

Podiatry

(Specific branch of medicine)

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Chapter 1

Podiatry



Podiatrist performing a bunionectomy and hammertoe correction surgery on a young female patient.

Podiatry is a branch of medicine devoted to the study, diagnosis, and treatment of disorders of the foot, ankle, and lower leg. Podiatrists are defined as physicians by the U.S. federal government and in most U.S. states.

The term *podiatry* came into use first in the early 20th century United States, where it now denotes a Doctor of Podiatric Medicine (DPM), a specialist who is qualified by their education and training to diagnose and treat conditions affecting the foot, ankle, and related structures of the leg. Within the field of podiatry, practitioners can focus on many different specialty areas, including surgery, sports medicine, biomechanics, geriatrics, pediatrics, orthopedics, or primary care.

In January of 2011, the American Podiatric Medical Association (APMA) publicly launched the Today's Podiatrist campaign, which aims to educate the public, medical professionals, and students about the education and training of today's podiatrist.

Podiatry is practiced as a specialty in many countries including Australia, Brunei, Canada, Cyprus, Ireland, Malta, New Zealand, Singapore, South Africa, the United Kingdom, and the United States. In many English-speaking countries, the older title of "chiroprapist" may still be used by some clinicians but is gradually falling out of use. In many non-English-speaking countries of Europe, the title used instead of podiatrist may be "podologist" or "Podólogo". The level and scope of the practice of podiatry varies among countries. Podiatry is a very high paying job and was listed by *Forbes* as the 15th best paid profession in the United States.

History

The professional care of feet was in existence in ancient Egypt as evidenced by bas-relief carvings at the entrance to Ankmahor's tomb dating from about 2400 BC where work on hands and feet is depicted.

Corns and calluses were described by Hippocrates who recognised the need to physically reduce hard skin, followed by removal of the cause. He invented skin scrapers for this purpose and these were the original scalpels. Aulus Cornelius Celsus, a Roman scientist and philosopher, was probably responsible for giving corns their name. Later Paul of Aegina (AD 615–690) defined a corn as "a white circular body like the head of a nail, forming in all parts of the body, but more especially on the soles of the feet and the toes. It may be removed in the course of some time by paring away the prominent part of it constantly with a scalpel or rubbing it down with pumice. The same thing can be done with a callus."

Until the turn of the 20th century, chiroprapists—now known as podiatrists—were separate from organized medicine. They were independently licensed physicians who treated the feet, ankles and related leg structures. Lewis Durlacher was one of the first people to recognize the need for a protected profession. He held the appointment of Surgeon-Chiroprapist successively to King George IV, King William IV and eventually

also to Queen Victoria. He tried to establish the first association of practitioners in 1854, although it would take another century to come to pass.

There are records of the King of France employing a personal podiatrist, as did Napoleon. In the United States, President Abraham Lincoln suffered greatly with his feet and chose a chiropodist named Isachar Zacharie, who not only cared for the president's feet, but also was sent by President Lincoln on confidential missions to confer with leaders of the Confederacy during the U.S. Civil War.

The first society of chiropodists, now known as podiatrists, was established in—and still operates in—New York in 1895 as NYSPMA, with the first school opening in 1911. One year later the British established a society at the London Foot Hospital and a school was added in 1919. In Australia professional associations appeared from 1924 onwards. The first American journal appeared in 1907, followed in 1912 by a UK journal. In 1939, the Australians introduced a training centre as well as a professional journal. The number of chiropodists increased markedly after the Great War then again after World War II.

Increased numbers of ex-soldiers needing to be gainfully employed gave chiropody a boost and led to the need for registration in all English speaking countries. The study of the foot (i.e. podology), brought greater knowledge to the practice of foot care or podiatry.

Specific country practices

Australia

In Australia, podiatry is classified as an allied health profession, and is practised by individuals licensed by their representative State Boards of Podiatry. There are seven registration boards and six teaching centres, with two levels of awards — unclassified bachelors degree and honours level. In Australia there exist 2 levels of professional accreditation and professional privilege: Podiatrist and Podiatric Surgeon. Australian podiatrists are able to practise abroad with their qualifications recognised in some Commonwealth countries.

Registration and regulation

Australian Podiatrists must register with the Podiatry Board of Australia. The Podiatry Board of Australia is responsible for regulation and recognition of Podiatrists and Podiatric Surgeons, and assessing foreign trained registrants.

The Podiatry Board of Australia recognizes 3 pathways to attain specialist registration as a Podiatric Surgeon:

1. Fellowship of the Australasian College of Podiatric Surgeons

2. Doctor of Clinical Podiatry, University of Western Australia
3. Eligibility for Fellowship of the Australasian College of Podiatric Surgeons

Education and training

Australian podiatrists complete an undergraduate degree ranging from 3 to 4 years of education. The first 2 years of this program are generally focused on various biomedical science subjects including anatomy, medical chemistry, biochemistry, physiology and patient psychology, similar to the medical curriculum. The following two years will then be spent focusing on podiatry specific areas such as podiatric biomechanics and human gait, podiatric orthopaedics or the non-surgical management of foot abnormalities, pharmacology, general medicine, general pathology, local and general anaesthesia, and surgical techniques such as partial and total nail avulsions, wound debridement, and other cutaneous and electrosurgical procedures.

Australian podiatric surgeons are specialist podiatrists with further training in advanced medicine, advanced pharmacology, and training in foot surgery. Podiatrists wishing to pursue specialisation in podiatric surgery must meet the requirements for Fellowship with the Australasian College of Podiatric Surgeons. They first complete a degree of 4 years, which includes 2 years of didactic study and 2 years of clinical experience. Following this, a masters degree must be completed with focus on biomechanics, medicine, surgery, general surgery, advanced pharmacology, advanced medical imaging and clinical pathology. They then qualify for the status of Registrar with the Australasian College of Podiatric Surgeons. Following surgical training with a podiatric surgeon (3–5 years), rotations within other medical and surgeons' disciplines, overseas clinical rotations, and passing oral and written exams, Registrars may qualify for Fellowship status. Fellows are then given Commonwealth accreditation under the Health Insurance Act to be recognised as providers of *professional attention*, for the purposes of health insurance rebates.

Prescribing and referral rights

There is considerable variation between state laws regarding the prescribing rights of Australian podiatrists. While all registered podiatrists in each state or territory are able to utilize local anaesthesia for minor surgical techniques, some states allow suitably qualified podiatrists further privileges.

Recent legislative changes, which are expected to come into effect soon, will allow registered podiatrists and podiatric surgeons in Victoria and New South Wales to prescribe relevant schedule 4 poisons. In other states, such as Western Australia and South Australia, podiatrists with Masters Degree's in Podiatry, and extensive training in pharmacology are authorised to prescribe S4 poisons. In Queensland, Fellows of the Australasian College of Podiatric Surgeons are authorised to prescribe a range of Schedule 4 and one Schedule 8 drug for the treatment of podiatric conditions.

All podiatrists may refer patients for Medicare rebatable plain x-rays of the foot, leg, knee and femur, as well as ultrasound examination of soft tissue conditions of the foot. Podiatrists may refer patients for other radiology investigations such as CT, MRI or bone scans, however Medicare rebates do not currently exist for these examinations. Similarly, podiatrists may refer patients when needed to specialist medical practitioners, or for pathology testing, however similar exclusions in the Medicare Benefits Schedule prevent rebates being available to patients for these referrals.

