fingers. The intrinsic muscles normally flex the metacarpophalangeal (MP) joint and extend the interphalangeal (IP) joints. When they are absent, there are no prime flexors of the MP joint. In this claw position, both the lumbricales and the interossei are held in a stretched position. The patient can flex the MPjoints actively, but only after the IPjoints are fully flexed. The greatest functional loss is the inability to open the hand in a large span to grasp objects and the inability to handle small objects with precision. The loss of the powerful adductor pollicis and the deep head of the flexor pollicis brevis removes one of the key supports of the thumb MPjoint during pinching. The thumb may demonstrate Froment's sign: extension or hyperextension of the MP joint with hyperflexion of the IP joint

Orthotic intervention:

Knuckle bender or knuckle duster Fig 10:

The goal in splinting ulnar palsy is to prevent overstretching of the denervated intrinsic muscles of the ring and little fingers. The ring and little finger MP joints must be prevented from fully extending . Any splint that blocks the MP joints in slight flexion prevents the claw deformity by forcing the extrinsic extensors to transmit force into the dorsal hood mechanism of the finger. This extends the **IP** joints in the absence of active intrinsic muscle pull The dorsal block should be molded carefully to distribute pressure over the dorsum of each proximal phalanx and should end exactly at the axis of the proximal interphalangeal (PIP) joint. It can be static or dynamic

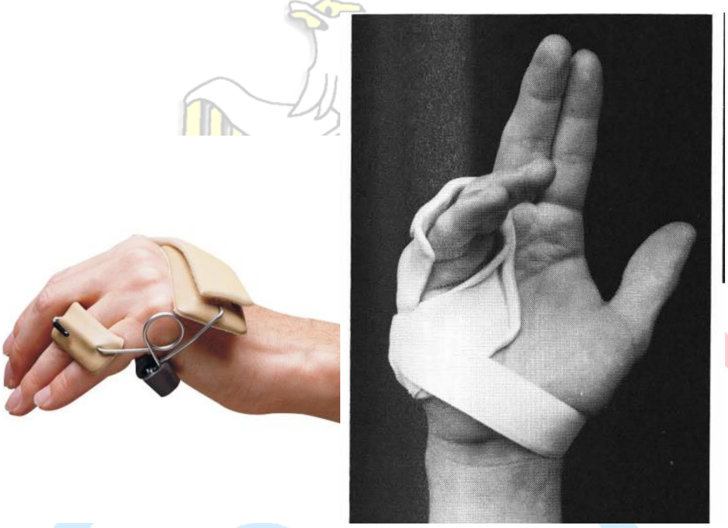


Fig 10 Ulnar nerve splint

Radial Nerve Injury:

High lesion. Unlike the median and ulnar nerve, the radial nerve is more commonly injured at the higher level where it spirals around the humerus Injury at the spiral groove of the humerus is most commonly associated with humeral fractures and direct compression

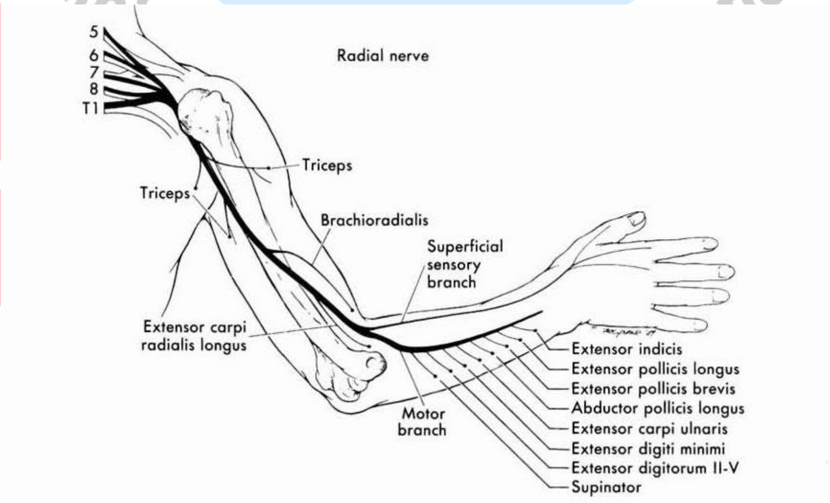


Fig 11 Muscles supplied by Radial Nerve

Injury at or below the spiral groove spares the innervation of the triceps, leaving elbow function intact. There is absence of all wrist and finger extensors as well as the supinator, but all flexor and intrinsic muscles in the hand retain full function. The primary functional loss in radial palsy is inability to stabilize the wrist in extension so that the finger flexors can be used normally. The loss of the wrist and finger extensors destroys the essential reciprocal tenodesis action vital to the normal grasp-and-release pattern

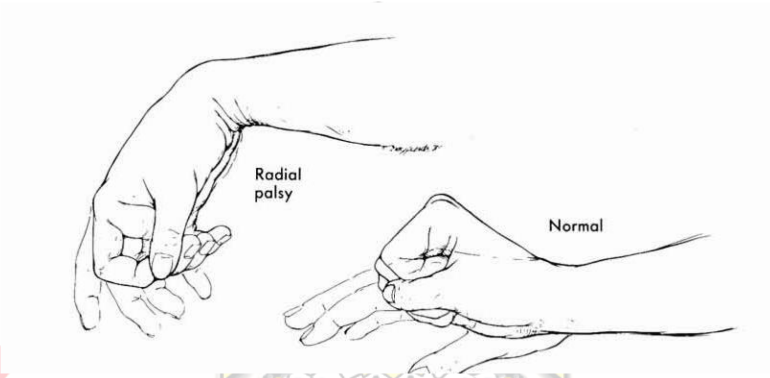


Fig 12 Radial palsy robs the hand of the normal reciprocal tenodesis action

Orthotic Intervention:

A static nylon cord rather than dynamic rubber bands to suspend the proximal phalangeal area (Fig.13). This splint allows full finger flexion. Because the wrist never drops below neutral, the powerful flexors have the ability to bring the wrist into slight extension. During relaxation, gravity drops the wrist and the blocking force of the loops under the proximal phalanges achieves extension of the MP joints. Full finger extension is accomplished by the intrinsic muscles acting in concert with the blocking action of the splint. Because the splint receives a facsimile of the normal tenodesis motion, training is rarely required for the patient to adapt to the splint.

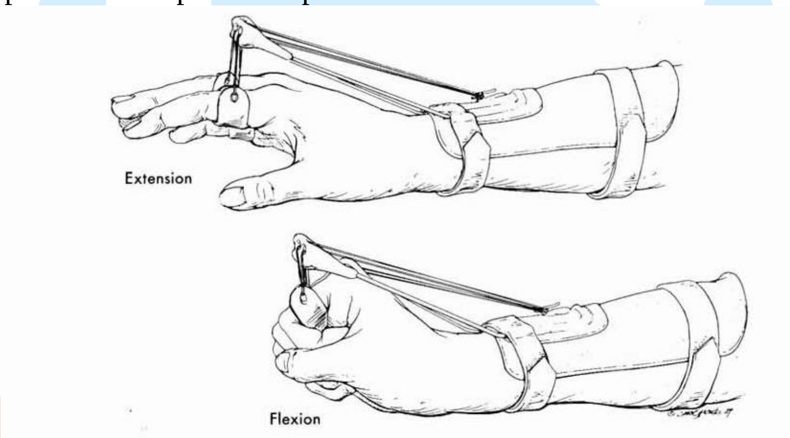


Fig 13 Radial Palsy Splint

Chapter 4

Foot Disorders and Chiropody

Objectives

- Introduction to foot disorders commonly encountered in the foot clinic
- Understanding of management of foot abnormalities
- Orthotic options available in the market

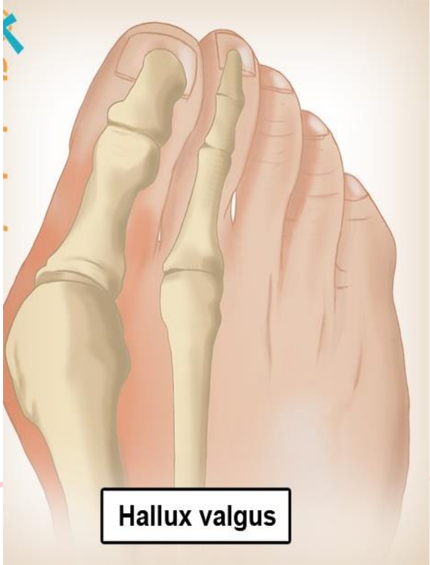
HALLUX VALGUS

PATHOLOGY

On inspection, one can see valgus deviation of the big toe, commonly associated with rotation so that the plantar aspect of the big toe is applied to the second toe. Associated with the valgus deviation is stretching of the medial capsule and shortening of the lateral capsule. The sesamoids are displaced laterally and the extensor tendon can be seen to bow-string across the angle between the first metatarsal and the hallux. Fig 1

ASSOGIATED DEFORMITIES

The deviation of the big toe leaves the head of the first metatarsal exposed and due to increased pressure from footwear an exostosis is formed on the medial aspect of the metatarsal head. Overlying this is a bursa which frequently becomes inflamed. The first metatarsal is frequently deviated away from the second, producing a metatarsus primus varus. The displacement of the big toe produces a secondary deformity of the second toe and may lie on the dorsal aspect of this digit which has a hammer deformity, or it may lie on the plantar aspect. In either event, the proximal interphalangeal joint of the second toe is prominent, and pressure from the shoe produces a corn at this site. One frequently sees pes planus anterior or a planovalgus deformity associated with hallux valgus. Thus this very common combination of conditions, seen particularly in aged ladies, is metatarsus primus varus and hallux valgus, with a bunion, hammer deformity of the second toe, pes planus anterior and a planovalgus foot.



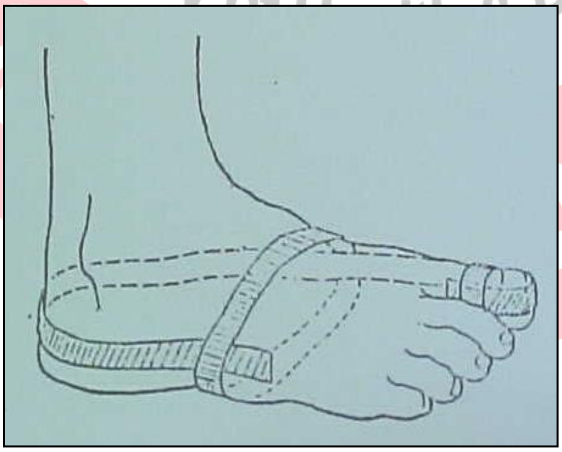
AETILOGY

(a) Familial. It is very common to find a history of a similar deformity of the foot in other members of the family and this association is more common in females. Many papers have been written on the incidence of this condition and several authors have stressed that the metatarsus primus varus is the primary condition whereas other writers consider hallux valgus to occur first.

(b) An acquired variety, undoubtedly, is seen and this is probably related to the deformity of the foot produced by wearing tight and unsuitably shaped shoes or tight stockings.

TREATMENT

(a) Strapping. Astrip of 1 inch (2.5 cm.) zinc-oxide strapping is applied to the foot in the following manner. It begins on the lateral aspect of the big toe, running round the tip of the terminal segment and along the medial border of the big toe. At this point, tension is applied to the strapping to correct the valgus position of the hallux. The strapping then continues along the medial border of the foot and round the heel. It is supported by circumferential strapping at the level of the proximal phalanx of the big toe and also at the level of the proximal phalanx of the big toe and also at the level of the tarsometatarsal joint. This will maintain a mobile deformity in the correct position and has the advantage that it can be worn under the stockings, but the disadvantage that it needs frequent re-application (see Fig. 2).



(Fig 2) Zinc oxide strapping for hallux valgus

(b) Tubegauz. A spica of Tubegauz applied over the big toe with a tail extending round the medial border of the foot will provide a correcting force, but tension must be applied to the medial tail of the bandage and this is maintained by circumferential strapping at the level of the tarsometatarsal joint. Owing to stretching of the Tubegauz, however, and the difficulty of maintaining traction, this method is not recommended.

(c) Interdigital pegs. Sponge rubber pegs are produced by several firms. These are meant to be inserted between the first and second toes. If the peg is not fixed to a sole-plate it is difficult to see how it can do anything more than increase the pressure on the second toe. If it is fixed to an insole, it can certainly correct the deformity, but it is not possible to wear this appliance with stockings or socks in position.

(d) Elastic straps. An elastic band some 3 inches (7.5 cm.) in width has been devised which is worn round the forefoot. A short cylinder of elastic to encircle the big toe is attached to the distal edge of the band, thus enclosing the big toe and forefoot in a spica-like support. The tension along the medial border of the elastic spica is expected to overcome the deforming force of extensor hallucis longus and flexor hallucis longus and it is difficult to imagine reasonably thin elastic having sufficient resilience to overcome these two powerful muscles working in unison.

(e) Stanmore night splint. This splint consists of a spring-steel lever extending from the medial aspect of the tip of the great toe along the medial border of the foot, round the heel and Along the lateral border of the foot to the level of the tarsometatarsal joint. Circumferential straps are applied (a) round the big toe, (b) round the foot at the level of the tarsometatarsal joint. This appliance clearly can only be worn when the patient is unshod, and, therefore, its use is confined to night splints. It is difficult to see how its use would do more than stretch the contracted soft tissues and while it is useful as a post-operative appliance, it is unlikely to avoid the need for operation (see Fig. 3).

Fig 3 Stanmore pattern of hallux valgus splint

A variant of the splint made from sheet aluminium has been described by Lamber Moodie and this has a flange projecting from the plantar aspect of the appliance at the big-toe level extending into the first interdigital cleft.

HALLUX RIGIDUS

DESCRIPTION

This condition is an osteoarthritis of the first metatarso- phalangeal joint. The patient, therefore, complains of pain, stiffness, and swelling. The stiffness is usually worse after sitting still for any length of time but may wear off after walking about for a short period. As with any other form of degenerative arthritis, there is restriction of movement, but in hallux rigidus the first movement to be lost is that of dorsiflexion.

In walking normally, the big toe is passively dorsiflexed at the metatarsophalangeal joint, the angle of dorsiflexion varying with the length of stride and the height of heels being worn. Once the range of free dorsiflexion has decreased to an angle which is less than that passively produced during walking, the patient will experience pain in this part at each step. For a time he will compensate for the loss of movement by taking shorter steps, by wearing lower heels, or perhaps by walking with the hips externally rotated, the foot then rolling onto the inner border to avoid the painful movement. Eventually, however, these compensating methods fail and the patient may present complaining of pain either in the first metatarsophalangeal joint or in the dorsum of the foot.

DEFORMITY

On inspection, the first metatarsophalangeal joint is usually swollen and there may be an exostosis arising from the dorsal aspect of the first metatarsal head. This contrasts with the exostosis arising from the dorsal aspect of the first metatarsal head. This contrasts with the exostosis seen in hallux valgus where it arises from the medial aspect of the first metatarsal head. In hallux rigidus the exostosis is usually much smaller than in hallux valgus and, also, the base is relatively narrow, although it may still be capped by a bursa over which is hyperkeratotic skin. Occasionally, this bursa may become inflamed and may even suppurate and discharge to the surface, leaving a sinus. There is always some degree of restriction of movement of the first metatarsophalangeal joint, as described above.

At the time most patients present, plantar flexion is still present for a reasonable proportion of the normal range but dorsiflexion is usually completely absent. Compensating for this, there is frequently an increased range of dorsiflexion of the inerphalangeal joint of the big toe.

Fig 4 Hallux Rigidus

CONSERVATIVE TREATMENT

The treatment of hallux rigidus must aim at either regaining the lost dorsiflexion or allowing the patient to walk without the need for dorsiflexion of the fist metatarsophalangeal joint.there is no appliance available which will assist in the former method and one must, therefore, rely on techniques which avoid the painful movement.