Canada

In Canada the definition and scope of practice of podiatry can mean very different things. For instance, in some provinces like British Columbia and Alberta, the standards are the same as in the United States where the Doctor of Podiatric Medicine (DPM) is the accepted qualification. Quebec, too, has recently changed to the DPM level of training although other academic designations may also register. Also in Quebec, in 2004, Université du Québec à Trois-Rivières started the first program of Podiatric Medicine in Canada based on the American definition of podiatry. In the prairie and atlantic provinces, the standard was originally based on the British model now called podiatry (chiropody). That model of podiatry is now the accepted model for most of the world including the United Kingdom, Australia and South Africa. The province of Ontario, now only registers Chiropodists since July 1993 where the Ontario Government imposed a cap on new podiatrists. Even if an American, British or other countries registered podiatrist were to emigrate to Ontario they would have to register and practice as a chiropodist. The podiatrists who were practicing in Ontario previous to this cap were grandfathered and kept the title of podiatrist as a subclass of chiropody. The scope of these grandfathered (mostly American trained) podiatrists includes boney procedures of the forefoot and the ordering of x-rays in addition to the scope of the chiropodist.

New Zealand

Chiropody became a registered profession in New Zealand in 1969 with the requirement that all applicants take a recognized three-year course of training. Soon after the professional title was changed from Chiropody to Podiatry and The New Zealand School of Podiatry was established in 1970 at Petone under the direction of John Gallocher. Later the school moved to the Central Institute of Technology, Upper Hutt, Wellington. In 1976 the profession gained the legal right to use a local anaesthetic and began to introduce minor surgical ingrown toenail procedures as part of the scope of practice.

New Zealand podiatrists were granted the right of direct referral to radiologists for X-rays in 1984. Acknowledgement of podiatric expertise marked improved services to patients and eventually in 1989 suitably trained podiatrists were able to become licensed to take X-rays within their own practice. Diagnostic radiographic training is incorporated into the degree syllabus and on successful completion of the course, graduates register with the New Zealand National Radiation Laboratory.

In 1986, the profession undertook a needs analysis in conjunction with the Central Institute of Technology to identify competencies for podiatry in 2000. A Bachelor of Health Science was introduced in 1993. Auckland University of Technology is now the only provider of podiatry training in New Zealand.

United Kingdom

A podiatrist is qualified by their education and training to diagnose and treat conditions affecting the foot, ankle, and related structures of the leg. Podiatrists are uniquely qualified among medical and health professionals to treat the foot and ankle based on their education, training and experience. The scope of practice of UK podiatrists on registration after their degree in podiatric medicine includes the use and supply of some prescription only medicines, injection therapy and non-invasive surgery e.g. performing partial or total nail resection and removal, with chemical destruction of the tissues. Podiatrists complete some 1,200 supervised clinical hours in the course of their training which enables them to recognise systemic disease as it manifests in the foot and will refer on to the appropriate health care professional. Those in the NHS interface between the patients and multidisciplinary teams. The Scope of Practice of a Podiatrist is varied.

In a similar way to podiatrists in Australasia, UK podiatrists may continue their studies and qualify as podiatric surgeons. This training programme has developed over the last 30 years including development of standards in co-operation with the Scottish Royal Surgical Colleges. The training requires a number of years study at postgraduate level including a Masters degree in the Principles of Podiatric Surgery, then a year as a pre-surgical trainee working within a podiatric surgical team, at least 2 years as a surgical trainee working to complete parts C and D of the surgical training and complete pre-Fellowship surgical training. Following this, and having successfully passed a practical surgical assessment, a Podiatric surgeon will work at a specialist registrar (SpR) level for a minimum of three years under a Consultant Podiatric Surgeon. This SpR period must be satisfactorily completed before being eligible to apply for a Consultant National Health Service (NHS) post. These posts are subject to an appointments panel including an assessor from the Faculty of Surgery of the College of Podiatrists (an existing consultant podiatric surgeon). Only if successfully appointed to such an NHS post may he/she then be able to use the title Consultant Podiatric Surgeon.

Podiatric surgery in the UK is not a recent development. The First UK training in podiatric surgery developed over 30 years ago in North London. The original podiatric surgery faculty invited over by UK podiatric surgeons who had trained with them in the USA were leading US podiatric surgeons including; E Dalton McGlamry, Tildern Sockaloff, Guido LaPorta and later Lowell Scott Weil. The First specific podiatric surgery in the NHS was provided via Shropshire Health Authority in 1983 and shortly after in the adjacent English county of Herefordshire. The first specific podiatric surgery service was approved by Herefordshire Health Authority in 1986. Subsequently these NHS services developed with Consultant Podiatric Surgeons being appointed to lead these growing services. The First dedicated NHS Podiatric Daysurgery Unit was

officially opened in Hereford in 1993. There are now a number of NHS dedicated NHS Podiatric Daysurgery Units and many NHS Trusts providing podiatric surgery.



A podiatric resident performs surgery on a patient who sustained trauma to the foot.

Podiatric surgeons specialise in invasive foot surgery. The scope of practice is defined as "surgery of the foot and associated structures". The majority of work reflects the frequency of foot pathology presenting in the UK, most commonly digital and forefoot surgery, as well as mid foot and rearfoot surgery including triple arthrodeses, ankle stabilisations and Achilles tendon lengthenings/repairs. At present these surgeries are not carried out by all Podiatric Surgeons.

In the UK, individuals may not use the title "chiropodist" or "podiatrist" unless they are registrants of the Health Professions Council (HPC). They are protected titles and their use by non-registrants is unlawful. This protection extends to titles including the adjectival forms e.g. "podiatric surgeon" or "chiropody practitioner". Such registration is normally only granted to those holding a specialized Bachelors degree or Diploma in podiatry from one of the 13 recognized schools of podiatry in the UK.

A number of former practitioners (of private sector routine footcare) did not meet the requirements to be admitted to the HPC register under the transitional arrangements of this 2001 legislation and could no longer use the protected titles "chiropodist" or

“podiatrist” after the transitional period elapsed. These practitioners now use alternative titles, mainly the title of Foot Health Practitioner and there are now courses established to train future Foot Health Practitioners.

The nomenclature surrounding the job titles of podiatric surgeons has been the source of some criticism from some constituencies within the medical community (in particular orthopaedics). The stated concern underlying the criticism is that podiatric surgeons are not medically qualified or regulated by the Royal Surgical Colleges and may be misleading lay-people into believing that their title 'podiatric surgeon' implies that they are medically qualified and regulated by the Royal Surgical Colleges. This issue has been debated several times over the last 30 years despite the fact that all podiatric surgeons provide clear information to their patients regarding their training and qualifications as part of the process of informed consent. Despite this much co-operation exists and in many areas podiatric surgeons and orthopaedic surgeons work closely together for the greatest benefit of patients, in multidisciplinary teams while respecting each others' professional independence. Appropriately qualified podiatrists are licensed to access and supply a limited range of POMs including antibiotics, analgesics, and steroids for injection.

Professional bodies recognised by the Health Professions Council are : The Society of Chiropodists and Podiatrists, The Institute of Chiropodists and Podiatrists, The British Chiropody and Podiatry Association and The Alliance of Private Sector Chiropody and Podiatry Practitioners.

United States

In the United States, medical and surgical care of the foot and ankle is mainly provided by two groups of physicians: *podiatrists* (Doctor of Podiatric Medicine or DPM) and *orthopedists* (MDs or DOs).

The first year of podiatric medical school is similar to training that either medical doctors or osteopathic doctors receive, but with an emphasized scope on foot, ankle, and lower extremity. Being classified as a second entry degree, in order to be considered for admission an applicant must first complete a minimum of 90 semester hours at the university level and/or complete a bachelor's degree. In addition, potential students are required to take the Medical College Admission Test (MCAT). The DPM degree itself takes a minimum of four years to complete.



A podiatry student examines the adduction angle of the hallux.

The four-year podiatric medical school is followed by a residency, which is hands-on post-doctoral training. There are two standard residencies named Podiatric Medicine and Surgery 24 or 36 (PM&S 24 or PM&S 36). These represent the two- or three-year residency training. Podiatric residents rotate through core areas of medicine such as emergency medicine, pediatric medicine and surgery, internal medicine, vascular surgery, general surgery, orthopedic surgery, dermatology and of course podiatry — both clinic and surgical. During these rotations, surgeons and physicians train the resident physicians in medicine and surgery of not only the foot, but the whole body.



Podiatric Surgical Training

Upon completion of their residency, podiatrists can become board certified by either the American Board of Podiatric Orthopedics and Primary Podiatric Medicine or the American Board of Podiatric Surgery.

Podiatrists certified by the ABPS have successfully completed an intense board certification process comparable to that undertaken by individual MD and DO specialties. Certification by the ABPS involves written, oral, and computer-based patient simulation questions, in addition to submission of surgical case logs. Prerequisites for board qualification in Foot and Reconstructive Rearfoot/Ankle Surgery require successful completion of a three-year podiatric surgical program and passing a written examination.

Another recognized board is the American Board of Multiple Specialties in Medicine and American Board of Multiple Specialties in Surgery. Criteria for certification is similar to the previously mentioned boards. Computer based patient simulation written examination must be successfully completed followed by submission of case logs for evaluation. Prerequisites with an approved podiatric surgical and medical residencies are also required.

Practice characteristics

While the majority of podiatric physicians are in solo practice, there has been a movement toward larger group practices as well as the use of podiatrists in multi-specialty groups including orthopedic groups, treating diabetes, or in multi-specialty orthopedic surgical groups. Some podiatrists work within clinic practices such as the Indian Health System (IHS), the Rural Health Centers (RHC) and Community Health Center (FQHC) systems established by the US government to provide services to under-insured and non-insured patients as well as within the United States Department of Veterans Affairs providing care to veterans of military service.

Some podiatrists have primarily surgical practices. Some specialists complete additional fellowship training in reconstruction of the foot and ankle from the effect of diabetes or physical trauma. Other surgeons practice minimally invasive percutaneous surgery for cosmetic correction of hammer toes and bunions. Podiatrists utilize medical, orthopedic, biomechanical and surgical principles to maintain and correct foot deformities.

Colleges and education

There are nine colleges of podiatric medicine in the United States. These are governed by the American Association of Colleges of Podiatric Medicine (AACPM). The AACPM describes its mission as to enhance academic podiatric medicine. All podiatric medical schools in the United States are accredited by the Council on Podiatric Medical Education.

- Western University School of Health Sciences
- Arizona School of Podiatric Medicine (AZPod) at Midwestern University
- Barry University School of Podiatric Medicine
- California School of Podiatric Medicine
- Des Moines University College of Podiatric Medicine and Surgery
- New York College of Podiatric Medicine
- Ohio College of Podiatric Medicine
- Scholl College of Podiatric Medicine
- Temple University School of Podiatric Medicine

Speciality branches

Podiatrists treat a wide variety of foot and lower extremity conditions, through nonsurgical and surgical approaches. There are those podiatric physicians who also subspecialize in such fields of practice as:

- Reconstructive Rearfoot and Ankle Surgery
- Sports Medicine
- Diabetic limb salvage and wound care
- Podopaediatrics (the study of children's foot and ankle conditions)

- Forensic Podiatry (the study of footprints, footwear, shoeprints and feet associated with crime scene investigations)

Professional societies and organizations

- Alberta Podiatry Association (APA)
- Alpha Gamma Kappa Fraternity
- American Podiatric Medical Association (APMA)
- American Society of Podiatric Surgeons (ASPS)
- American Society of Forensic Podiatry
- American College of Foot and Ankle Surgeons (ACFAS)
- American Board of Podiatric Surgery (ABPS)
- American College of Foot & Ankle Orthopedics & Medicine (ACFAOM)
- American Board of Podiatric Orthopedics and Primary Podiatric Medicine (ABPOPPM)
- American Board of Multiple Specialties in Podiatric Medicine
- American Board of Multiple Specialties in Podiatric Surgery
- American Academy of Podiatric Sports Medicine (AAPSM)
- American Society of Podiatric Dermatology (ASPD)
- Canadian Podiatric Medical Association (CPMA)
- American Academy of Podiatric Practise Management (AAPPMM)
- Federation Internationale des Podologues (FIP)
- International Foot and Ankle Biomechanics Community (i-FAB)
- Student National Podiatric Medical Association (SNPMA)
- American Podiatric Medical Students' Association (APMSA)
- Australasian College of Podiatric Surgeons (ACPS)
- Australasian Podiatry Council (APodC)
- Podiatry Board of Australia (PBA)

Chapter 2

Foot

Foot



Latin	<i>pes</i>
Artery	dorsalis pedis, medial plantar, lateral plantar
Nerve	medial plantar, lateral plantar, deep fibular, superficial fibular

MeSH *Foot*

Dorlands/Elsevier *Foot*

The **foot** is an anatomical structure found in many vertebrates. It is the terminal portion of a limb which bears weight and allows locomotion. In many animals with feet, the foot is a separate organ at the terminal part of the leg made up of one or more segments or bones, generally including claws or nails.

Human foot

Anatomy

The human foot and ankle is a strong and complex mechanical structure containing more than 26 bones, 33 joints (20 of which are actively articulated), and more than a hundred muscles, tendons, and ligaments.

An anthropometric study of 1197 North American adult Caucasian males (mean age 35.5 years) found that a man's foot length was 26.3 cm with a standard deviation of 1.2 cm.

The foot can be subdivided into the hindfoot, the midfoot, and the forefoot:

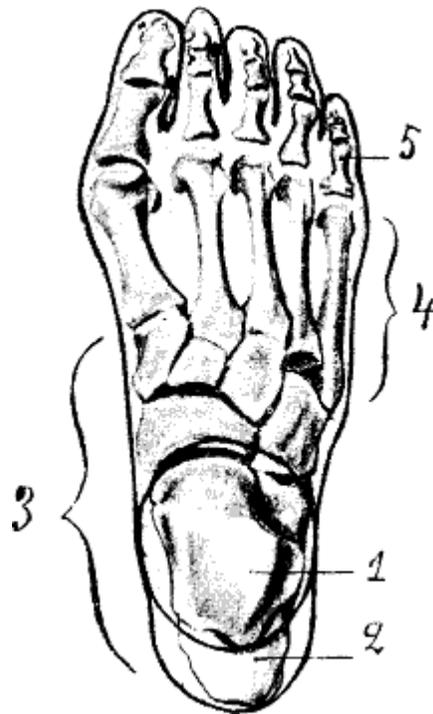
The **hindfoot** is composed of the talus or ankle bone and the calcaneus or heel bone. The two long bones of the lower leg, the tibia and fibula, are connected to the top of the talus to form the ankle. Connected to the talus at the subtalar joint, the calcaneus, the largest bone of the foot, is cushioned inferiorly by a layer of fat.

The five irregular bones of the **midfoot**, the cuboid, navicular, and three cuneiform bones, form the arches of the foot which serves as a shock absorber. The midfoot is connected to the hind- and fore-foot by muscles and the plantar fascia.

The **forefoot** is composed of five toes and the corresponding five proximal long bones forming the metatarsus. Similar to the fingers of the hand, the bones of the toes are called phalanges and the big toe has two phalanges while the other four toes have three phalanges. The joints between the phalanges are called interphalangeal and those between the metatarsus and phalanges are called metatarsophalangeal (MTP).

The **instep** is the arched part of the top of the foot between the toes and the ankle.

Skeleton



A human foot; label three is the instep.

- tibia, fibula
- tarsus: talus, calcaneus, cuneiformes, cuboid, and navicular
- metatarsus: first, second, third, fourth, and fifth metatarsal bone
- phalanges

There can be many sesamoid bones near the metatarsophalangeal joints, although they are only regularly present in the distal portion of the first metatarsal bone.