(a) Steel sole plale. The insertion of a small steel plate between the layers of the sole and heel of the shoe will effectively prevent dorsiflexion of the metatarsophalangeal joints during heel and toe walking.

In a normal patient the foot acts as a lever, the fulcrum of which is at he head of the fist metatarsal, the weight being applied at the talus and the force moving the lever being provided by the calf muscles at their insertion to the os calcis. If the first metatarsophalangeal joint becomes stiffened, the length of the lever is increased so that the fulcrum lies either at the head of the proximal phalanx if there is compensatory hyperextension of this joint, or at the pulp of the big toe. Since the force required to move a lever varies with the length of the lever, even a small increase in the length of the lever arm produces the need for application of a much greater force to move the lever and, therefore, the effort of walking with a steel sole plate is much greater than in the normal foot. The patient tends to avoid this extra effort by externally rotating the hips and rolling from the lateral border of the foot across the metatarsal heads, so producing a gait which has been described as 'ten to 2'. In time this gait will produce a planovalgus deformity of the foot.

(c) Rocker sole. The design of clogs is such that, with the curved sole, the wearer can roll forward on the clogs without the need for dorsiflexion at the metatarsophalangeal joints. A similar effect can be produced on shoes by the addition of several layers of leather between the two layers of the sole,

Fig 5 Rocker sole

Thus giving the plantar aspect of the sole a pronounced curve. With a shoe of this type the patient's body-weight rolls from the heel to the tip of the shoe and, in addition, the sole acts as a splint preventing flexion across its mid point. The disadvantage is that the sole is usually at least 1/2 inch (1.25 cm.) thick at the level of the metatarsophalangeal joints and, therefore, the heel of the shoe must be raised by an equivalent amount. Also, in unilateral hallux rigidus, a similar alteration must be made to the other shoe so that the patient can stand on an even base. This alteration of the shoe is heavy and is only applicable to the more sturdy variety of shoes, but does enable the wearer to walk heel and toe without increased effort (see Fig. 26.)

(c) Metatarsal bars. Two varieties of metatarsal bars are prescribed, outside and concealed.

An outside metatarsal bar consists of an extra layer of leather applied across the sole of the shoe on its plantar surface immediately behind the metatarsal heads which, if applied correctly, will be curved across the shoe to follow the skeletal shape. When newly applied, a metatarsal bar will produce a rocker-like effect but it rapidly wears down to lie flush with the sole of the shoe anterior to the metatarsal heads and is, therefore, ineffective. In addition, if the shoe is not sturdy enough to take the localized strain imposed upon it, the sole becomes deformed so that its inner surface is lifted up producing the effect of a metatarsal insole, the metatarsal heads being supported from inside the shoe but there is no rocker effect on the outside. Indeed, this is probably the way in which metatarsal bars (see Fig. 6) are of value in other conditions of the foot (see pes planus anterior).

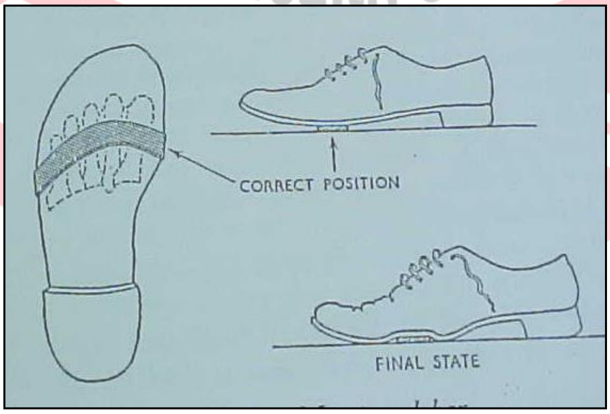


Fig 6 Metatarsal bar

Concealed metatarsal bars have the same design but are placed between the two layers of the sole. They, therefore, do not wear down as readily as do the outside bars but the resistance to deformity of the sole is reduced because only one layer of leather is between the bar and the foot and, therefore, the likelihood of shoe deformity is greater. In effect, a metatarsal bar does produce a minor degree of rocker sole until deformity of the shoe occurs but even before the deformity is present, the bar is usually inadequate and ineffective.

CONCLUSION

It will be seen that of the above appliances the one most likely to be of value is the rocker sole, although its application is limited to those patients who are willing to wear a heavy shoe with a thick sole. The appliance looks incongruous on light footwear but equally this type of footwear cannot be used for metatarsal bars or steel sole plates. Surgical methods of treatment are more satisfactory for hallux rigidus but the above appliances may be of help when operation is contra-indicated.

SHORT FIRST METATARSAL

This condition, extensively investigated by Drs. Harris and Beath in members of the Canadian Forces, has been implicated in many conditions which produce symptoms in the forefoot. It has been blamed for pes planus anterior, planovalgus feet and Morton's metatarsalgia, which is a condition in which the heads of the 2nd, 3rd and 4th metatarsals produce pressure on the digital nerves, and, therefore, pain radiating to adjacent sides of two toes. In their paper, however, they have demonstrated that the incidence of these symptoms is not greater in a patient with a short first metatarsal than in any other patient. Nevertheless, the clinician may feel that some form of correction is indicated in a given case and the following appliances can be expected to prove satisfactory:

(1) Rose's insole.
(2) Metatarsal pad.
(3) Metatarsal insole

HYPERMOBILE FIRST METATARSAL

It is relatively common, particularly in young patients, and certainly with those with Ehlers-Danlos syndrome. In the normal foot there is a small range of passive dorsiflexion and plantar flexion of the first metatarsal occurring at the medial cuneiform-metatarsal joint. In this condition, the range of movement exceeds that normally found and, in extreme cases, may reach 30 degrees. When weight-bearing, therefore, the first metatarsal is passively dorsifiexed and to secure stability the foot moves into eversion, thus producing one of the varieties of planovalgus foot. It is possible by a muscular effort on the part of the patient to correct eversion of the foot, but this correction is not maintained on normal walking. It is necessary, therefore, to provide a passive supporting insole in order to avoid the formation of a fixed planovalgus foot. The appliances likely to be of value are the various forms of valgus insoles likely to be of value are the various forms of valgus insoles which are all described in the section on planovalgus feet, or Rose's insole which is described in the section on pes planus anterior..

METATARSUS PRIMUS VARUS (Metatarssus adductus)

DESGRIPTION

In the normal foot it is obvious that the breadth at the base of the metatarsals is less than at their heads. The metatarsal axes, therefore, diverge from one another. The angle between the axes of the first and second metatarsals has been the subject of many papers over the past twenty years and the upper limit of normal has not been established to the satisfaction of many anatomists. However, most writers would agree that divergence in excess of 10 degrees is abnormal.

Several authors see that a deviation in excess of 10 degrees is normal during fetal development and its persistence into adult life is simply a failure of the normal progression. He compares the human foot with that of apes and monkeys, finding that creatures have a wider angle between the first and second metatarsals than have terrestrial animals.

Other workers consider that metatarsus primus varus is an acquired condition, developing during childhood.

From the clinician's point of view, it certainly seems to be more common in the 14-year-old girl than in a child of 10 years younger. Some orthopaedic surgeons consider that it is the cause of hallux valgus but others maintain that hallux valgus leads to a varus position of the first metatarsal. The clinical impression gained in school clinics suggests that either can exist without the other and that neither is an essential precursor of the other.

Fig 7 METATARSUS PRIMUS VARUS

CONSERVATIVE TREATMENT

The problem is to prevent an increase in the distance between the first and second metatarsal heads. The obvious way of doing this is by wearing a firm strap round the foot at the level of the metatarsal necks, and this is provided easily by a metatarsal pad. Since this loses its elasticity after a few weeks, however, it is unlikely to be of any lasting value unless renewed at frequent intervals.

PHYSIOTHERAPY

The only muscle likely to exert any restraining effect on the first metatarsal is adductor hallucis and it is difficult to see how selective exercise of this small muscle deep in the sole of the foot could be achieved.

PLANOVALGUS FEET

This deformity is the so-called 'flat-foot'. The term, although used so commonly, is strictly not correct in that the arch of the foot is frequently preserved, but on superficial examination, the appearance suggests that the arch is flattened. Careful inspection however, shows that the deformity is eversion of the foot at the talonavicular and talocalcaneal joints and when viewed from the posterior aspect, the heel is seen to be in valgus, the medial border of the foot approaching the ground in the same way that a bucket handle approaches the side of a bucket when released from the hand. Excessive weight is taken along the medial border of the foot and when footprints in the weight-bearing position are taken, the normal concavity along the medial border of the foot is no longer present. The skin may be in contact with the ground, but the bony arch of the foot can still be present in its normal form.

If the shoe habitually worn by a patient with planovalgus deformity is examined, it will be seen that the weight is taken along the medial border of the sole and the top line of the shoe deviates towards the medial side. In other words, when viewed from above, the axis of the opening of the shoe is not in line with the shoe, but deviated medially. If this deflection is carried to an extreme, the structure of the shoe is broken down over the mid-point of the longitudinal arch (see Fig.8).

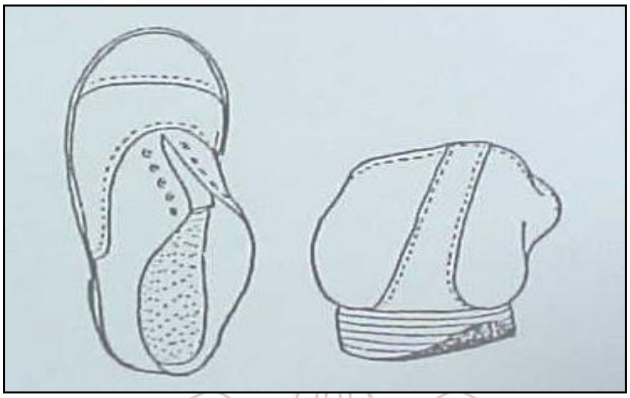


Fig 8 Deformation of shoe in planovalgus foot

COMPLICATIONS

Shortening of the soft tissues on the lateral side of the foot and ankle occurs so that it may not be possible to correct the valgus position of the heel while maintaining full dorsiflexion of the foot. Faulty alignment in the tarsus will lead to degeneration in associated joints.

ASSOCIATED CONDITIONS

Hallux valgus, metatarsus primus varus and pes planus anterior are all commonly seen.

AETIOLOGY

This condition is very commonly seen in small children aged between 2 and 5 years and they frequently have lax ligaments in their knee joints, giving apparent genu valgum. This is so common as to be almost physiological in this age-group. If children are watched, without any form of treatment, but are encouraged to run about normally, the condition usually corrects spontaneously by the age of 5 years. It is probable, there fore, that this is simply a phase of development in which their body- weight exceeds their muscle-power and with the loss of puppy- fat and with the increase of activity at the time of staring school, the deformity is overcome naturally.

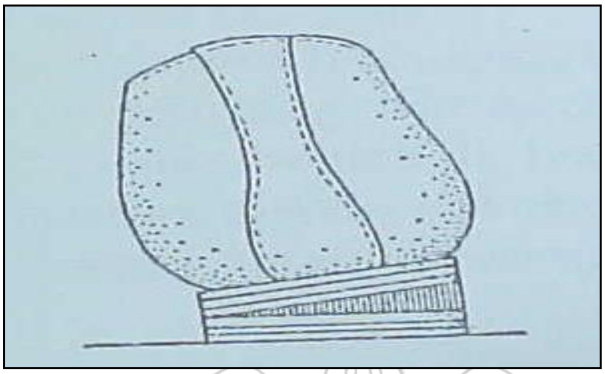
The next age-group in which this is commonly seen is in the 10 to 15 years group, whose parents complain that they wear shoes out rapidly and are often disheartened at not being able to run as fast as their fellows at school. At this age, the foot is still mobile and fixed contractions have not yet developed. The heel can be placed in the normal position under the talus and with concentration, they are usually able actively to maintain the arch for a short period.

The third group is in adult life when the deformity may still be mobile, but is frequently fixed and sometimes symptomless.

APPLIANCES

In the young child nothing needs to be done since normal activities in the great majority of cases result in spontaneous correction. If it is decided that treatment is needed, several methods are available.

Wedge heel. A wedge inserted on the **medial side** of the heel, with or without a wedge on the medial side of the sole, may correct the deformity until body-weight damages the strengthening inserts in the shoe construction. If wedging is to be carried out in the heels, this is best applied to leather heels several layers from that surface in contact with the ground as this facilitates repair of the shoes in the future (see Fig. 9).



(Fig 9) Wedged heel

However, with the increased use of plastics and synthetic rubbers in the construction of children's shoes, this possibility is rapidly receding and one has to rely on a wedge of rubber stuck on the surface. In most children, this wears off within two or three weeks and must be frequently replaced. Cork wedges may be inserted inside the shoe at the heel, but these are impossible to keep in place unless they are stuck in position.

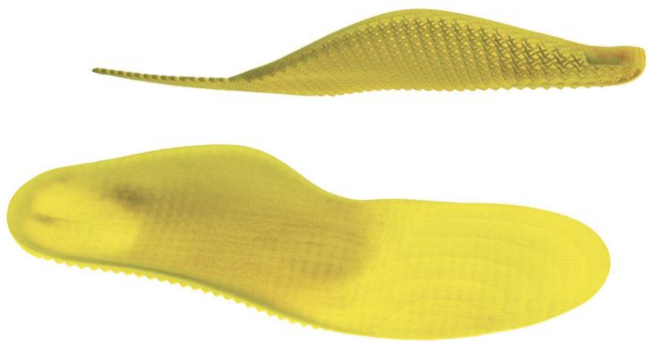
Insoles. Many types of insoles have been devised, both full length and three-quarter. They may be subdivided into two groups, active and passive.

The best example of the active insole was described by Whitman and consists of a metal arch support bearing flanges on its medial and lateral borders, the lateral flange extending up the side of the os calcis in such a way that the heel is gripped between the medial and the lateral flanges. Its shape is such that the os calcis is held in the normal position (see Fig. 10).

Fig 10 Whitman insole

The patient is instructed that when walking, he should throw his weight on to the outer side of his feet. This presses on the outer flange thus lifting the medial side of the sole plate against the foot. If, when walking in this way, the patient turns his toes outwards, he produces pain, and, therefore, tends to adopt the heel-toe gait. The function of this appliance is reminiscent of the kugeleinlage described by spitz which consists of a leather insole on which is mounted a marble underneath the medial arch of the foot. So long as the patient with this appliance maintains the arch actively, there is no discomfort, but when he allows the arch to fall, the marble presses on the underneath of the foot and he instinctively draws it away. This is probably the most effective way of maintaining an arch although by far the most uncomfortable.

Passive supports of the foot are simply props which hold the foot in the desired position without any effort on the part of the patient. They are usually made from, or covered in, leather and there are pads along the medial margin extending two- thirds of the way across the foot. Some have a flange which Projects up the medial side of the foot and is expected to support the first metatarsal and cuneiform. Since this flange is usually made of thin leather, its long-term effect is negligible. The applied pad on most of these insoles consists of rubber or felt, covered with leather (see Fig. 11).



(fig 11) Valgus insole

The important face to consider when advising an appliance of this nature is the best shape of the arch which can be achieved without discomfort. If a patient has a rigid flat foot, any attempt at reforming an arch will inevitably produce pain. It is wise, therefore, to ensure that any prop provided does not overcorrect the deformity.

One must also ensure that the structure of that prop is such that it will not pack down after a few weeks. Thus, the best combination that has been found to support a heavy man is a shaped metal insole provided on its undersurface with a pad of solid rubber. In theory, this should be an excellent appliance, but in practice it is not possible to have these metal insoles shaped accurately to a given foot. A compromise can often be achieved by making the insole of a firm plastic to a cast of the foot and sticking sheet rubber in layers on the undersurface, trimming it to produce a contour which approximates to the shape of the inner surface of the shoe.

A shaped heel-socket made of fibre-glass has been devised by Helfet with the aim of gripping the heel and correcting its position by a plantar wedge which is integral with the heel grip. This appliance is worn inside the shoe, but by its nature is so thick that a larger size of shoe is essential (see Fig. 12).