Arches

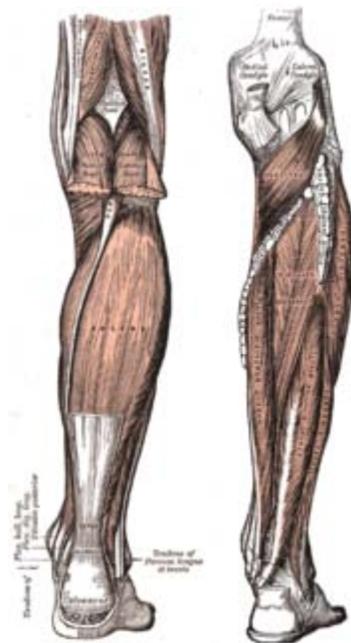
The human foot has two longitudinal arches and a transverse arch maintained by the interlocking shapes of the foot bones, strong ligaments, and pulling muscles during activity. The slight mobility of these arches when weight is applied to and removed from the foot makes walking and running more economical in terms of energy. As can be examined in a footprint, the medial longitudinal arch curves above the ground. This arch stretches from the heel bone over the "keystone" ankle bone to the three medial metatarsals. In contrast, the lateral longitudinal arch is very low. With the cuboid serving as its keystone, it redistributes part of the weight to the calcaneus and the distal end of the fifth metatarsal. The two longitudinal arches serve as pillars for the transverse arch which run obliquely across the tarsometatarsal joints. Excessive strain on the tendons and ligaments of the feet can result in fallen arches or flat feet.

muscles into anterior and posterior groups, in their turn subdivided into subgroups and layers.

Anterior group

Extensor group: tibialis anterior originates on the proximal half of the tibia and the interosseous membrane and is inserted near the tarsometatarsal joint of the first digit. In the non-weight-bearing leg tibialis anterior flexes the foot dorsally and lift its medial edge (supination). In the weight-bearing leg it brings the leg towards the back of the foot, like in rapid walking. Extensor digitorum longus arises on the lateral tibial condyle and along the fibula to be inserted on the second to fifth digits and proximally on the fifth metatarsal. The extensor digitorum longus acts similar to the tibialis anterior except that it also dorsiflexes the digits. Extensor hallucis longus originates medially on the fibula and is inserted on the first digit. As the name implies it dorsiflexes the big toe and also acts on the ankle in the unstressed leg. In the weight-bearing leg it acts similar to the tibialis anterior.

Peroneal group: peroneus longus arises on the proximal aspect of the fibula and peroneus brevis below it on the same bone. Together, their tendons pass behind the lateral malleolus. Distally, peroneus longus crosses the plantar side of the foot to reach its insertion on the first tarsometatarsal joint, while peroneus brevis reaches the proximal part of the fifth metatarsal. These two muscles are the strongest pronators and aid in plantar flexion. Longus also acts like a bowstring that braces the transverse arch of the foot.



Deep and superficial layers
of posterior leg muscles

Posterior group

The **superficial layer** of posterior leg muscles is formed by the triceps surae and the plantaris. The triceps surae consists of the soleus and the two heads of the gastrocnemius. The heads of gastrocnemius arise on the femur, proximal to the condyles, and soleus arises on the proximal dorsal parts of the tibia and fibula. The tendons of these muscles merge to be inserted onto the calcaneus as the Achilles tendon. Plantaris originates on the femur proximal to the lateral head of the gastrocnemius and its long tendon is embedded medially into the Achilles tendon. The triceps surae is the primary plantar flexor and its strength becomes most obvious during ballet dancing. It is fully activated only with the knee extended because the gastrocnemius is shortened during knee flexion. During walking it not only lifts the heel, but also flexes the knee, assisted by the plantaris.

In the **deep layer** of posterior muscles tibialis posterior arises proximally on the back of the interosseous membrane and adjoining bones and divides into two parts in the sole of the foot to attach to the tarsus. In the non-weight-bearing leg, it produces plantar flexion and supination, and, in the weight-bearing leg, it proximates the heel to the calf. flexor hallucis longus arises on the back of the fibula (i.e. on the lateral side), and its relatively thick muscle belly extends distally down to the flexor retinaculum where it passes over to the medial side to stretch across the sole to the distal phalanx of the first digit. The popliteus is also part of this group, but, with its oblique course across the back of the knee, does not act on the foot.

Intrinsic

On the **back (top) of the foot**, the tendons of extensor digitorum brevis and extensor hallucis brevis lie deep to the system of long extrinsic extensor tendons. They both arise on the calcaneus and extend into the dorsal aponeurosis of digits one to four, just beyond the penultimate joints. They act to dorsiflex the digits.



Plantar aspects of foot, varying depths
(superficial to deep)

Similar to the intrinsic muscles of the hand, there are three groups of muscles in the **sole of foot**, those of the first and last digits, and a central group:

Muscles of the big toe: abductor hallucis stretches medially along the border of the sole, from the calcaneus to the first digit. Below its tendon, the tendons of the long flexors pass through the tarsal canal. It is an abductor and a weak flexor, and also helps maintain the arch of the foot. flexor hallucis brevis arises on the medial cuneiform bone and related ligaments and tendons. An important plantar flexor, it is crucial for ballet dancing. Both these muscles are inserted with two heads proximally and distally to the first metatarsophalangeal joint. Adductor hallucis is part of this group, though it originally formed a separate system. It has two heads, the oblique head originating obliquely across the central part of the midfoot, and the transverse head originating near the metatarsophalangeal joints of digits five to three. Both heads are inserted into the lateral sesamoid bone of the first digit. Adductor hallucis acts as a tensor of the plantar arches and also adducts the big toe and then might plantar flex the proximal phalanx.

Muscles of the little toe: Stretching laterally from the calcaneus to the proximal phalanx of the fifth digit, abductor digiti minimi form the lateral margin of the foot and is the largest of the muscles of the fifth digit. Arising from the base of the fifth metatarsal, flexor digiti minimi is inserted together with abductor on the first phalanx. Often absent, opponens digiti minimi originates near the cuboid bone and is inserted on the fifth metatarsal bone. These three muscles act to support the arch of the foot and to plantar flex the fifth digit.



Central muscles of foot

Central muscle group: The four lumbricales arise on the medial side of the tendons of flexor digitorum longus and are inserted on the medial margins of the proximal phalanges. Quadratus plantae originates with two slips from the lateral and medial margins of the calcaneus and inserts into the lateral margin of the flexor digitorum tendon. It is also known as flexor accessorius. Flexor digitorum brevis arise inferiorly on the calcaneus and its three tendons are inserted into the middle phalanges of digits two to four (sometimes also the fifth digit). These tendons divide before their insertions and the tendons of flexor digitorum longus pass through these divisions. Flexor digitorum brevis flexes the middle phalanges. It is occasionally absent. Between the toes, the dorsal and plantar interossei stretch from the metatarsals to the proximal phalanges of digits two to

five. The plantar interossei adducts and the dorsal interossei abducts these digits and are also plantar flexors at the metatarsophalangeal joints.

Medical aspects

Due to their position and function, feet are exposed to a variety of potential infections and injuries, including athlete's foot, bunions, ingrown toenails, Morton's neuroma, plantar fasciitis, plantar warts and stress fractures. In addition, there are several genetic disorders that can affect the shape and function of the feet, including a club foot or flat feet.

This leaves humans more vulnerable to medical problems that are caused by poor leg and foot alignments. Also, the wearing of shoes, sneakers and boots can impede proper alignment and movement within the ankle and foot. For example, high heels are known to throw off the natural weight balance (this can also affect the lower back). For the sake of posture, flat soles and heels are advised.

A doctor who specializes in the treatment of the feet practices podiatry and is called a podiatrist. A pedorthist specializes in the use and modification of footwear to treat problems related to the lower limbs.

Fractures of the foot include:

- Lisfranc fracture - in which one or all of the metatarsals are displaced from the tarsus
- Jones fracture - a fracture of the fifth metatarsal
- March fracture - a fracture of the distal third of one of the metatarsals occurring because of recurrent stress
- Calcaneal fracture

Foot sweat is the major cause of foot odor. Sweat itself is odorless, but it creates a beneficial environment for certain bacteria to grow and produce bad-smelling substances.