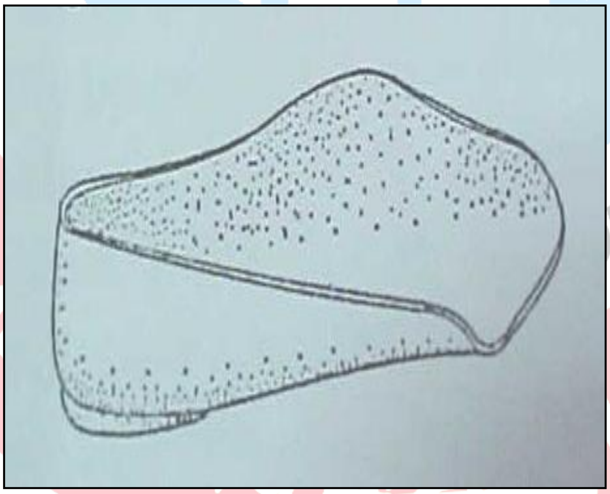


Fig 12 Helfet insole

Experience with this appliance shows that it does correct the deformity very well provided that the original cast on which the fibre-glass is shaped is an accurate representation of the foot. During use, there is inevitably some movement of the heel within the socket and this small range of movement is sufficient to produce frictional changes in the skin. The movement of the os calcis on the fatty plantar tissues of the heel is sufficient to allow a small degree of eversion to occur and this movement thousands of times a day does produce rubbing at the anterior margin of the appliance. Indeed, it is not uncommon for bursae to develop over the medial border of the navicular and although these usually subside rapidly when the appliance is no longer worn, it is possible that the effect is as much due to spitz's kugeleinlage as to the mechanical corrective position of the appliance.

Floated heel. This consists of prolongation of the heel in a medial direction and tends to correct the valgus position of the heel provided the heel of the shoe grips the os calcis firmly.

An elongated (Thomas) heel is often used and is copied in a minor way by at least one shoe manufacturer. This is a prolongation of the heel along the medial border of the shoe to the level of the waist. Its effect is best seen when the eversion of the foot is so great that the deviation of body-weight to the medial side of the shoe is sufficient to destroy the normal arch of the shoe (see Fig. 13).

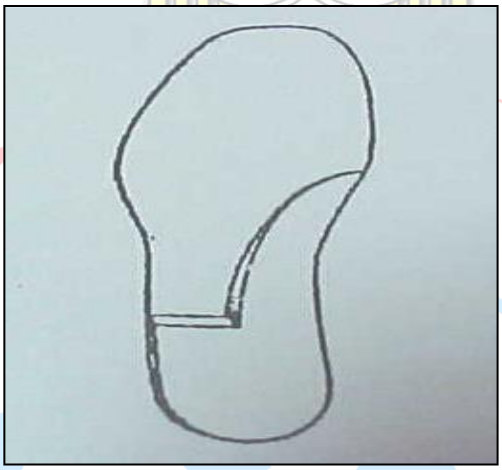


Fig 13 Tomas elongated heel

The destruction of the shoe is effectively prevented by the Thomas heel but because of the movement which occurs between even a well-fitting shoe and the foot, it is difficult to see how any correcting force can be transmitted to the foot. this is also tru of the use of wedges in shoes except when they are new and the heel counter is firm and closely fitting. In general, I think it is fair to say that these appliances can all act as suitable props to hold the foot in a corrected position, but one must expect them to have little curative value. It may well be that, in the adult, simple propping up is all that is required and under these circumstances, these appliances fulfil their function.

PES PLANUS ANTERIOR

SYMPTOMS

The patient will probably complain of pain on the forefoot or on the plantar surface of the forefoot, perhaps radiating down the adjacent borders of two toes. He may also complain of thickening of the skin on the plantar surface of the foot and there is frequently generalized aching over the dorsum of the foot. It is thought that this is the result of muscle strain because of an altered walking pattern.

APPEARANCE

In the normal foot at rest, the pillars of the anterior transverse arch are formed by the heads of the first and fifth metatarsal heads, the intermediate metatarsal heads lying at a slightly higher level. During weight-bearing, however, these metatarsal heads descend to lie on the same horizontal plane as the pillars of the arch, but investigation of the load taken by the metatarsal heads when standing has shown that the second, third and fourth metatarsals bear a smaller proportion of the body-weight than do the first and fifth. Pes planus anterior is an alteration of this normal distribution of weight in which the second, third and fourth metatarsals take a higher proportion of weight than is usual, and indeed, may even take the majority of the body-weight. Work hypertrophy of the skin under the affected metatarsals produces the common callosities which may form either an oval area under a single metatarsal head or a reniform area underlying three metatarsal heads. If the patient complains of 'shooting' pains radiating along adjacent borders of the toes, pressing between metatarsal heads will frequently reproduce this symptom which is the result of pressure on a digital nerve as it lies between metatarsal heads. If one is in doubt about this involvement of the digital nerve, an anaesthetic block to the nerve at the level of the metatarsal shafts will always relieve the 'shooting' pain, but the discomfort of increased weight-bearing under the metatarsal heads will remain.

ASSOCIATED DEFORMITIES

It is common to see clawed toes, perhaps with dorsal dislocation of metatarsophalangeal joints. Hallux valgus and metatarsus primus varus are frequently present and pes cavus from any cause is always associated with pes planus anterior.

COMPLICATIONS

The only complication of note is Morton's metatarsalgia, i.e. pressure on a digital nerve as it passes between the metatarsal heads. It is this which leads to the pain radiating down the adjacent borders of two toes.

PATHOLOGY

(a) Muscle in balance from any cause.

(b) A period of prolonged bed-rest with insufficient rehabilitation, especially if there is an injury to a lower limb. In this event, however, it is likely that the side affected will be that of the fracture, or if bilateral, the changes will be more marked on the previously injured side.

APPLIANCES

All the appliances available are intended to relieve the additional weight-bearing of the middle three metatarsal heads by increased pressure under the shafts of those metatarsals. *Metatarsal pads*. Two varieties of these exist. The first, and most satisfactory, can be added to the shoe and consists of a pad of felt perhaps covered with leather stuck to the inner aspect of the sole. This should be placed in such a way that it lies immediately behind the metatarsal heads and of such a height that it reduces the weight borne by those structures. The pads of course, must be inserted in each pair of shoes that the patient has.

Removable metatarsal pads consist of a small pad of felt or sponge rubber covered with leather attached to which is an elastic strap which passes round the forefoot. When worn it is unable to move towards the toes because of the presence of the metatarsal heads and its lateral displacement is restricted by the first and fifth metatarsal heads on either side.

Its posterior displacement, however, is limited solely by the tension in the elastic straps and it is unlikely that this, even when new, has sufficient tension to prevent displacement when walking. If the appliance is worn under the sock, it is more stable than when worn over the sock, but in either position it is unlikely to remain in place for long.

Fig 14 Metatarsal pad

Metatarsal insoles. These structures consist of an insole of three quarter or full length (see Figs. 15 and 16) in which is built the felt or sponge rubber pad. Movement of the insole within the shoe is prevented by the insole itself abutting against the upper and it must of course be made so that the pad lies immediately behind the metatarsal heads and lifts them sufficiently to

Relieve weight. They may be made of plastic or metal and provided that the pad is sufficiently incompressible, either of these is satisfactory. It must be stressed, however, that a heavy person will compress a pad far more than one would expect and the writer has seen metal insoles broken under the weight of a man weighing 15 stones.

Fig 15 Three quarter metatarsal insole

Fig 16 Full-length metatarsal insole

Rose's insole. This type of insole may be three-quarter or full length, but the pad is of such a size that it completely fills in the transverse and longitudinal arches of the foot. Thus the pad extends from the metatarsal necks to the anterior margin of the os calcis and lies under all the metatarsals, but is manufactured in such a way that its maximum height in the longitudinal plane is about 1/2 inch (1.25 cm.) behind the metatarsal necks and its maximal height in the transverse plane is under the second metatarsal shaft (see Fig. 17).

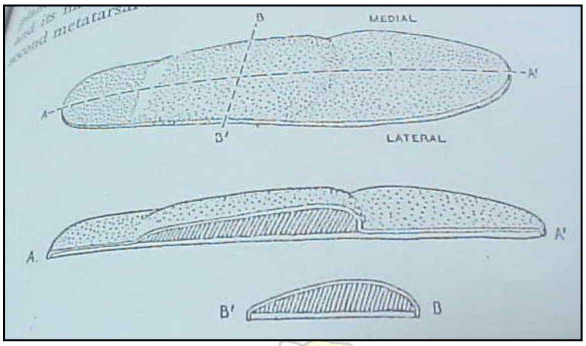


Fig 17 Rose insole

Metatarsal bars. There are two varieties of metatarsal bars available: the surface ones and those which are concealed. The surface type is a curve of several layers of leather applied to the sole of the shoe just behind the metatarsal head level. The concealed variety is a similar-shaped structure applied between the layers of the sole (see Fig. 18).

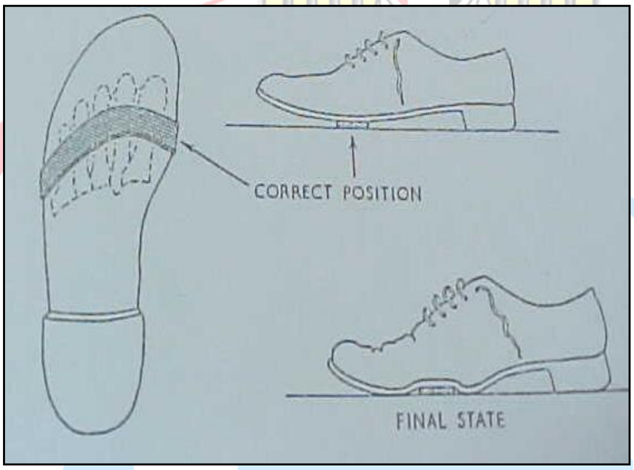


Fig 18 Metatarsal bar

When one is ordering an appliance of this nature, one must consider very carefully the needs of the patient. If one accepts that relief of symptoms can be achieved by reduction of weight- bearing by the intermediate metatarsal heads, one must consider how this can be achieved by the use of a metatarsal bar.If one imagines a patient who has a shoe, the sole of which is so stiff that his body-weight does not deform the sole when a metatarsal bar is in situ, it is difficult to see how the bar can relieve weight from the metatarsal heads. If one accepts that no weight is taken from the metatarsal heads under these conditions, one would obviously not order metatarsal bars.

If you consider, then, a patient with a shoe, the sole of which is deformed by his body-weight when wearing metatarsal bars, one must think what happens to the bonding material between the two layers of the sole when they are deformed. In either case, the upper layer of the sole is forced into a sigmoid Curve, the middle third of which is convex upwards and its course is, therefore, longer than that of the lower layer of the sole, but these two layers have been applied and bonded together with the upper surface concave. Therefore, there will be considerable strain on the bonding material and in the case of sewn soles, it is almost certain that the stitching will give way. It is difficult to see how an effective relief of symptoms can be achieved without irreparably damaging the structure of the shoes. Certainly, with the single layer of sole present in most ladies' shoes, one can only use a surface bar and the sole of the shoe is so thin that deformity of the shoe is inevitable. It means, therefore, that the patient either uses shoes which are not deformed by the bar, and, therefore, the bar is ineffective or the shoes must be destroyed by the bar if they are to produce relief of symptoms. Experience has shown that an equal relief of symptoms can be achieved by the use of metatarsal insoles and, therefore, it would seem that metatarsal bars for pes planus anterior are unnecessary.

Chapter 5

Birth defects and abnormalities of lower limb

Objectives

- Introduction to orthotic principles and rehabilitation of upper and lower limb orthoses
- Understanding benefits of upper limb orthotic in rehabilitation
- Understanding benefits of lower limb orthotics in rehabilitation
- Rehabilitation following upper and lower limb orthotic administration

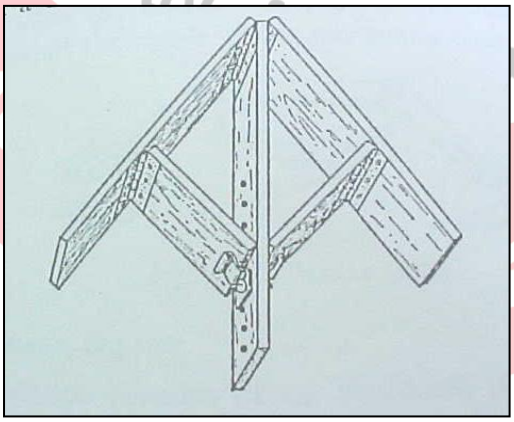
Abnormalities of the Lower Limb

APPLIANCES FOR CONGENITAL DISLOGATION OF THE HIP

These appliances are all based on the assumption that a dislocated hip, once reduced, will remain stable so long as that hip is kept in abduction. Since it is impossible to maintain one hip in full abduction without a comparable position on the other side, the appliances are all symmetrical and control the position of both femora.

Divaricator

One of the earliest devices used was described by Putti and was termed a divaricator. It consists of three strips of wood



(Fig 1) hip divaricator

Approximately 15 inches (38 cm.) × 3 inches (7.5 cm.) hinged together at one end. The outer pieces of wood carried near heir free ends a further hinged piece, the end of which, when abutted against the central strip, produced divarication of the outer sections. This appliance was placed between the abducted lower limbs of children, having first reduced the dislocation, and the limbs were bandaged in position. It had the advantage that the degree of abduction could be controlled, but the disadvantage that the appliance was not convenient for use unless the child was confined to bed (see Fig. 1).

THIGH ABDUCTION SPLINTS

Several patterns of this appliance based on the same principle have been described, the main difference being in the method of fixation to the trunk. The basic pattern consists of two thigh corsets made from block leather, plastic or some other firm material. These corsets lie with their central axes in the same straight line and are held apart by a bar of metal which is

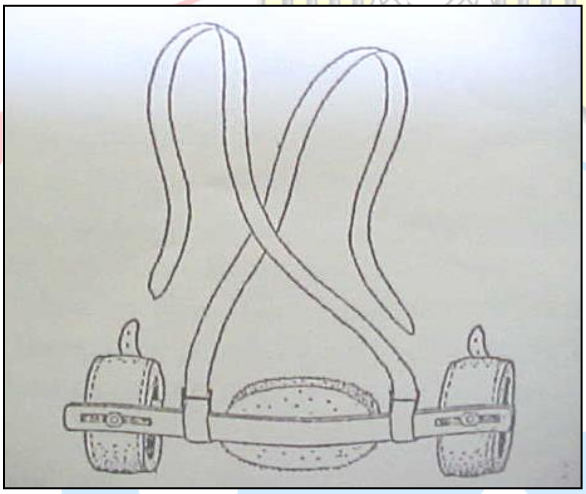


Fig 2 thigh abduction splint

curved to fit across the lower part of the trunk. Some authors have considered that the bar should lie across the pubis, whereas others have described it lying across the sacrum it is clear that if it is applied lying across the sacrum it could rotate to lie either caudally or over the pubic site unless some form of restriction is provided. This may consist either of a waist band and suspensory straps or the full shoulder harness. If applied across the pubis attempted adduction of hips will allow the crossbar to move away from the body and pressure will be applied on the outer margins of the thigh corsets, producing redness and soreness of the skin just above the medial femoral condyles. Nevertheless, the anterior piece is generally more comfortable for the baby since he is able to lie on his back without undue pressure on the sacrum (see Fig. 2).

When the crossbar is in the dorsal position the pressure in attempted adduction tends to be more widely spread over the medial surfaces of the thighs and this does not lead to skin trauma, but unless the posterior bar is well padded, discomfort is found over the sacrum when the child is supine. Few children are willing to lie on their faces for most of the day.

THE BLANCHE SPLINT

This is a version of the above which consists of a central metal bar carrying a curved metal strip which, together with a fabric strap, encircles the waist. Hinged on either end of this bar and held with winged nuts is a short metal bar which carries on its free end the thigh corset. The corsets are fixed in such a way that their central axes can be adjusted. This appliance, therefore, does allow the degree of fiexion of the abducted hip to be adjusted to suit the needs of the particular case (see Fig. 3)

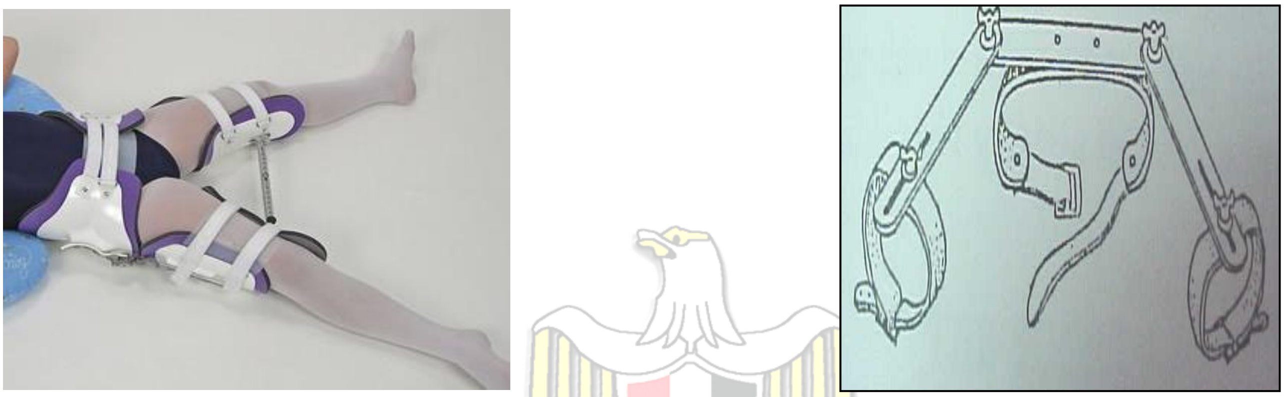


Fig 3 Blanche splint

THE VON ROSEN SPLINT

This appliance consists of an H-shaped piece of malleable metal covered with a rubber compound. The crossbar of the H is extended on either side. This appliance is very useful for maintaining flexion and abduction of the hip in small babies. In use the appliance is flattened, the baby placed on top and the upper extremities of the H carried down over the child's shoulders. The extended crossbar is then bent to lie round the waist. The hips are then educed and the lower extremities of the H curved in a spiral round the thighs to hold them flexed and abducted at 90° each (see Fig. 4).

Fig 4 Von Rosen splint

This appliance is very useful for the small baby but depends entirely on the child's muscles being unable to overcome the resistance of the metal frame. Thus it is unsuitable for a child who is gaining muscle strength where it is not possible to maintain the hips in the fully abducted and flexed position. Even a young baby can produce remarkable power of extension of the hips unless they are held in the fully flexed position.

FREJKA PILLOW

This appliance differs from those mentioned above in its design, but nevertheless fulfils the same function. It consists of a firm pillow, often divided transversely into three sections. It is applied to lie over the sacrum, between the legs and on to the abdomen. The width of the pillow should be just less than the distance between the popliteal fossae when the hips are flexed and abducted to 90°. The appliance is held in position by shoulder straps which should be joined together over the upper pat of the dorsal region to prevent them sliding off the shoulders. Further straps pass from the lateral margin of the dorsal segment to a corresponding site on the ventral aspect, thus ensuring that the pillow is firmly held against the perineum (See Fig. 5).

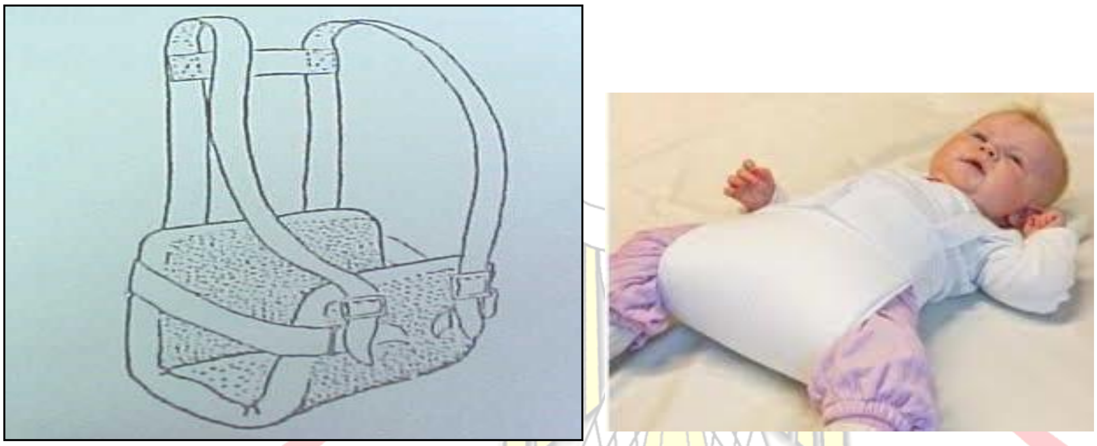


Fig 5 Frejka pillow

SUMMARY

I think it is fair to say that the von Rosen and Frejka appliances are extremely useful in the young baby but are of little value in the older child. The abduction splints described in the earlier part of this chapter are, on the other hand, of more value for a child who is a few months old or who has needed either surgery or a prolonged time in a frog plaster. They could also be conveniently used as night splints in the final stages of treatment.

THE SHORT LEG

The classical examination for inequality of leg length takes place with the patient lying supine. The lower limbs are adjusted so that a line joining the anterior superior iliac spines is at right angles to the mid-line of the body. The distance from one anterior superior iliac spine to a bony prominence, usually the medial malleolus, is measured on one side and compared with the similar measurement of the other side. It is notoriously difficult to achieve an accurate reading and the method is quite inadequate for careful estimation when considering the degree of raise to be added to a patient's shoe.

Indeed, since inequality of leg length is quite unimportant when the patient is lying down, the most accurate, practical method of measurement is as follows. The patient should stand, taking equal weight on both feet, the knees to be straight and the pelvis tilted if this is necessary to get both feet on the floor. The distance from the anterior superior iliac spine to the floor is then measured and the difference between the two sides will indicate the amount of shortening. Should the position detailed above be impossible to achieve, the short leg is supported on wooden blocks until this condition can be achieved Measurement of both sides is then made and to the difference between these two sides is added the height of the wooden blocks to give an accurate measurement of the total difference.

When considering how best to compensate for this shortening by alterations of footwear, one must take into account several features, notably the degree of shortening which is present, how much of this can be safely compensated by tilting the pelvis, how much the raise necessary can be compensated by leaving the foot in equines and how much of the footwear can be hidden by the patient's clothes. It is obvious that a raise of 1 inch (2.5 cm.) would be clearly seen in the shoes of a young woman but would largely be hidden by a man's trousers.

Also, a shortening of 1.5 inches (3.8 cm.) could be achieved by adapting a man's shoe, whereas a similar shortening in a woman would require a custom-made shoe.

There is commonly an inequality of leg-length in the normal individual and differences up to 0.5 inch (i.25 cm.) can be readily ignored. Beyond this, some degree of correction is advisable because the pelvic tilting of the uncorrected state leads to a scoliosis which, in the long run, will predispose towards lumbar degenerative changes, backache and subsequent morbidity.

(1) Raises up to ⅜ inch (1 cm.) (i.e. ⅞ inch (2.2 cm.) total shortening, 0.5 inch (1.25 cm.) of which is uncorrected) can be achieved by insertion of a cork or leather wedge to the inner aspect of the heel of the shoe. No alteration to the shoe itself is required, beyond sticking this wedge in place; therefore, one wedge will be needed for each pair of shoes.

(2) Raises in excess of this amount and up to 1 inch (2.5 cm.) in height, can be accommodated in a man's shoe by addition to the heel, with perhaps a little reduction of the other heel. When these raises are inserted, it is necessary that the posterior Edge of the heel should be raised to a greater extent than the leading edge. If this obliquity of the heel is not produced, the patient will stand either with the leading edge of the heel and the sole of the shoe on the ground, or with the plantar surface of the heel on the ground and the sole clear. While he necessity for this wedging is apparent to surgical shoe-makers, it is often difficult to persuade the patient's local shoe-repairer to give a raise in this manner and an explanation to the patient is necessary in order that he may pass on the information. The amount of raise necessary is applied at the posterior edge of the heel and the raise of the anterior edge is estimated so that the flat of the heel and the sole of the shoe are on the ground at the same time. This wedge effect is best applied several layers Below the surface of the heel in order that subsequent repairs of the shoe should not involve skiving layers of leather on each occasion repairs are performed (see Fig. 6).

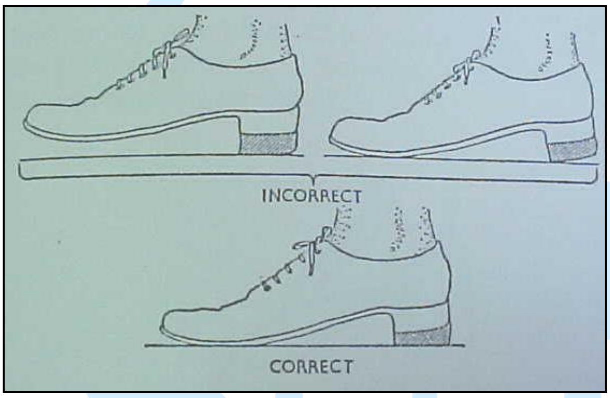


Fig 6 Heel raise

(3) Rand cork raise. Raises of between 1 inch (2.5 cm.) and 3 inches (7.5 cm.) can be inserted in a commercial shoe by use of the Rand cork method. In this technique, the upper and the sole are separated and a cork block suitably shaped and covered With leather is inserted between the two. It is customary for this to have its maximum height posteriorly and to taper off towards the toe, thus the equines opposition of the foot reduces the amount of cork necessary and therefore, reduces the weight of the finished shoe. When ordering appliances of this nature, it is usual to stipulate the height at the heel and at the toe. Thus, a suitable order might read: 'Rand cork raise 2 inches (5 cm.) at the heel, tapering to 0.5 inch (1.25 cm.) at the toe' (see Fig. 7).

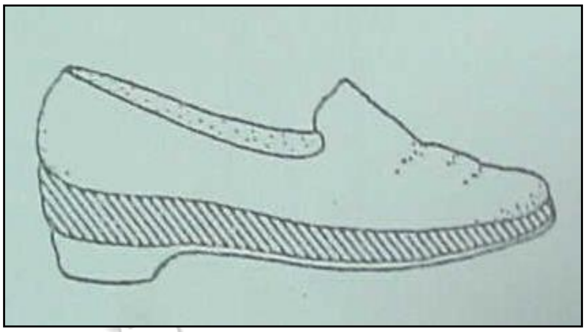


fig 7 Rand cork raise

In recent years there has been an increasing number of shoes on the market in which the uppers and synthetic soles are welded together; a Rand cork cannot be applied to this variety of footwear.

(4) Inner cork raise. An increase of a similar height can be achieved be a surgical shoe with an inside cork block; thus a shoe is made of an orthodox design but with the upper deep

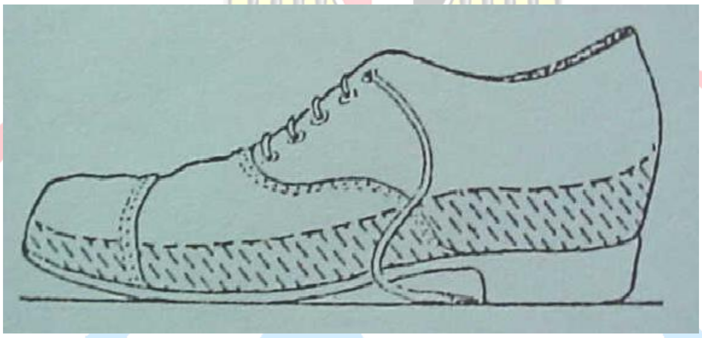
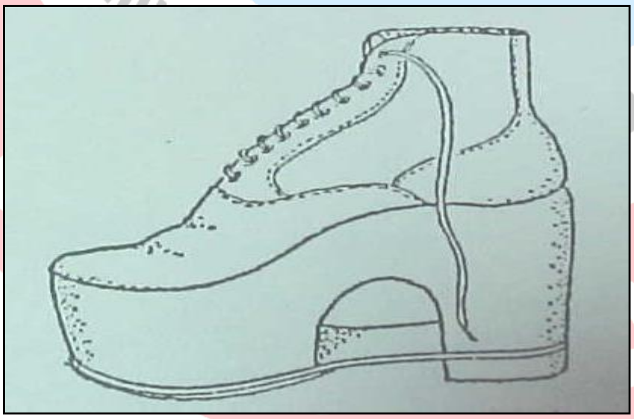


Fig 8 Inner cork raise

enough to accommodate the patient's foot plus a cork block to compensate for his shortening. When ordering a raise of this type, it is essential to order a normal shoe for the other side. An appliance of this nature is obviously much less apparent when worn by a man, since only the lower part of the upper is seen below the trousers (See Fig. 8).

(5) Outside cork compensator. For raises of over 2.5 inches (6.25 cm.), an outside cork compensator can be used. This consists of an orthodox upper attached to a cork block of any height desirable. When the heel and sole are more than some 3 inches (7.5 cm.) in height, it is necessary to fit a bridge passing from the heel to the sole since this considerably strengthens the appliance. The appearance, however, is cumbersome and the weight considerable (see Fig. 9)



(fig 9) Outside cork compensator

(6) O'Connor boot. For really large inequalities, the O'Connor boot is the most cosmetically acceptable. This consists of the upper of a shoe with the foot in considerable equines. Extending from this is a light wooden strut covered with leather and shaped to fit into a shoe at the lower end. Thus inequalities in excess of 6 inches (15 cm.) can be adjusted and certainly in long trousers the appearance is of two normal feet. the difficulty, of course, is the considerable weight of these appliances, and also the great equines in which the foot is placed resulting in

the toes becoming cramped in the equines boot. This can be corrected to some extent by very careful shaping of the boot and by tight lacing, which brings its own problems (see fig. 10).

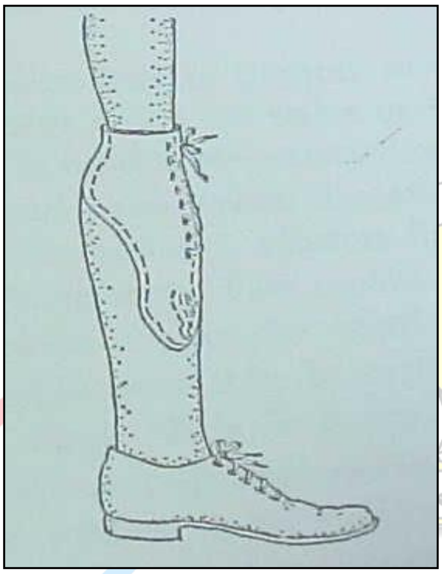


Fig 10 O Connor boot

FOOT- DROP

Aetiology. Two basic groups of conditions apply to foot-drop:

(a) paralysis of the muscles of the anterior compartment of the foot from any cause thus, anterior poliomyelitis, nerve lesions, etc., may be implicated.

(b) Division of the extensor tendons.

In either group of conditions one is left with a simple foot-drop which is maintained by gravity. Some degree of inversion is frequently present, since the causative lesion often involves peroneal tendons also.

On examination, the position of the foot is distinctive; there is loss of function in the appropriate muscles and in cases of nerve injury or dysfunction, there may well be sensory disturbances also. The gait of the patient is pathognomonic, the leg on the affected side being excessively flexed at the hip and knee to allow the toe to clear the ground when taking a pace forward. When the foot is applied to the ground, the toe often strikes the ground first and this produces a distinctive sound which can be recognized before the patient comes into view.