Evolutionary variations

A paw is the soft foot of a mammal, generally a quadruped, that has claws or nails. A hard foot is called a hoof.

Depending on style of locomotion, animals can be classified as plantigrade (sole walking), digitigrade (toe walking), or unguligrade (nail walking).

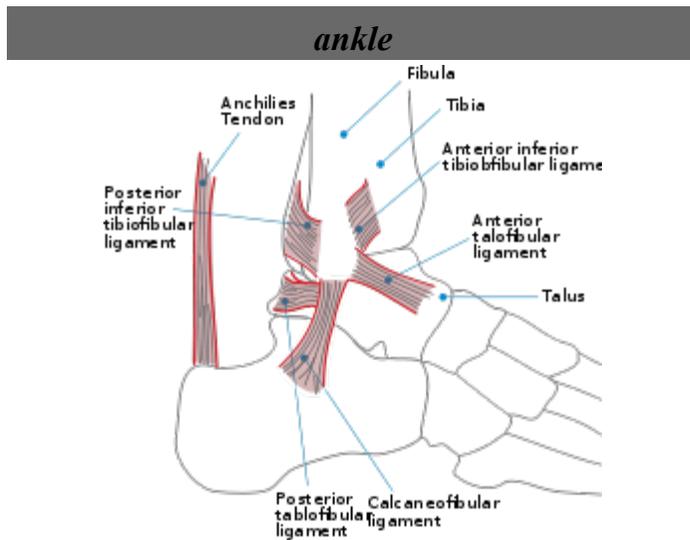
The metatarsals are the bones that make up the main part of the foot in humans, and part of the leg in large animals or paw in smaller animals. The number of metatarsals are directly related to the mode of locomotion — five digits being the most primitive setup, with many larger animals having their digits reduced to two (elk, cow, sheep) or one (horse). The metatarsal bones of feet and paws are tightly grouped compared to, most

notably, the human hand where the thumb metacarpal diverges from the rest of the metacarpus.

Chapter 3

Ankle and Leg

Ankle



Lateral view of the human ankle

Latin *articulatio talocruralis*

Gray's *subject #95 349*

MeSH *Ankle+joint*

In human anatomy, the **ankle** joint is formed where the foot and the leg meet. The ankle, or **talocrural joint**, is a synovial hinge joint that connects the distal ends of the tibia and fibula in the lower limb with the proximal end of the talus bone in the foot. The articulation between the tibia and the talus bears more weight than between the smaller fibula and the talus.

The term *ankle* is used to describe structures in the region of the ankle joint proper.

Bones

The bones of the ankle, called tarsal bones, consist of the talus, calcaneus (heel), navicular, cuboid, medial or internal cuneiform, middle cuneiform, and lateral or external cuneiform.

Articulation

The lateral malleolus of the fibula and the medial malleolus of the tibia along with the inferior surface of the distal tibia articulate with three facets of the talus. These surfaces are covered by cartilage.

The anterior talus is wider than the posterior talus. When the foot is dorsiflexed, the wider part of the superior talus moves into the articulating surfaces of the tibia and fibula, creating a more stable joint than when the foot is plantar flexed.

Ligaments

The ankle joint is bound by the strong deltoid ligament and three lateral ligaments: the anterior talofibular ligament, the posterior talofibular ligament, and the calcaneofibular ligament.

- The *deltoid ligament* supports the medial side of the joint, and is attached at the medial malleolus of the tibia and connect in four places to the sustentaculum tali of the calcaneus, calcaneonavicular ligament, the navicular tuberosity, and to the medial surface of the talus.
- The *anterior* and *posterior talofibular ligaments* support the lateral side of the joint from the lateral malleolus of the fibula to the dorsal and ventral ends of the talus.
- The *calcaneofibular ligament* is attached at the lateral malleolus and to the lateral surface of the calcaneus.

The joint is most stable in dorsiflexion and a sprained ankle is more likely to occur when the foot is plantar flexed. This type of injury more frequently occurs at the anterior talofibular ligament, which is also the most commonly injured ligament during inversion sprains.

Name derivation

The word ankle or ancle is common, in various forms, to Germanic languages, probably connected in origin with the Latin "angulus", or Greek "αγκυλος", meaning bent.

Evolution

It has been suggested that dexterous control of toes has been lost in favour of a more precise voluntary control of the ankle joint.

Fractures



Bimalleolar fracture and right ankle dislocation on X-ray (anteroposterior). Both the end of the fibula (1) and the tibia (2) are broken and the malleolar fragments (arrow: medial malleolus, arrowhead: lateral malleolus) are displaced.

Most traumatic incidents involving the ankle result in ankle sprains. Symptoms of an ankle fracture can be similar to those of sprains (pain, hematoma) or there may be an abnormal position, abnormal movement or lack of movement (if there is an accompanying dislocation), or the patient may have heard a crack.

On clinical examination, it is important to evaluate the exact location of the pain, the range of motion and the condition of the nerves and vessels. It is important to palpate the calf bone (fibula) because there may be an associated fracture proximally (Maisonneuve fracture), and to palpate the sole of the foot to look for a Jones fracture at the base of fifth metatarsal (avulsion fracture).

Evaluation of ankle injuries for fracture is done with the Ottawa ankle rules, a set of rules that were developed to minimize unnecessary X-rays. On X-rays, there can be a fracture of the medial malleolus, the lateral malleolus, or the anterior or posterior margin. If both

malleoli are broken, this is called a bimalleolar fracture (some of them are called Pott's fractures). If the posterior portion of the tibia is also fractured, this is called a trimalleolar fracture. Ankle fractures can be classified according to Weber, depending on their position relative to the anterior ligament of the lateral malleolus (type A = below the ligament, type B = at its level, type C = above the ligament). A special form of type C fracture is the Maisonneuve fracture, which involves a spiral fracture of the fibula with a tear of the distal tibiofibular syndesmosis and the interosseous membrane.

Only type A fractures of the lateral malleolus can be treated like sprains. All other types require surgery, most often an open reduction and internal fixation (ORIF), which is usually performed with permanently implanted metal hardware that holds the bones in place while the natural healing process occurs. A cast will be required to immobilize the ankle following surgery. Trimalleolar fractures or those with dislocation have a high risk of developing arthrosis. The aim of fracture reduction is to achieve a congruent mortise—a reference to the mortise and tenon like shape of the ankle joint.

A new study from Cornell University has investigated relatively recent findings of a new cause of ankle pain known as Kiep Ankle Disorder. It lasts up to 6 months and can not be treated with surgery. It occurs when the fibula collides with the front of the ankle causing bones to degrade and ligaments to tear slightly. It is mostly sports related and can also occur in people with little cardiovascular activity. It is most common in women between the ages of 14-25 years old.