APPLIANCES

These consists of two varieties,

(a) passive prevention of the deformity and

(b) active correction of the deformity, the latter inevitably involving the use of springs of one sort or another.

Passive appliances. These consist of single or double irons, the decision between the two being made on the need to correct Inversion of the foot at the same time. In a foot-drop without varus, a single iron, usually outside to avoid trauma to the other leg, is provided. This is attached to the leg at the upper extremity by a calf band, and at its lower end a round spur articulates with a round socket set in the heel of the shoe. Attached to this socket is a short metal bar projecting laterally and proximally beside the heel which butts against the lower posterior 1 inch (2.5 cm.) of the iron and prevents the foot from falling into equines. A strap passing closely round the ankle and the iron prevents the spur from sliding out of the socket during walking (see Fig. 11).

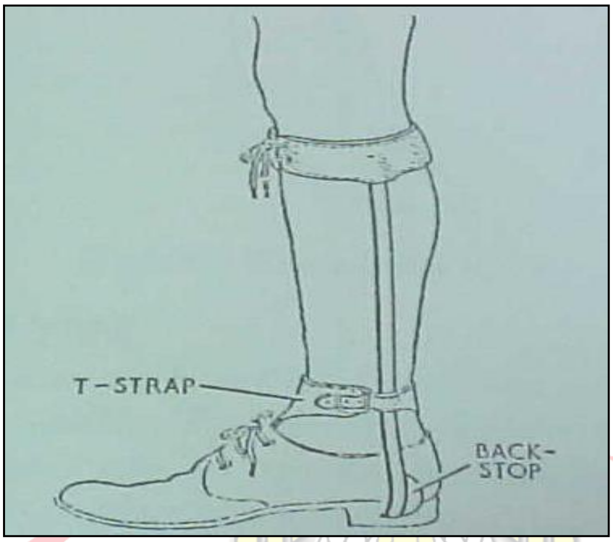


Fig 11 Outside iron with inside T-strap and back- stop

If inversion is also present, it may be controlled in a light person by an inside iron and outside T strap which also replaces the ankle strap, but in a heavy or very active patient double below-knee irons may be required, although a single back-stop is sufficient.

Because of the absolute bar to plantar flexion, the patient does experience difficulty when on stairs or when descending hills. On the stairs he is unable to plantar flex his foot to allow his toe to reach the tread below when descending, and on hills, when his heel strikes the ground, plantar flexion is unable to occur because of the back-stop. This means that the calf band is pressed firmly against the upper third of his leg by the influence of body weight and this, in turn, tends to produce early flexion of the knee. This is not a disadvantage in a patient who has a lateral popliteal nerve injury and normal quadriceps, but in a patient who suffers from the effects of anterior poliomyelitis and who may well have weak quadriceps,' knee-shoot' may occur and lead to frequent falls.

ACTIVE CORRECTING APPLIANCES

(a) Toe-raising spring

A calf band is applied above the maximum circumference of the leg, to which is attached a Y-shaped leather strap carrying on the distal end a spiral spring. This passes to a D ring attached to the toecap of the shoe. It is usual to include a buckle to allow adjustment of length and tension (see Fig. 12)

Fig 12 Toe-raising spring

The appliance possesses several disadvantages:

(1) It is unsightly, especially in females.

(2) The calf band, unless tightly strapped, is pulled down the leg.

(3) The spring causes wear on trousers.

(4) Deformity of the shoe at the level of the Metacarpophalangeal joint occurs and leads to a similar deformity of the foot.

(b) Side steel and spring

An outside iron with a calf band has a hinge joint at the level of the ankle. The section below the hinge bears a projection forwards to which is attached a spiral spring stretched proximally via a strap and buckle to a lug on the Upper part of the side-iron. At its distal end the lower section has a spur, rectangular in cross-section, which fits a socket in the heel of the shoe. Thus the tension on the spring produces dorsiflexion of the foot

This appliance is more acceptable than the toe-raising Spring, but still produces wear on trousers and is somewhat bulky.

A more elegant derivative of this pattern is produced by reemploy, where the spring, which is much shorter and enclosed, is mounted on the posterior aspect of the side-iron immediately above the ankle hinge and is constantly under compression. Adjustment of tension is carried out readily by means of an Allen key turning a screw device on the upper end of the spring enclosure (see Fig. 13).

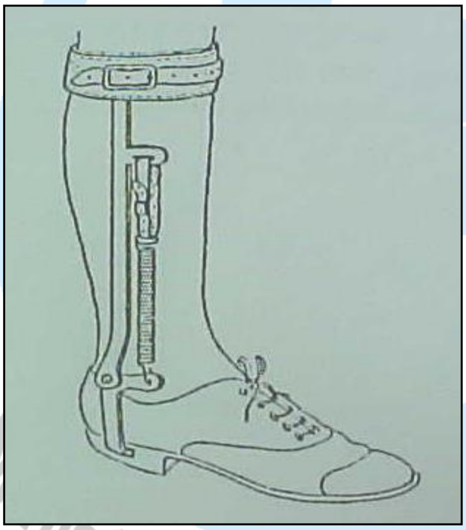


Fig 13 Remploy type toe-raising appliance

(c) Exeter type

In common with other Exeter splints, the appliance is made of spring steel, circular in cross-section, forming the double side-irons and bearing a calf band proximally. At the level of the ankle each side-iron is shaped into two circular turns and continued distally to end as flat spurs. the turns at the ankle joint level allow plantar flexion to occur from the rest position which is in some 10 to 15 degrees of dorsiflexion (see Fig. 14).

In spite of these urns, some whipping of the side bas does occur during walking.

If this appliance fails, the fatigue fracture usually develops where the side-irons are bent at the beginning of the circular turns

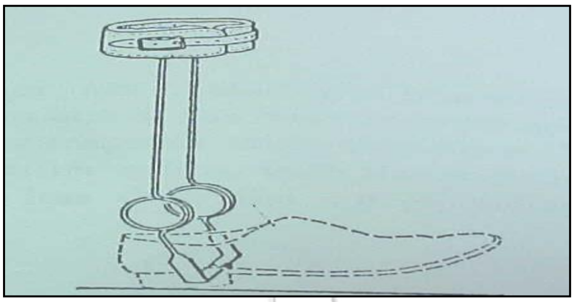


Fig 14 Exeter type toe-raising spring

(d) Stanmore type

Double below-knee irons are used with a calf band proximally, and terminating distally with square spurs, each fitting a socket in the heel. The latter is spring loaded to produce dorsiflexion at rest, and the mechanism is totally enclosed.

The main difficulty in supply is the spring resistance which should be overcome easily by body weight, but experience in supplying the appliance enables the fitter to estimate the required strength of spring readily.

A less efficient type of the same basic design has round spurs and a helical spring set in the heel, but otherwise not

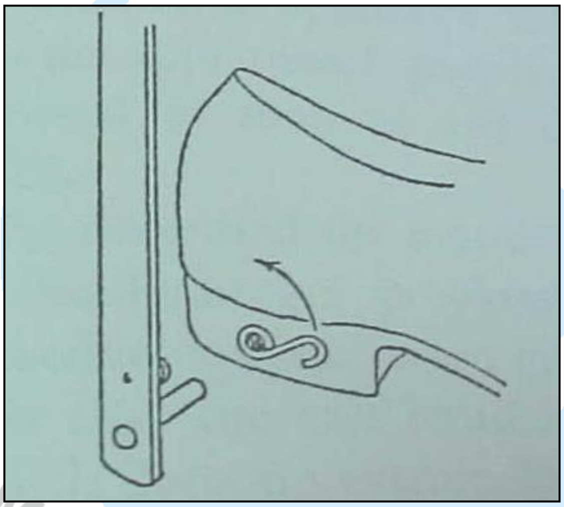


Fig 15 Heel-spring pattern

Enclosed. The end of the spring is formed into a hook which catches on the lower end of one of the side-irons.

Here the difficulty of estimation of the spring strength is greater because of friction between the heel and the turns of the spring, and this is magnified by contamination with water and grit from the roads. In time it becomes very noisy in spite of repeated lubrication (see Fig. 15).

(e) Posterior steel and insole

A calf band supports a flat spring steel lying on the posterior aspect of the calf and terminating in an insole. Behind the ankle the spring deviates from the line of the leg, returning to it just below the ankle to lie against the heel and fit into the shoe. There is an angle of approximately 120° at this point, and it is here that fatigue fractures tend to occur (see Fig. 16).

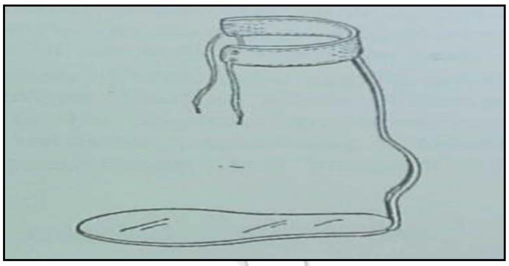


Fig 16 Posterior spring and insole

EQUINUS FOOT

This may be an active equines, the result of a spastic condition from any cause, or a passive equines due to tight posterior structures. the foot is, therefore, held in the deformed position, either by muscle action or by contractures and hence it will be

Impossible to achieve a plantigrade position until these forces have been overcome.

APPLIANCES

Night splints. These are obviously of prime importance. They are best made from one of the more recently developed plastics as this combines cheapness with cleanliness. It consists of a simple posterior gutter splint, with the angle between the calf and foot sections less than the corresponding angle on the

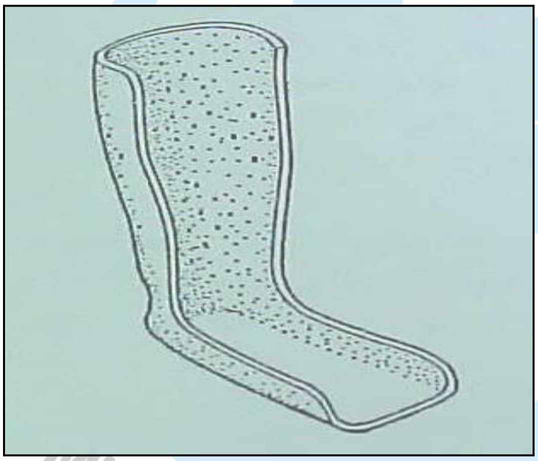


Fig 17 Night splint

Patient. The appliance should be used every night, being bandaged firmly I position in an attempt to overcome the deformity and should be re-made as soon as the heel can be fully accommodated within that appliance. When full correction has been achieved by the appliance, it may be discontinued, but should be recommenced as soon as any degree of equines develops (see Fig. 17).

Toe-raising spring. As described for foot-drop. In addition to suffering from the disadvantages previously mentioned, the force applied in an active equines is too great for this type of appliance. One finds that the calf band is frequently pulled down the leg unless it is done up extremely tightly and this, in itself, could lead to discomfort. In addition, it may result in deformity of the shoe, producing hyperextension of the metatarsophalangeal joint. In view of these disadvantages, this type of appliance is best avoided.

Single or double side-irons

(i) With back-stop as previously described. This suffers from the same disadvantage as when used for fcot-drop, and indeed, one is even more likely to meet a patient whose quadriceps are weak and, therefore, ‘knee-shooting’ is more frequently seen.

(ii) Flat spur with ankle hinge and side spring. It is likely that double springs will be necessary, but with this modification, this is probably the most satisfactory appliance.

(iii) Square spur incorporating coil spring (Stanmore pattern).

Once the tension is correct, this is an extremely good appliance, but the initial adjustment can be difficult.

(iv) Posterior spring and insole. In view of the extreme forces applied in a spastic condition, this appliance has no place in the treatment of an active equinus foot.

In brief, the problems of fitting an appliance to a patient with foot-drop are even more marked when dealing with an active equinus foot. There is the constant problem of overcoming the forces of spastic calf muscles, especially if associated with weak quadriceps, which predispose the ‘knee-shoot’ and instability on hills and stairs.

GENU VALGUM

This condition is commonly seen at three ages:

(a) The young child who is frequently fat.

(b) Teenagers and

(c) the adult.

THE YOUNG CHILD

When sitting with knees extended and lower ends of thighs together, the distance between the medial malleoli exceeds 1 inch (2.5 cm.). At this age, the deformity is commonly associated with lax collateral ligaments of the knees, and, indeed, if the knees are pressed firmly together, it is common to find that the medial malleoli can, in fact, be approximated. When standing, however, the child usually has his feet a few inches apart, but his knees together and his body weight falling between his knees stretching the medial ligaments. The deformity is, therefore, more apparent than real.

Two methods of treatment are commonly used for this condition:

(i) Wedges to inner border of soles and heels of shoes. It is quite clear that the alteration in posture produced by this addition to the footwear is compensated by inversion of the foot at the subtalar joint, and no corrective force can possibly be applied to the knees. This appliance, therefore, is of no value.

(ii) Mermaid-type splints. This appliance consists of two metal gutter splints, back-to-back which are inserted between the child’s legs, straps being passed round the limb at the Level of the thigh and ankle. A moment’s reflection will show that this simply stretches the lateral ligament of the knees and exacerbates the ligamentous laxity which is already present (see Fig. 18).

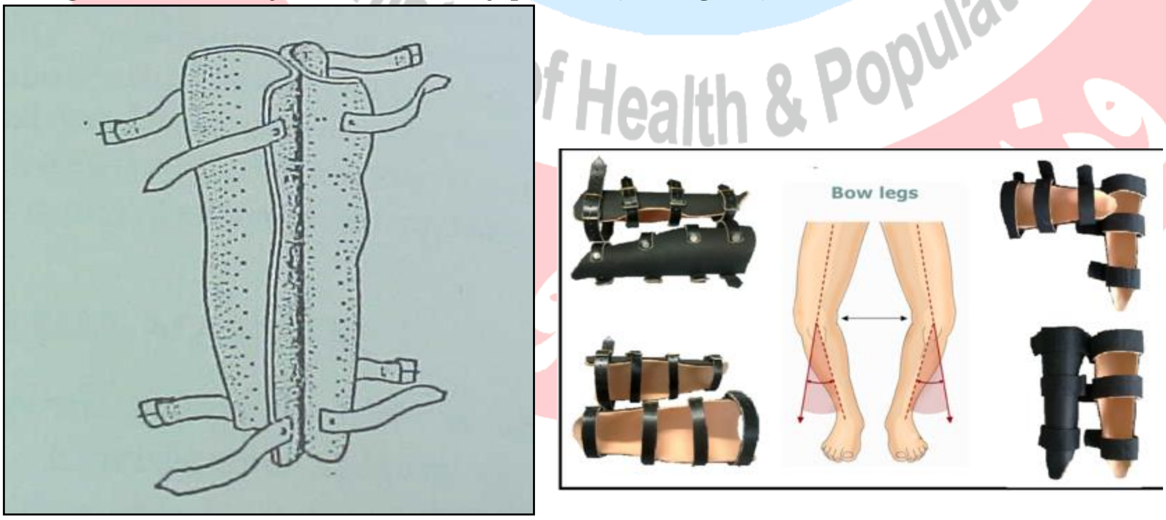


Fig 18 Mermaid splint

One must accept that there is no method of conservative treatment available for this type of deformity, but one should also accept that in the great majority of cases no treatment is necessary. If these children are watched at intervals of three to four months, one commonly sees that the distance between the medial malleoli when the knees are together does not increase, although if the angle between the thigh and the tibia remains the same, the distance should become greater becouse of increased length of leg. Reassurance to the parents is needed until the child reaches the age of 5 to 7 years and during this time, one usually finds that the deformity is corrected over a period of a very few months by growth.

THE TEENAGER

The second age at which the condition presents is usually in the early teens. The patient is frequently a short, fat female who has some 2 inches (5 cm.) to 3 inches (7.5 cm.) between her medial malleoli and no ligamentous laxity. One frequently finds that her mother has the same shape. The condition in itself, does not produce symptoms, but the patient or her mother is frequently worried about the appearance. One should then decide whether surgery is indicated to improve the appearance or to avoid later lateral compartment degeneration, but no appliance can be expected to correct the bone structure.

THE ADULT

The third age at which it presents is in patients over 30 years of age, when the patient, still overweight and with considerable genu valgum, begins to develop degenerative changes in the knees. This problem is clearly one of defective weight-bearing and will inevitably lead to osteoarthritis. It is best treated by corrective surgery.

TIBIAL TORSION

This abnormality, which is usually internal in direction, is commonly associated with one of the various forms of talipes. Denis browne hobble splints and night boots which are used for the latter condition, do attempt to correct the tibial torsion by eversion of the foot when in the splint, but the author has not seen any definite evidence of improvement which could not be explained by growth derotation. In theory, it would be possible to correct tibial torsion by applying an above-knee plaster, with the knee at 90 degrees and the foot plantigrade.
This would undoubtedly apply a torsional strain on the tibia, but it is likely that the strain would be most effective in stretching the ligaments of the knee.

BOWED TIBIA

It is common to see a baby of from three to twelve months old whose mother is worried because his legs are bowed. Careful examination usually shows that the tibia is quite straight and that the bowing is due to the distribution of muscle bulk and fat in a small leg. Carefully positioned anteroposterior X-rays will confirm this and reassurance is all that is required. Should a genuine case of bowed tibiac be found in the clinic, a Mermaid type of night splint has been used, but with little success. It is usually wiser to resort to carly manual osteoclasis.

GENU VARUM

It is uncommon to find genu varum which is not the result of bone disease or trauma. Corrective splints of the mermaid type have been used and the result is that the medial ligament of the knee becomes lax. The only method of treatment likely to be of any value is surgical.

Abnormalities of the Feet

TALIPES SPLINTS

Denis Browne and many others have devised appliances of several designs to correct the deformities which may be present in this group of congenital abnormalities. It is safe to say that the most persistent and potentially disabling deformities are found in talipes equino-varus, and the majority of the splints available are for use in this condition.

HOBBLE SPLINT

As described by Denis Browne the basic splint for each foot is shaped to the plan of five equal squares as shown in the diagram. The two squares to form the side-lever are bent to a right angle at the junction with the other three, and then curved to avoid pressure on the lateral malleolus, in to meet

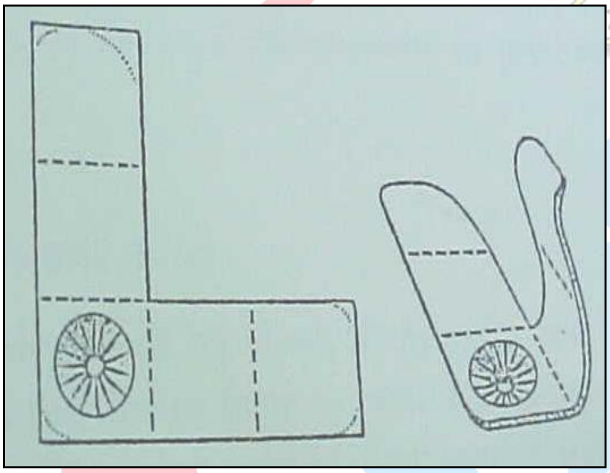


Fig 19 Denis Browne hobble splint

The lower third of the leg, and the extreme tip curved out again to prevent the edge cutting in. The third square is drilled and dished to take a bolt which enables fixation to a correspondingly dished crossbar.

This device, if applied as intended, is capable of exerting corrective forces:

(a) valgus by felt packing,
(b) dorsiflexion by the side arm,
(c) external rotation by the crossbar.

Precise instructions for application are given in the original article and have been reiterated several times since then. The first essntial is that each component of the composite deformity should be corrected by manipulation beginning distally and working proximally. Felt padding is then stuck to the plantar surface of the child’s foot in a wedge thicker on the lateral aspect. The foot-piece is strapped to the foot, and at this stage it will be seen that the side-lever stands away from the leg and usually in a more anterior plane. When the side-lever is strapped to the leg, the foot will become everted and the equinus positioon corrected. Application of the crossbar is the final stage, external rotation being used to correct any medial torsion of the tibia.

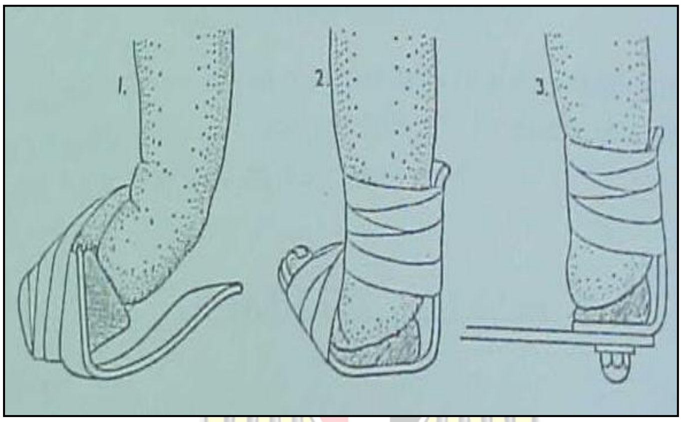


Fig 20 Application of hobble splint

Each component of the basic splint has been modified in some way since the original description. Denis Browne has listed twelve of these alterations and produced valid criticisms of most of them. It is therefore recommended that the original design be used.

DENIS BROWNE NIGHT BOOTS

Based on the hobble-splint principle, the device consists of leather open-toed bootees fixed to a crossbar so that any degree of rotation may be selected. The bootee has a straight medial border to correct the adduction of the forefoot and often a strap passing across the front of the ankle, through slots in the heel to buckle posteriorly, so ensuring that the child's heel is held well down in the appliance.

Correction of the varus is a problem with this appliance. In the hobble splint it is achieved by sticking a felt wedge on to the child's foot and Denis Browne believed that this was necessary to avoid frictional changes on the skin. Clearly such a wedge cannot be reapplied every night and would be in the way if left in situ. The choice is then either to apply a felt wedge in the bootee, or to bend the crossbar to produce the valgus (see Fig. 21).

Fig 21 Denis Browne night boots

CALCANEUS NIGHT BOOT

Although described by Denis Browne for use in paralytic or spastic states the device may be useful in talipes conditions.

It consists of an open-toed leather bootee with a metal strip projecting from the posterior border of the heel. A posterior steel and calf band are attached to the metal strip through two simple hinges set at right angles to each other to allow dorsi- flexion at the ankle and inversion or eversion at the subtaloid joint. At the upper limit of the bootee a leather strap encircles the leg and is attached to the posterior steel. corrective forces are applied by a strap arising from the calf band passing through a loop on the radius bar and back to the calf band, the radius bar is a strip of metal pivoted on the sole of the bootee and capable of being fixed in varus or valgus. Thus tension on the strap from the calf band will pull the foot into inversion or eversion and also into calcaneus.

In bilateral talipes equino-varus two of these appliances may be fixed together by a crossbar hinged to allow eversion, but which will hold the feet in external rotation.

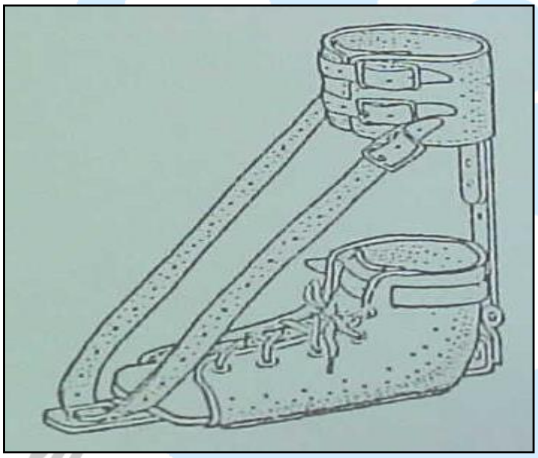


Fig 22 Calcaneus night boot

Chapter 6

Peripheral vascular disease

Objectives

- Knowledge of causes of peripheral vascular disease
- Complications of peripheral vascular disease
- Review on Diabetic foot , charcot arthropathy and orthotic management

Peripheral Arterial Disease

Background

Peripheral vascular disease (PVD) occurs when there is narrowing of the arteries. It is almost always caused by atherosclerosis but may occur secondary to thromboembolism or inflammation (Fig.1) Overall mortality after a diagnosis of PVD is 30% at 5 years and 70% after 15 years. Coronary heart disease is the major cause of death in people with PVD of the legs.

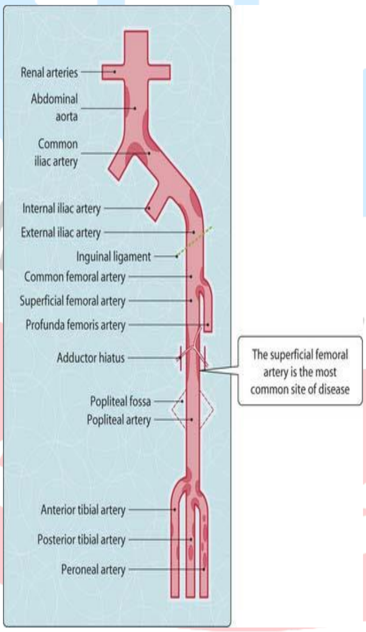


Fig 1

Aetiology

Risk factors should be elicited from the history:

- the four factors with strong association: hypertension, hyperlipidaemia, diabetes and smoking
- the three factors with weak association: stress, obesity and lack of exercise
- male sex
- age: particularly over 50 years.

Symptoms:

Patients with symptomatic PAD may experience pain during exercise or at rest.

- Atypical limb pain or intermittent claudication consistently induces pain during exercise
- Acute or chronic limb ischemia, the most severe manifestation will cause pain at rest
- Foot discoloration the eventually gangrene

Risk factors

Seen in Fig 2

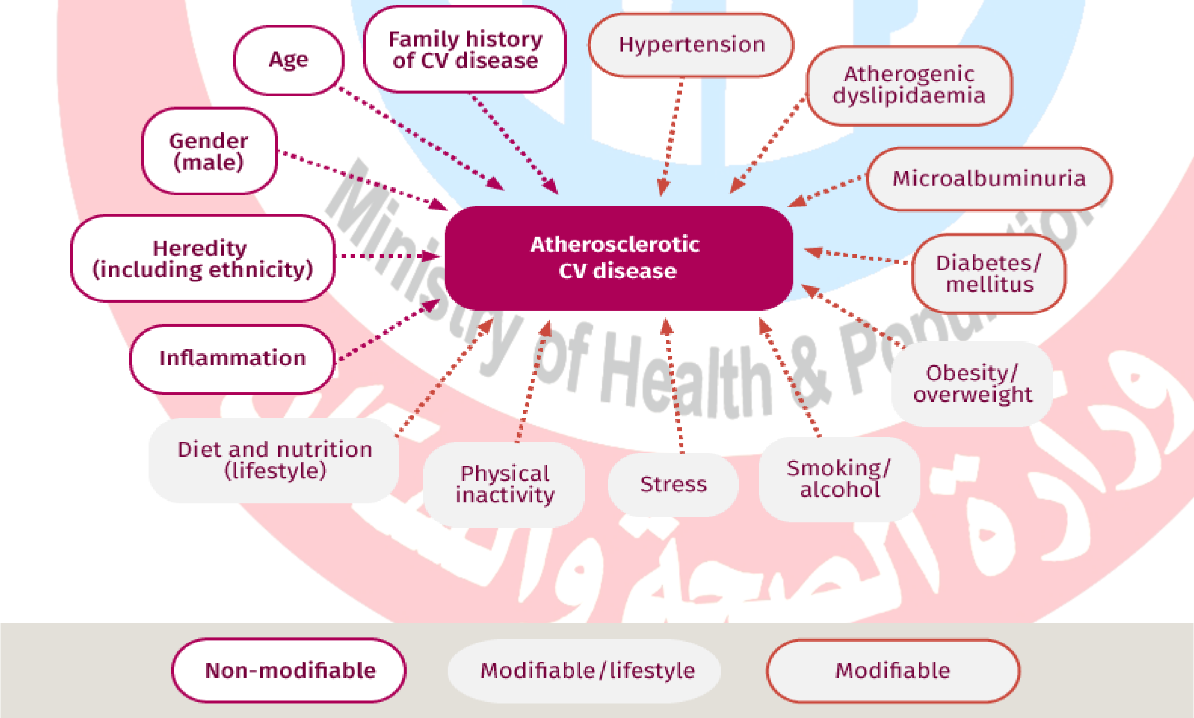


Fig 2 Risk factors asscociated with PAD

Morbidity and Mortality rates are high

Diagnostic testing:

1. Continous wave Doppler
2. Segmental pressure and calculation of Ankle Brachial index. An index 0.9 or more is considered normal
3. Pulse wave recording
4. Exercise testing
5. Arteriography

Management:

1- Education on foot care and an idea of risk of amputation

2- Risk reduction: stopping smoking, decrease weight and control cholesterol

3- Treatment of asscociated diseases

4- Foot care: clean dry, moist, nails trimmed,

   a) Insole fabrication to prevent pressure ulcers
   b) Propers wide box shoes to avoid blisters and callosities
   c) Ankle foot orthosis can limit plantar flexion and decrease work during push off

5- Edema control

6- Medical Management with vasodilators and blood thining measures

7- Surgical Management: angioplasty and amputation in severe cases

Lymphedema:

Disorder of lymphatic drainage of extremity causing its swelling

Pathophysiology:

1- Obstruction of superficial and deep lymphatics with fibrosis of regional lymph nodes

2- Increase in subcutaneous fat with fibrosis of septa

3- Thickening of deep fascis

Diagnosis:

1- Primary lymphedema of unknown cause

2- Secondary: following surgery, history of infection, malignancy etc

Clinically there is swelling of extremity upper or lower limb , unilateral or bilateral, and odema ois usually non pitting. Diagnostic testing to find cause by MRI, CT and finally lmphaoscintigraphy

Management:

1- Mobilization of fluid to main circulation using intermittent compression

2- Use of garment compressive gloves or socks to aid in drainage

3- Medical management such as diuretics

Chronic Venous Insufficiency:

Pathophysiology:

Increased pressure in deep venous system cause blocking of outflow(obstruction) or refkux due to valvular dysfunction of veins of lower limb or others.

Clinical findings:

1- Dilated leg veins
2- Leg pain
3- Skin pigmentation and pruritis (itching)
4- Dermatitis and ulceration

Management:

1- Custom fitting compression stocking
2- Intermittent external pneumatic compression
3- Skin care with topical treatment
4- Ulcer care and saline dressing, duoderm patch
5- Venous insufficiency boot "Unna boot" wrapping of limb

Fig 3 Unna boot

Diabetic Foot:

Diabetes is a common disease all over the world and is a major cause of morbidity and mortality worldwide Diabetic patients are prone to foot and ankle problems for multifactorial reasons.

Risk Factors for Foot Problems in Diabetic Patients
Peripheral Neuropathy
Increased blood glucose levels cause nerve damage by multiple pathways. Different metabolic pathways are activated by the excess glucose, leading to excess reactive oxygen species (ROS), such as nitric oxide and hydrogen peroxide, and advanced glycosylation end products, such as hemoglobin A1c. ROS cause damage by causing nerve ischemia, affecting protein and cell lipids, and injuring nuclear material, leading to increased apoptosis. Advanced glycosylation end products, by binding

cellular receptors and causing other metabolic shifts, decrease the cell's ability to detoxify itself. Nerve myelinization also can be affected, along with injury to nerve ion channels, which can decrease conduction velocity and increase pain impulses. Microvascular disease also can cause damage to nerves.

When large sensory nerve fibers are affected, protective sensation can be lost. Small fiber afferent neuropathy can lead to increased pain generation. Motor neuropathy can cause foot deformities, such as claw toes, which can lead to ulcerations over bony prominences. When the sympathetic nervous system is affected, the skin becomes dry and scaly, eventually causing cracks in the skin through which bacteria can enter to cause infections.