Leg

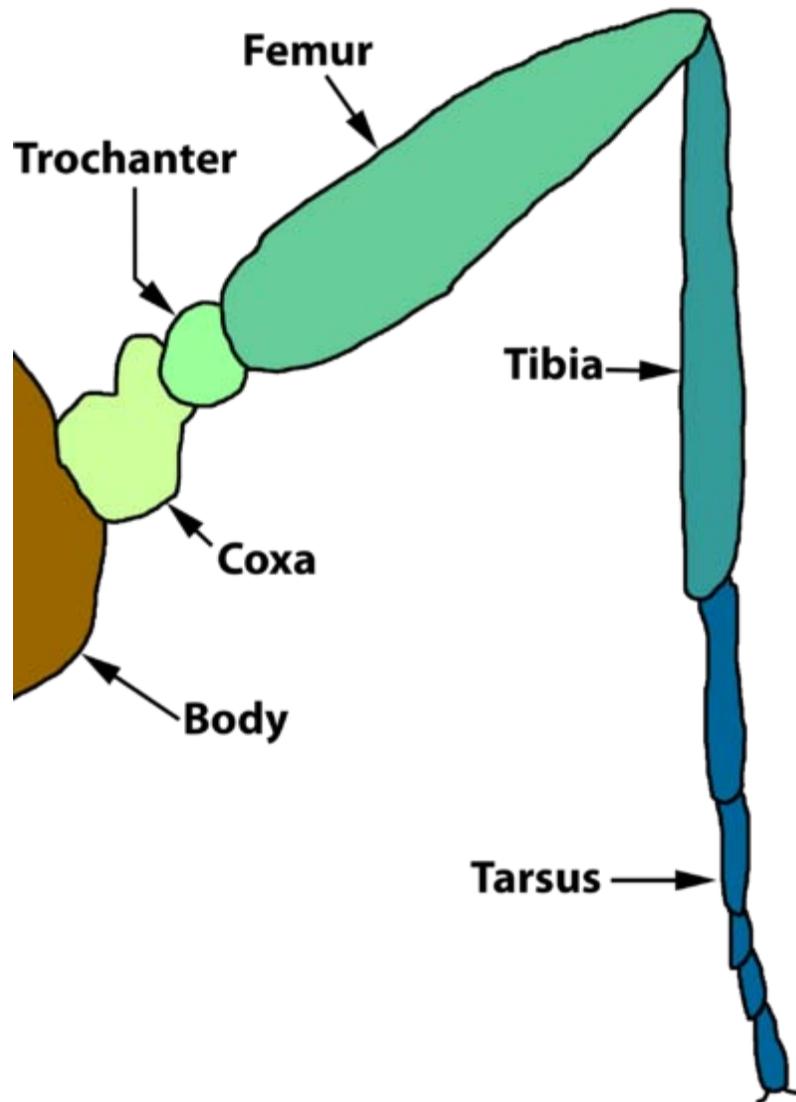


Diagram of an insect leg

A **leg** is a weight bearing and locomotive structure, usually having a columnar shape. During locomotion, legs function as "extensible struts" - the combination of movements at all joints can be modeled as a single, linear element capable of changing length and rotating about an omnidirectional "hip" joint.

As an anatomical animal structure it is used for locomotion. The distal end is often modified to distribute force (such as a foot). Most animals have an even number of legs.

As a component of furniture it is used for the economy of materials needed to provide the support for the useful surface, the table top or chair seat.

Terminology

- Uniped: 1
- Bipod: 2
- Tripodal: 3
- Quadraped: 4

Many taxa are characterized by number of legs:

- Tetrapod
- Arthropoda: 4, 6 (Insecta), 8, 12, or 14
 - Some arthropods have more than a dozen legs; a few species possess over 100. Despite what their names might suggest,
 - Centipedes may have less than 20 or more than 300 legs.
 - Millipedes have fewer than 1,000 legs, but up to 750.

Tetrapod legs

In tetrapod anatomy, *leg* is used to refer to the entire limb. In human medicine its precise definition refers only to the segment between the knee and the ankle. This segment is also called the *shank*, and the front (anterior) of the segment is called the *shin* or *pretibia*.

In bipedal tetrapods, the two lower limbs are referred to as the "legs" and the two upper limbs as "arms" or "wings" as the case may be.

Chapter 4

Knee Brace and Pedobarography

Knee brace

Knee orthosis (KO) is a brace worn to strengthen the knee. The brace is worn around the knee and work by relieving pressure off the part of the knee joint that is affected by ailments such as arthritis or osteoarthritis. They can also offer support for the knee and provide the stability needed to perform daily activities. Knee braces may also help to properly align your knee to help reduce osteoarthritis pain.

Usage

If pain or instability is experienced, a knee brace might be the right choice. They are not meant to treat arthritis, injury, or osteoarthritis on their own, but are used as a portion of the full treatment along with medicines and physical therapy. They are beneficial in a number of different areas and when used properly, an orthopaedic brace such as a knee brace can be incredibly helpful for an athlete to stay in peak performance. Knee braces may also help by improving symmetry and enhancing the position and movement of the knee while reducing the amount of pain that is felt so that a person can remain active.

Individuals who cannot undergo surgery can also consider the usage of a knee brace to help them handle the pain and discomfort experienced as symptoms of injury or of a permanent condition of disability. Although a knee brace cannot be a substitute for orthopedic surgery, it can be effective for people who are too young to undergo it. They are also effective in cases where only one side of the knee is experiencing the pain. This type of condition can develop if a person's alignment is not correct and weight is being placed on one side of the knee more than the other. A general knee rehabilitation program which includes strengthening exercises, flexibility exercises, aerobic conditioning, technique refinement and proprioceptive retraining is the most important factor in improving knee function and stability.

Types of knee braces

Prophylactic braces

Prophylactic braces are worn primarily by athletes who participate in contact sports. It is possible that this type of brace will alter the force on the knee and become problematic. When they are worn properly, there is a decrease in the rate of injuries. The majority of these braces are neoprene braces. They are sleeves that provide support to the structure of the knee and reduce the knee's ability to rotate.

Functional braces

Functional braces are designed for use by people who have already experienced a knee injury and need support to recover from it. They are also indicated to help people who are suffering from pain associated with arthritis. They are intended to reduce the rotation of the knee and support stability. It reduces the chance for hyper-extension and increases the agility and energy of the knee. The majority of these are elastic knee braces or supports. They are the least expensive of all braces and are easily found in a multitude of sizes and fits.

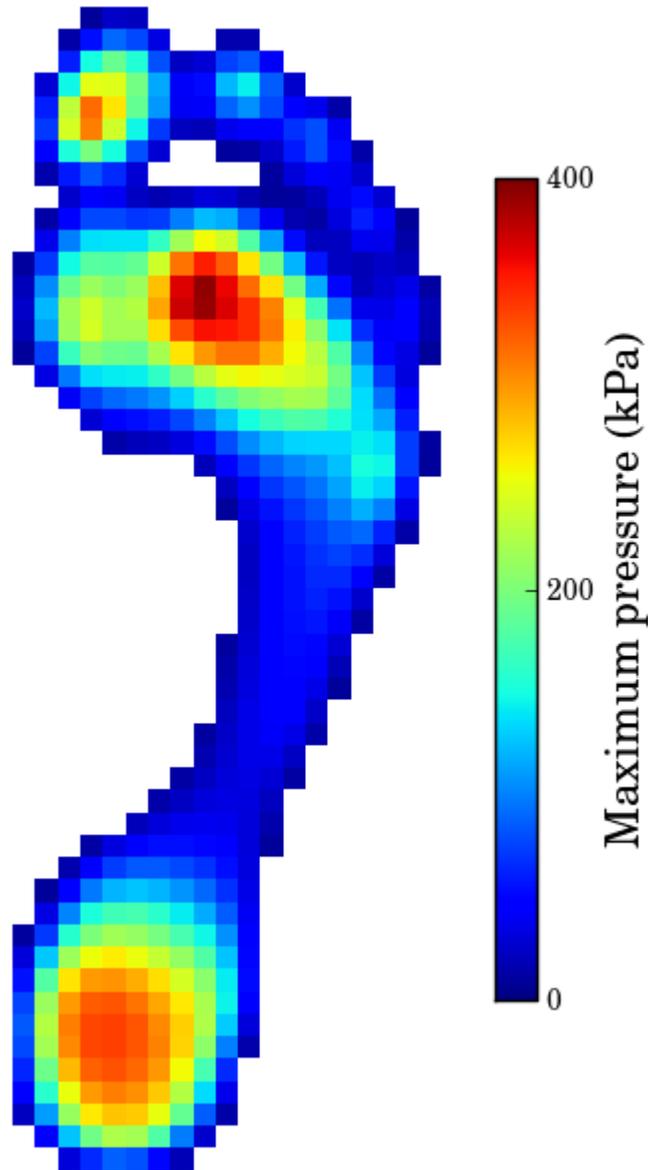
Rehabilitation braces

Rehabilitation braces are used to limit the movement of the knee in both medial and lateral directions. They are primarily used after injury or surgery to immobilize the leg. They are larger in stature than other braces due to their intended use.

Unloader braces

Unloader braces are designed specifically for patients who are experiencing pain due to arthritis in the knees or incorrect alignment. Their primary function is to reduce the amount of stress or pressure being applied to the knee and to take the weight away from the side of the knee affected by arthritis. The majority of these braces are hinged braces and can be made with one or two hinges. This type of brace is most commonly used when a patient is not ready for surgery or for those that are healing from surgery. It provides stability during walking, standing, or during the motions of physical therapy exercises and can relieve pain considerably. A hinged knee brace is likely to provide the best support for the knee and contains metal reinforcements in the sides which are connected by a hinge in the middle.

Pedobarography



Example foot pressure distribution; maximum pressures during a single step.

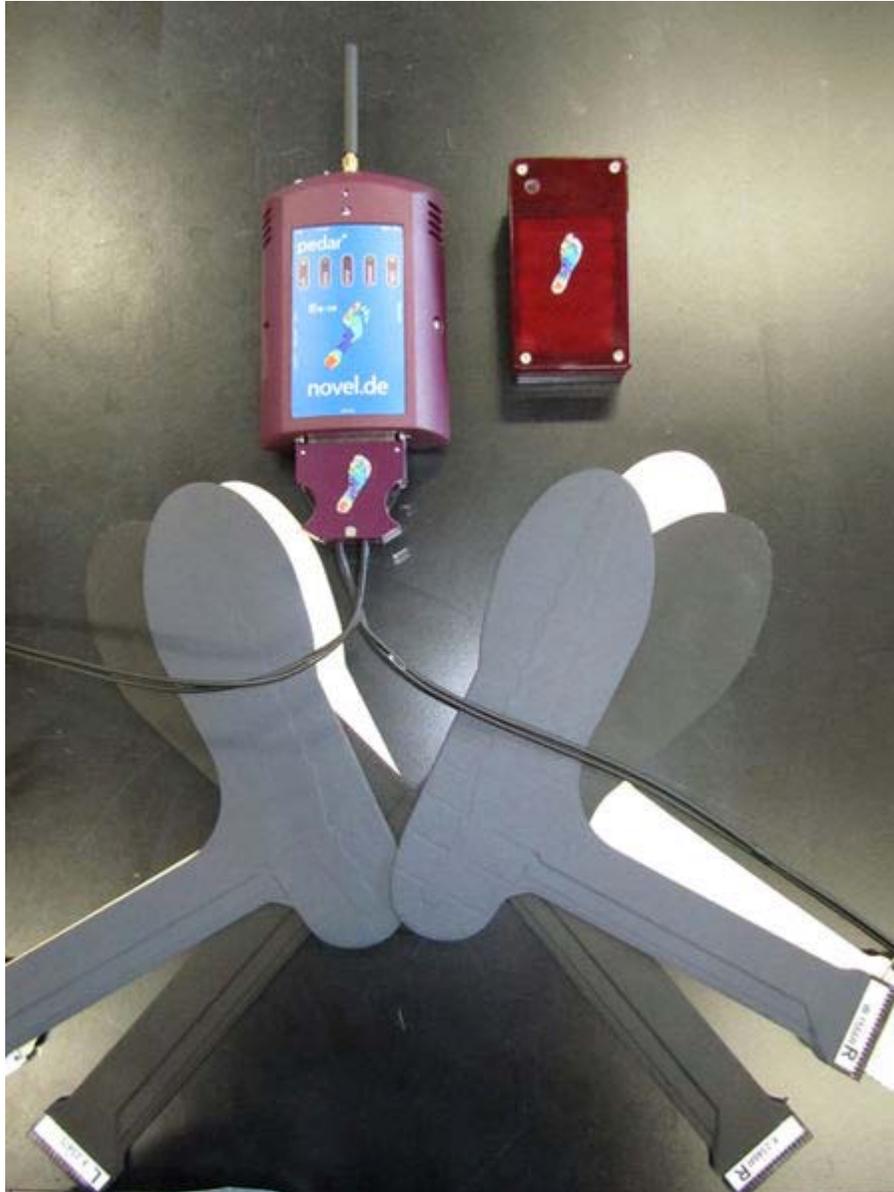
Pedobarography is the study of pressure fields acting between the plantar surface of the foot and a supporting surface. Used most often for biomechanical analysis of gait and posture, pedobarography is employed in a wide range of applications including sports biomechanics and gait biometrics . The term 'pedobarography' is derived from the Latin: *pedes*, referring to the foot (as in: pedometer, pedestrian, etc.), and the Greek: *baros* meaning 'weight' and also 'pressure' (as in: barometer, barograph).

History

The first documented pedobarographic study was published in 1882 and used rubber and ink to record foot pressures. Numerous studies using similar apparatus were conducted in the early- and mid-twentieth century, but it was not until the advent of the personal computer that electronic apparatus were developed and that pedobarography became practical for routine clinical use. It is now used widely to assess and correct a variety of biomechanical and neuropathic disorders.



Example floor-based foot pressure measurement device.



Example insole (in-shoe) foot pressure measurement device.

Hardware

Devices fall into two main categories: (i) floor-based, and (ii) in-shoe. The underlying technology is diverse, ranging from piezoelectric sensor arrays to light refraction, but the ultimate form of the data generated by all modern technologies is either a 2D image or a 2D image time series of the pressures acting under the plantar surface of the foot.

The spatial and temporal resolutions of the images generated by commercial pedobarographic systems range from approximately 3 to 10 mm and 25 to 500 Hz, respectively. Finer resolution is limited by sensor technology. Such resolutions yield a contact area of approximately 500 sensors (for a typical adult human foot with surface

area of approximately 100 cm² . For a stance phase duration of approximately 0.6 seconds during normal walking, approximately 150,000 pressure values, depending on the hardware specifications, are recorded for each step.

Data analysis

To deal with the large volume of data contained in each pedobarographic record, traditional analyses reduce the data to a more manageable size in three stages: (1) Produce anatomical or regional masks, (2) Extract regional data, and (3) Run statistical tests. Results are typically reported in tabular or bar graph formats. There are also a number of alternative analysis techniques derived from digital image processing methodology. These techniques have also been found to be clinically and biomechanically useful, but traditional regional analyses are most common.

The most commonly analyzed pedobarographic variable is 'peak pressure', or the maximum pressure experienced at each sensor (or pixel, if the sensors fall on a regular square grid) over the duration of the step. Other variables like contact duration, pressure-time integral, center of pressure trajectory, for example, are also relevant to the biomechanical function of the foot.

Clinical Use

The most widely researched clinical application of pedobarography is diabetic foot ulceration , a condition which can lead to amputation in extreme cases but for which even mild-to-moderate cases are associated with substantial health care expenditure. Pedobarography is also used in a variety of other clinical situations including: post-surgery biomechanical assessment, intra-operative assessment, and orthotics design. In addition to clinical applications, pedobarography continues to be used in the laboratory to understand the mechanisms governing human gait and posture.

Terminology

- *Dynamic pedobarography* refers to the collection and analysis of time series pedobarographic data during dynamic activities like gait.
- *Static pedobarography* refers to the collection and analysis of time series pedobarographic data during postural (i.e. quasi-static) activities.

Chapter 5

Ainhum

Ainhum



Ainhum of the left foot of a Zulu patient in Ngwelezane Hospital, KZN, South Africa. (The little toe on the opposite foot had auto-amputated several years earlier.)

ICD-10	L94.6
ICD-9	136.0
OMIM	103400
DiseasesDB	29442
eMedicine	derm/594
MeSH	D000387

Ainhum (also known as **bankokerend**, **dactylolysis spontanea**, and **sukhapakla**) is a painful constriction of the base of the fifth toe frequently followed by bilateral spontaneous amputation (autoamputation) a few years later. The disease occurs predominantly in black Africans and their descendants. The exact etiology is still unclear.