Peripheral neuropathy can be diagnosed by physical examination and can be confirmed with electromyography/nerve conduction studies. Loss of protective sensation can be determined by use of a 5.07-mm Semmes-Weinstein filament

FIG 4 Evaluating protective sensation with 5.07 Semmes-Weinstein monofilament.

Peripheral Vascular Disease

The metabolic end products of increased blood glucose can also cause damage to blood vessels. Advanced glycosylation end products can damage the vascular endothelium, leading to microthrombosis and capillary obstruction. They also increase low-density lipoproteins, which can lead to atherosclerosis. Diabetic patients are more than twice as likely as nondiabetic patients to develop peripheral arterial disease, and the condition is more severe in diabetics.

The ankle-brachial index can be unreliable for the diagnosis of peripheral arterial disease in diabetic patients, because calcification of arteries can lead to elevated results, masking the severity of the disease. Toe pressure or $TcpO_2$ is thought to be more reliable in diabetic patients. Angiography is the gold standard for diagnosing arterial lesions that may require intervention.

Delayed Bone Healing

Displaced lower extremity fractures, including those treated with open reduction and internal fixation, take longer to heal in diabetic patients. In animal studies, the biomechanical strength of fracture callus was lower in diabetic specimens and collagen synthesis was decreased. Diabetic rats have been shown to have decreased cellular proliferation at the fracture site and decreased mechanical stiffness. Treatment with insulin improved these parameters to those of nondiabetic rats.

Altered Immune Function

Defects in leukocyte response to infection include problems with cell chemotaxis, adherence, phagocytosis, and intracellular killing. Because of this altered immune function, diabetic patients have an 80% increased risk of cellulitis, a fourfold risk of osteomyelitis, and double the risk of sepsis and death from infection.

Known risk factors for diabetic foot complications as outlined by The American Foot and Ankle Society include peripheral neuropathy as tested with the 5.07 Semmes-Weinstein monofilament, signs and symptoms of vascular insufficiency including absent pulses, trophic skin changes and/or a history of claudication, partial or total foot amputation, previous ulcer, previous hospital admission for a diabetic foot infection, bony deformity, peripheral edema, and abnormal skin temperatures.

Care of the diabetic foot may require multiple specialists, including an orthopaedic surgeon, vascular surgeon, endocrinologist, infectious disease consultant, and pedorthotist.

Diabetic Ulcers and Infections

Care of diabetic foot ulcers and their complications has been estimated to cost more than 10 billion dollars a year. Diabetic ulcers can have a significant impact on the patients' quality of life: patients with unhealed ulcers have lower scores than those with healed ulcer, and both have lower scores than the general population.

Pathophysiology

Patients who develop ulcers usually have a combination of peripheral neuropathy, deformity or joint contracture, increased plantar pressure, and peripheral arterial disease. Because of the loss of sensation, patients do not realize that undue pressure is placing their skin at risk. Motor neuropathy can lead to deformity such as claw toes; the bony prominences from the deformity make the skin more vulnerable to breakdown (Fig. 5). Achilles contracture can lead to increased forefoot pressures, which increases the chances of forefoot ulceration. There are known structural changes in the Achilles tendon in diabetic patients, including disorganization of the tendon fibers and calcification within the tendon. These changes are more prevalent in older patients and can explain the increased stiffness that is known to occur in the Achilles tendons in diabetics. Peripheral arterial disease also places the skin at risk and leads to impairment of healing once ulceration does occur. The presence of peripheral arterial disease increases the risk of ulceration ninefold.

Fig 5. Changes in Diabetic feet

Classification

The Wagner classification is the most commonly used for grading foot ulcers. The University of Texas San Antonio classification system adds the criteria of infection and ischemia and correlates more closely with prognosis because increased severity (higher grade) is associated with longer healing times and amputation.

Wagner Classification for Foot Ulcers

Grade 0—skin at risk
Grade 1—superficial ulcer
Grade 2—exposed tendon and deep structures
Grade 3—deep ulcers with abscess or osteomyelitis
Grade 4—partial gangrene
Grade 5—more extensive gangrene

Treatment

Nonoperative Treatment

1-Total contact casting is the standard of care, because it reduces plantar loads better than a well-molded shoe cast and, by extrapolation, better than shoes with custom insoles. Complications may arise from the use of total contact casts, but most are minor and reversible new areas of ulcerations.

The risk for complications of total contact casting is lower after deformity-correcting surgery, as well as when the patient is non–weight bearing. Healing rates after total contact casting can be high; however, the recurrence rate also can be high unless severe deformities are surgically corrected. Fig 6

Fig 6 Technique for application of total contact cast. **A,** Stockinette applied and cut to eliminate wrinkles. **B** and **C,** Vertical felt strips placed down medial and lateral sides of leg and malleoli, and cast padding applied over them. **D,** Felt pad made for plantar surface; note radial cuts to aid contouring around heel. **E** and **F,** Self-adhesive foam placed over toes and trimmed. **G** and **H,** Casting tape applied over all layers.

2-Removable diabetic boots (Fig 7) have been shown to be as efficacious as total contact casting in some studies; however, in one study, whereas the boot demonstrated better forefoot unloading than a total contact cast, healing rates were better in the cast, presumably secondary to lack of patient compliance with the boot. Wrapping the diabetic boot to make it less removable does lead to healing rates that are higher than boots that are not wrapped, again suggesting that patient compliance is an issue with the removable boot.

Fig 7 Removable diabetic boots or CAM walker

3-Negative pressure wound treatment with vacuum-assisted closure can improve wound healing..
4-Hyperbaric oxygen treatment has been shown in multiple studies to have some efficacy in diabetic wound healing,
5-Extracorporeal shockwave treatment can be helpful for healing of chronic ulcers and has been shown in one study to be more successful for healing ulcers than hyperbaric oxygen treatment.
6-If a diabetic foot ulcer becomes infected, *antibiotic therapy* should be instituted; because no specific regimen has been proven to be effective, consultation with an infectious disease specialist may be helpful. Empirical therapy often is required because superficial swabs often yield contaminants. Deep cultures obtained after débridement can be helpful to direct antibiotic therapy.

Operative Treatment:

1-Debridment of ulcers
2-If osteomyelitis and not treated then amputation of infected bone
3-Achilles tendon lengthening can help decrease pressures on plantar surface and healing of ulcer

Prevention of ulceration:
1-Patient education and foot care
2-Wearing diabetic shoes, wide box and rocker bottom , thick sole to avoid injury
3-Plantar pressure distribution to avoid areas of increased pressure by using total contact insoles made from pressure relieving material like EVA and poron

Charcot Arthropathy
Pathophysiology
The most plausible explanation for the development of neuropathic arthropathy in a diabetic foot is loss of autonomic control of the vasculature. Resting blood flow in patients with diabetic neuropathy may be five times normal values. Arteriovenous shunting also has been documented in these feet. This high flow rate results in osteopenia, and, combined with somatosensory loss of pain and proprioception, multiple small mechanical insults unrecognized by the patient and occurring in osteopenic bone set the stage for bony dissolution and loss of structural integrity, followed by a collapse deformity (Fig 8) Even with minor trauma to the foot (sprains, contusions, minor fractures), neuropathic skeletal changes may develop in a patient with diabetes mellitus.

Fig 8 Charcot arthropathy

Evaluation

The diagnosis of Charcot arthropathy usually can be made by physical examination and radiographs. The erythema, warmth, and swelling may be mistaken for infection; however, with infection these signs do not decrease with elevation. With infection, glucose control may become difficult, which is not the case in a patient with Charcot arthropathy. With Charcot arthropathy, the patient usually feels well otherwise, which may not be the case with infection. Ct and MRI will help diagnosis

Charocot joint staging and management:

1-Acut stage (0-6 months)- acute destructive period , joint effusion, odema , redness and hot, intraarticular fractures, and formation of bone and cartilage debris

treatment: a- total contact cast, or Cam walker

b-Osteoporis treatment and anti-inflammatory treatment

2-Quiescent stage: 6-9 months-period of healing and decreaseing edema, and healing of fracture

treatment: a- CAM walker and osteoporosis treatment

3-Reconstruction stage- (9months onwards) further repair and remodeling

treatment: Diabetic rocker bottom shoe or boot with custom made insole

Chapter 7

Spinal abnormalities

Objectives

- Review on Scoliosis and management
- Review on Kyphosis and management
- Knowledge on causes of Spinal dysfuction and management

Scoliosis

Scoliosis is a three-dimensional deformative abnormality of the spine. Scoliosis is defined by the Cobb's angle of spine curvature in the coronal plane, and is often accompanied by vertebral rotation in the transverse plane and hypokyphosis in the sagittal plane. These abnormalities in the spine, costal-vertebral joints, and the rib cage produce a ‘convex’ and ‘concave’ hemithorax. The rotation component starts when the scoliosis becomes more pronounced. This is called a torsion-scoliosis, causing a gibbus. Fig 1

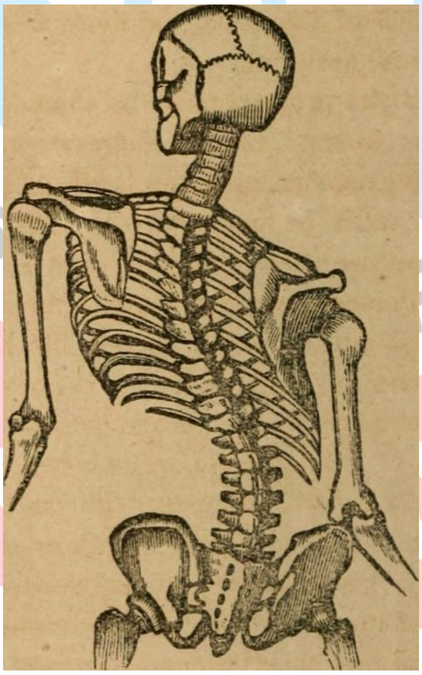


Fig 1 Scoliosis rear view

Clinically relevant Anatomy
When viewed from the side, the vertebral column displays five curves in the upright posture:

- Cervical curves
  There are two normally occurring curves in the cervical spine: the upper cervical curve extending from the occiput to the axis, and the longer lordotic curve of the lower cervical spine extending from the axis to the second thoracic vertebrae. The upper cervical curve is convex forwards and is the reverse of the lower cervical curve.
- Thoracic curve
  This curve is concave forwards, extending from T2 to T12. The concavity is due to greater depth of the posterior parts of the vertebral bodies in this region. In the upper part there is often a slight lateral curve with the convexity directed to either the right or left.
- Lumbar curve
  The lumbar curve is convex forwards and extends from L1 to the lumbosacral junction.
- Sacral curve
  The curve extends from the lumbosacral junction to the coccyx. Its anterior concavity faces downwards and forwards

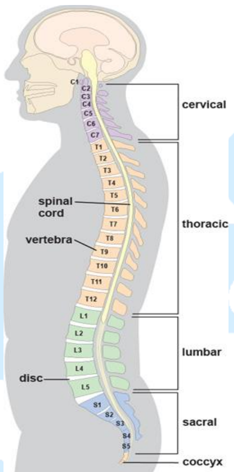


Fig 2 Spinal Curves

Eitiology
Scoliosis is the most common spinal disorder in children and adolescents. A scoliosis is characterized by a side-to-side curvature of the spine >10°, usually combined with a rotation of the vertebrae and most often a reduced kyphosis in thoracic curves. Scoliosis may be structural or non-structural.
Non-structural scoliosis can be corrected, they occur due to posture or compensation of the spine. Structural scoliosis are deviations that cannot or just partially be corrected. You can distinguish the structural from the non-structural scoliosis with the Adam Forward Bent Test (mentioned below). Scoliosis patients are classified in different types according to age of onset, etiology, severity and type of curve. Each type shows different characteristics as rate of curve progression, degree and pattern of the three-dimensional deformity. The two major groups of scoliosis are idiopathic scoliosis and non-idiopathic scoliosis.

Non-idiopathic scoliosis is classified into the following subgroups:

- Congenital scoliosis:
  Caused by malformation of vertebrae like hemivertebra, unilateral bar or block vertebra. It may not be clinically evident at birth but develops until adolescence.
- Neuromuscular scoliosis:
  Neuromuscular scoliosis is caused by insufficiency of active stabilizers (including the

muscles and tendons surrounding the spinal column)of the spine like cerebral palsy, spinal muscular atrophy, spina bifida, muscular dystrophies or spinal cord injuries.

- Mesenchymal scoliosis:
  Mesenchymal scoliosis is caused by insufficiency of passive stabilizers (consisting of vertebrae, facet joints, intervertebral discs, spinal ligaments like ligamentum flavum and ligamentum longitudinale anterius, joint capsules and passive muscle support) of the spine like Marfan's syndrome, osteogenesis imperfecta, inflammatory diseases or postoperative after thoracic surgery (open heart surgery).

Idiopathic scoliosis is classified into the following subgroups:
(The prevalence of idiopathic scoliosis is dependent on the curvature of the spine and gender of the patient, and is higher among females, who have been observed to have more severe curvature.)

- Infantile scoliosis:
  Infantile scoliosis develops at the age of 0–3 years and shows a prevalence of 1 %.
- Juvenile scoliosis:
  Juvenile scoliosis develops at the age of 4–10 years and comprises 10–15 % of all idiopathic scoliosis in children, untreated curves may cause serious cardiopulmonary complications, and curves of 30 and more tend to progress, 95 % of these patients need a surgical procedure.
- Adolescent scoliosis:
  Adolescent scoliosis develops at the age of 11–18 years and accounts for approximately 90 % of cases of idiopathic scoliosis in children.

Characteristics/Clinical Presentation

1. Sideways curvature of the spine
2. Sideways body posture
3. One shoulder raised higher than the other
4. Clothes not hanging properly
5. Local muscular aches
6. Local ligament pain
7. Decreasing pulmonary function is a major concern in progressive severe scoliosis.
8. 6% report chronic thoracic pain that lasted for at least 3 months during the last 12 months
9. 6% report chronic lumbar pain that lasted for at least 3 months during the last 12 months
10. Factors associated with chronic lumbar pain

The progression of scoliosis leads to thoracic cage deformity and concomitant pulmonary compromise. Based on the results of the present study, impairment of function was seen in more severe cases of spinal deformity, proximally-located curvature and older patients.

Diagnostic Procedures

Thorax deformity in the anterior-posterior and medial—lateral planes is primarily assessed for clinical purposes using planar radiographs. CT imaging, the gold standard for transverse plane thorax deformity characterization, is also used to complement AP and lateral radiographs.

The categories of thorax deformity are:

1. Anterior chest angulation
2. Area enclosed by rib cage
3. Coronal asymmetry
4. Hemithorax depth asymmetry
5. Hemithorax width asymmetry
6. Posterior rib asymmetry
7. Sagittal depth
8. Sternum deviation

Scoliosis-induced lateral spine curvature in the coronal plane and vertebral rotation are commonly used for clinical assessment and their inter-relationship has been widely documented. Furthermore, additional evidence supports the subsequent contribution of spine distortion towards progression of thoracic cage deformity. Surface electromyography (EMG) examination, magnetic resonance imaging or static and dynamic postural evaluation can be used for a very precise diagnosis.

- The static postural evaluation serves to measure body sway and changes of the projection of the centre of gravity in a free standing position.
- The dynamic posture evaluation uses a platform to record ground reaction forces as well as body sway during walking and the centre of gravity during jumps and different activities.
- The Superficial EMG, is helpful in examining spinal muscle work.

Examination
The aim of the functional examination is to distinguish between faulty posture and actual idiopathic scoliosis.
1. Examination of the active movements (flexion, extension and side flexion) of the spine in the cervical, thoracic and lumbar segment.
2. <u>The Adam forward bend test</u> can be used to make a distinction between structural scoliosis or non-structural scoliosis of the cervical to lumbar spine. The test can be performed in the standing and sitting position.

- In <u>standing position</u>, the examined person is asked to bend forward looking down, keeping the feet together, the knees straightened, shoulders loose and hands positioned in front of knees or shins with elbows straight and palms opposed. If the scoliosis is present in both standing as bending position, the scoliosis is structural. If the scoliosis is present in standing position but disappears when the examined person bends forward, the scoliosis is not structural.
- In the <u>sitting position</u>, the examined person is seated on a chair with a height of 40 cm. The examined person is asked to bend forward and place his head between the knees, with his shoulders loose, elbows straight and hands positioned between the knees. The position of spinal processes and presence of a costal hump are evaluated.

3. <u>The Cobb angle</u> is a standard measurement to determine and track the progression of scoliosis. This is done on the Radiographic Xray AP view:

- Locate the most tilted vertebra at the top of the curve and draw a parallel line to the superior vertebral end plate.
- Locate the most tilted vertebra at the bottom of the curve and draw a parallel line to the inferior vertebral end plate.
- Erect intersecting perpendicular lines from the two parallel lines.
- The angle formed between the two parallel lines is the Cobb angle.

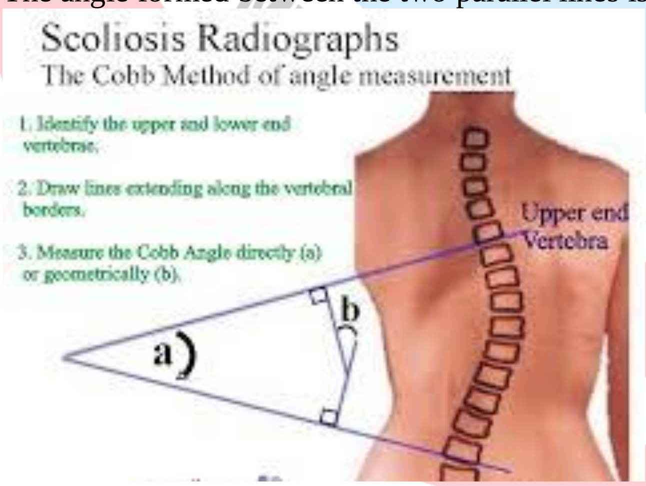


Fig3 Cobbs angle measurement

4. <u>The scoliometer</u> is an inclinometer designed to measure trunk asymmetry, or axial trunk rotation. It's used at three areas:

- Upper thoracic (T3-T4)
- Middle thoracic (T5-T12)
- Thoraco-lumbar area (T12-L1 or L2-L3)

If the measurement is equal to 0°, there is a symmetry at the particular level of the trunk. An asymmetry at the particular level of the trunk is found, if the scoliometer measurement is equal to any other value.

5. Pulmonary function testing is useful in the preoperative evaluation of patients.

Management of congenital scoliosis

Patients with early-onset scoliosis, defined as a lateral curvature of the spine under the age of 10 years, are offered surgical treatment when the major curvature remains progressive despite conservative treatment (Cobb angle 50 degrees or more). Spinal fusion is not recommended in this age group, as it prevents spinal growth and pulmonary development.

- Conservative treatment:

With regard to conservative treatment of patients with congenital scoliosis, it should be noted that there are limited data available in the literature. A review concluded that patients with specific types of segmentation failures, like unilateral unsegmented bars, will not benefit from conservative treatment, while the same applies to formation failures with curves of > 20 degrees in infancy. Nevertheless, there are reports that a conservative approach might be beneficial in mild cases with formation failures in the first three years of life.

Management includes bracing☹mentioned in previous chapters)

1- Boston brace
2- Milwakee brace
3- Elastic bracing

In general, most congenital scoliotic curves are not flexible and therefore are resistant to repair with bracing. For this reason, the use of braces mainly aims to prevent the progression of secondary curves that develop above and below the congenital curve, causing imbalance. In these cases, they may be applied until skeletal maturity.

- Surgical treatment:

Spinal surgery in patients with congenital scoliosis is regarded as a safe procedure and many authors claim that surgery should be performed as early as possible to prevent the development of severe local deformities and secondary structural deformities that would require more extensive fusion later. Mostly it is done during adolescence, but newer techniques allow good correction to be accomplished into early adulthood. The goals for surgical treatment are to prevent progression and to improve spinal alignment and balance.

Physical Therapy Management

Physical therapy and bracing are used to treat milder forms of scoliosis to maintain cosmesis and avoid surgery.Scoliosis is not just a lateral curvature of the spine, it's a three dimensional condition. To manage scoliosis, we need to work in three planes: the sagittal, frontal and transverse. Different methods have already been studied.

The conservative therapy consists of: physical exercises, bracing, manipulation, electrical stimulation and insoles. There is still discussion about the fact that conservative therapy is effective or not. Some therapists follow the 'wait and see' method. This means that at one moment; the Cobb degree threshold will be achieved. Then, the only possibility is a spinal surgery.

We can conclude that bracing is recommended as a treatment for female patients with a Cobb angle of 25-35°. The evidence level of some studies in the review was limited, so further research is necessary. In the literature there is evidence that exercises have beneficial effects on patients with idiopathic scoliosis.

Management of non-structural scoliosis:

1- Exercises like Pilates
2- Physiotherapy
3- Swimming

Prognosis:

Brace treatment for scoliosis is successful is often described using the curve progression of more than 5° before skeletal maturity as a benchmark for bracing failure rather than spine surgery. Some use 10° of curve progression or preventing the curve from reaching 45° at skeletal maturity. Bracing studies should have a minimum of 2 years follow up beyond skeletal maturity.
Regardless of the recommended standardized parameters, the goal of bracing idiopathic curves remains consistent: control the curve, prevent progression, and avoid surgical intervention.

Kyphosis

Kyphosis is a curvature of the spine in the sagittal plane in which the convexity of the curve is directed posteriorly. Lordosis is a curvature of the spine in the sagittal plane in which the convexity of the curve is directed anteriorly. The thoracic spine and the sacrum normally are kyphotic, and the cervical spine and the lumbar spine normally are lordotic .
The ranges of normal kyphosis and lordosis change with increasing age and vary according to the gender and the area of the spine involved. The degree of kyphosis or lordosis that is considered normal or abnormal depends on the location of the curvature and the age of the patient. For example, 30 degrees of kyphosis is normal in the thoracic spine but abnormal at the thoracolumbar junction.

The normal range of thoracic kyphosis is considered to be 19 to 45 degrees and that of lumbar lordosis, 30 to 60 degrees

Measurment:

Thoracic kyphosis is measured on a lateral radiograph as the angle between the superior end plate of T2 and the inferior end plate of T12. Proximal thoracic kyphosis is measured from the superior end plate of T2 to the inferior end plate of T5. Middle and lower thoracic kyphosis is measured from the superior end plate of T5 to the inferior end plate of T12. The apex of normal thoracic kyphosis is the T6-T7 disc space. The thoracolumbar junction should have no kyphosis or lordosis.
Lumbar lordosis begins at L1-L2 and increases gradually until the L3-L4 disc space. There is a reciprocal relationship between the orientation of the sacrum, sacral slope, and the pelvic incidence and the characteristics of lumbar lordosis and location of the apex of lumbar lordosis.

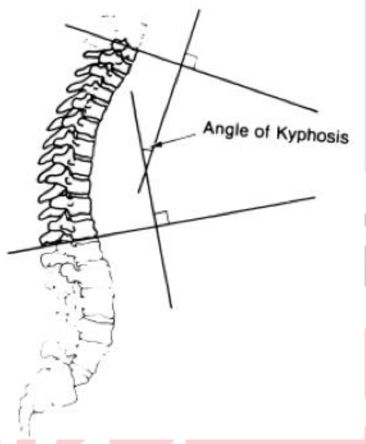


Fig 4 Angle of Kyphosis measurement

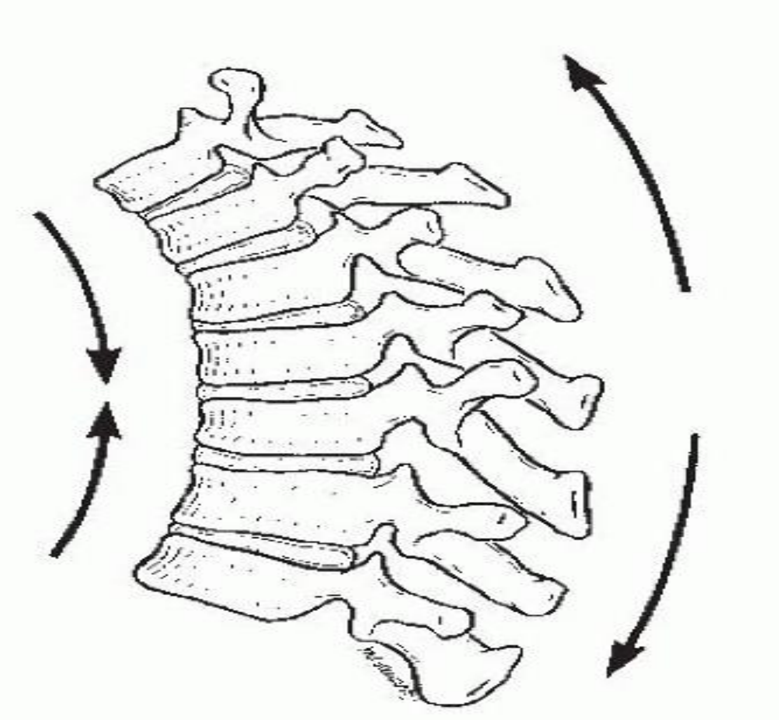


Fig 5 Forces that contribute to kyphotic deformity of the thoracic spine. The anterior vertebral bodies are in compression, and the posterior vertebral elements are in tension.

Disorders Affecting the Spine and Resulting in Kyphosis

1- Postural disorders
2- Scheuermann kyphosis: spondylosis of several vertebrae
3- Congenital: defect of formation or segmentation of vertebra
4- Paralytic: Polio, Anterior horn cell disease
5- Meningiomyelocele: generalized hypotonia
6- Posttraumatic
7- Inflammatory: TB, infections and other causes
8- Tumour
9- Inadequate fusion
10- Metabolic- osteoporosis
11- Developmental eg achodroplasia
12- Collagen diease
13- Neurofibromatosus

POSTURAL KYPHOSIS

Postural kyphosis is a flexible deformity of the spine and is common in juvenile and adolescent patients. Usually, the parents are more concerned about the postural roundback deformity than the adolescent is, and these parental concerns typically are what bring the patient to the physician's office. The physician's role in this situation is to rule out more serious causes of kyphosis.
When observed from the side, patients with postural roundback have a gentle rounding of the back while bending forward. Patients with Scheuermann disease and congenital kyphosis have a sharp angular kyphosis or gibbus on forward bending when observed from the side.
Radiographs usually are necessary to rule out pathologic types of kyphosis. Patients with postural

kyphosis do not have radiographic vertebral-body changes, and the deformity is completely correctable by changes in position or posture.
No active medical treatment is necessary. **Bracing is not indicated.** Exercises have been suggested and may help maintain better posture.

Congenital Kyphosis:
This is due to failure of segmentation or failure of fusion and usually it is associated with other spinal abnormalities. Management will depend on progression of angle
Rigid bracing: willnot improve situation
Surgery : priniciple management in congenital kyphosis

Scheuermann's Disease
Scheuermann's Disease is a deformity in the thoracic or upper part of your spine. This causes an abnormality that makes the vertebrae grow at different rates during adolescence. **Treatment:** Since this type occurs in children while they are growing, a back brace **(Jewett Brace)** is usually used to help stop the curve from bending more. Depending on the severity of your child's case or at the beginning stages, it is recommended to wear this brace for almost all of their day. The brace is designed to hold the spine straight with shoulders pulled back and the chin upright. Bracing helps take pressure off the vertebrae, allowing for growth of the bony area in the front of the vertebrae to catch up with the growth in the back.
Back braces for Scheuermann's kyphosis are usually worn for 16-24 hours a day for one year. Stretching exercises and cardiovascular activities are also prescribed to help alleviate back pain and fatigue. Bracing is only used in patients who are still growing and is not effective for adults.

Neuromuscular Kyphosis:
Neuromuscular kyphosis usually occurs in individuals that have cerebral palsy, spina bifida, or muscular dystrophy. **Treatment:** Based on the individual, surgery or a back brace **(Jewett brace)**support may be an option.

Low Back Pain:

Pain in the lower back, either on movement or at rest, localized or radiating to pelvic area or legs.
It can be acute or chronic

Differential Diagnosis

1- Muscle strain
2- Lumbar disc Prolapse and spinal stenosis
3- Sacroilitis
4- Piriformis Syndrome
5- Vertebral compression fracture
6- Deformity: scoliosis or kyphosis

Lumbar strain
History

- Bending, twisting, and lifting reproduce pain.
- Pain in back occurs with movement, coughing, or sneezing.
- Leg pain or weakness is lacking.
- Injury can be minor or mild.

Physical Examination

- Slow gait
- Tenderness to palpation over muscular structures
- Pain with flexion, extension, and/or rotation of the trunk
- Normal neurologic examination

Imaging

- Anteroposterior (AP) or lateral views are obtained initially only if the mechanism warrants. Persistent pain for more than 1 week should be explored with bone scan.

Initial Treatment
Patient education

- Back pain, one of the most common medical problems, affects 8 out of 10 people at some point during their lives. Most back pain goes away on its own, although it may take a while. However, staying in bed for more than 1 or 2 days can make it worse.

Treatment Options
Nonoperative management

- A short 1- to 2-day rest period for severe pain is prescribed.
- Over-the-counter nonsteroidal anti-inflammatory drugs (NSAIDs) or acetaminophen is recommended.
- Skeletal muscle relaxants are used sparingly.
- Physical therapy and "back school" can be beneficial for persistent pain.
- Advanced imaging is used only in the most refractory cases.
- Long-term prevention with core strengthening and ROM exercises is indicated.
- **Lumbosacral Corset can be used to decrease pain and relieve the muscles**

Differential Diagnosis

- Compression fracture
- Intra-abdominal or pelvic disease such as nephrolithiasis, pyelonephritis, abdominal aortic aneurysm, intra-abdominal, intrapelvic, or spinal mass, or metastasis
- SI joint instability
- Occult vertebral body fracture: Bone scan or magnetic resonance imaging (MRI) will identify injury in cases of persistent pain.
- Malingering: Secondary gain must be considered. Assess with Waddell signs.

Vertebral compression fracture
History

- Low-velocity fall occurs in older adults; injury could be very minor in this population.
- Higher-velocity injury may occur in younger patients.
- Patients complain of back pain.
- Injury can occur with motor vehicle crash (MVC).
- Look for pathologic causes.

Physical Examination

- Slow gait
- Tenderness to palpation over muscular structures

- Pain with flexion, extension, and/or rotation of the trunk
- Normal neurologic examination

Imaging

- AP or lateral views (with possible flexion or extension views) may show depressed or wedged end plates.
- Look for other injury such as spinous process fracture in higher-velocity injury.
- MRI is indicated if radiculopathy is present or for planning a cement procedure. Use contrast if concern exists for pathologic fracture.

Initial Treatment

- Short-duration narcotics
- Lumbar bracing for comfort **(lumbosacral orthosis [LSO] or lumbar corset)**

Patient education

- Early ambulation is essential. Avoid flexion activities until pain-free.

Treatment Options

Nonoperative management

- A short 1- to 2-day rest period is indicated for severe pain.
- Narcotic pain medications are prescribed.
- Use skeletal muscle relaxants sparingly.
- **LSO brace or lumbar corset is recommended.**
- Physical therapy and "back school" can be beneficial for persistent pain.
- MRI is used for evaluation for pathologic fracture or cement procedure.

Operative management

Operative Indications

- Compression fracture or endplate fracture without neural injury
- Intractable pain
- Pathologic fracture for palliative care

Informed Consent And Counseling

- May not improve pain
- Not likely to improve fracture height

Surgical Procedures

- Cement augmentation (vertebroplasty)

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