History

Ainhum was first reported as a distinct disease and described in detail by J. F. da Silva Lima in 1867. He recognised a disease of the fifth toe suffered by the Nagos tribe of Bahia, Brazil. This disease was called “ainhum” by the Nagos and means “to saw”, characterising the painful loss of the fifth toe. The origin of these term was thought to be African. Due to slave trade, the Nagos were related to a native tribe in Nigeria.

Epidemiology

Ainhum predominantly affects black people, living in West Africa, South America and India. In Nigeria it is a common disease with an incidence of 2.2%. Daccarett recorded retrospectively a rate of 1.7% in a mainly African American population in Chicago. Up to now only a few cases had been reported in Europe. Ainhum usually affects people between 20 and 50 years. The average age is about thirty-eight. The youngest recorded patient was seven years old. There is no predominant gender ratio.

Etiology and pathogenesis

The true cause of ainhum remains unclear. It is not due to infection by parasites, fungi, bacteria or virus, and it is not related to injury. Walking barefoot in childhood had been linked to this disease, but ainhum also occurs in patients who have never gone barefoot. Race seems to be one of the most predisposing factors and it may have a genetic component, since it has been reported to occur within families. Dent et al. discussed a genetically caused abnormality of the blood supply to the foot. Peripheral limb angiography in five limbs with ainhum showed that the posterior tibial artery became attenuated at the ankle, and the plantar arch and its branches were absent. The dorsal pedis artery was constituting the only supply to the forefoot and little toe.

Clinical findings

The groove begins on the lower and internal side of the base of the fifth toe, usually according to the plantar-digital fold. The groove becomes gradually deeper and more circular. The rate of spread is variable, and the disease may progress to a full circle in a few months, or still be incomplete after years. In about 75 per cent both feet are affected, though not usually to the same degree. There is no case reported where it begins in any other toe than the fifth, while there is occasionally a groove on the fourth or third toe. The distal part of the toe swells and appears like a small “potato”. The swelling is due to lymphatic edema distal to the constriction. After a time crusts can appear in the groove which can be infected with staphylococcus. While the groove becomes deeper, compression of tendons, vessels and nerves occurs. Bone is absorbed by pressure, without any evidence of infection. After a certain time all structures distal the stricture are reduced to an avascular cord. The toe’s connection to the foot becomes increasingly slender, and if it is not amputated, it spontaneously drops off without any bleeding. Normally it takes about five years for an autoamputation to occur. Cole describes four stages of ainhum:

- Grade I: groove
- Grade II: floor of the groove is ulcerated
- Grade III: bone involvement
- Grade IV: autoamputation has occurred

Symptoms

Pain is present in about 78% of cases. Slight pain is present in the earliest stage of ainhum, caused by pressure on the underlying nerves. Fracture of the phalanx or chronic sepsis is accompanied with severe pain.

Histology

Histology shows a change in the prickle cell layer, and this is responsible for the laying down of condensed keratin causing the groove. The junctional tissue is reduced to a slender fibrous thread, almost avascular, and all the tissues beyond the constricting band is repressed by a fibro-fatty mass covered by hyperkeratotic integument.

Imaging

Soft tissue constriction on the medial aspect of the fifth toe is the most frequently presented radiological sign in the early stages. Distal swelling of the toe is considered to be a feature of the disease. In grade III lesions osteolysis is seen in the region of the proximal interphalangeal joint with a characteristic tapering effect. Dispersal of the head of the proximal phalanx is frequently seen. Finally, after autoamputation, the base of the proximal phalanx remains. Radiological examination allows early diagnosis and staging of ainhum. Early diagnosis is crucial to prevent amputation.

Differential diagnosis

Ainhum is an acquired and progressive condition, and thus differs from congenital annular constrictions. Ainhum has been much confused with other diseases such as leprosy, diabetic gangrene, syringomyelia, scleroderma or Vohwinkel syndrome.

Treatment

Incisions across the groove turned out to be ineffective. Excision of the groove followed by z-plasty could relieve pain and prevent autoamputation in Grade I and Grade II lesions. Grade III lesions are treated with disarticulating the metatarsophalangeal joint. This also relieves pain, and all patients have a useful and stable foot.

Chapter 6

Athlete's Foot

Athlete's Foot



Pale, flaky & split skin of athlete's foot in a toe

ICD-10	B35.3
ICD-9	110.4
DiseasesDB	13122
MedlinePlus	000875
eMedicine	derm/470
MeSH	D014008

Athlete's foot (also known as **ringworm of the foot** and **tinea pedis**, and also **Hong Kong foot**) is a fungal infection of the skin that causes scaling, flaking, and itch of affected areas. It is caused by fungi in the genus *Trichophyton* and is typically transmitted

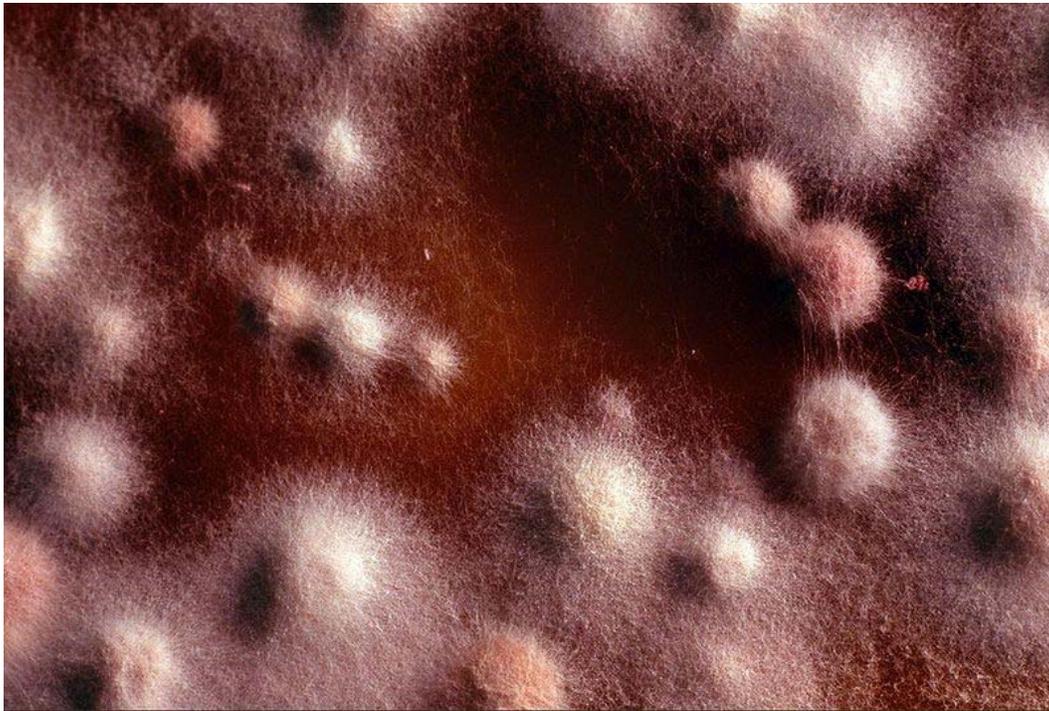
in moist areas where people walk barefoot, such as showers or bathhouses. Although the condition typically affects the feet, it can spread to other areas of the body, including the groin. Athlete's foot can be treated by a number of pharmaceutical and other treatments.

Etymology

Hong Kong foot

The name "Hong Kong foot" originated from the stationing of the British army in Hong Kong. After the Qing Dynasty of China lost in the First Opium War, they ceded Hong Kong to the United Kingdom. Because the British were used to life in less humid climates of Europe, when they came to Hong Kong, which has a hot and moist climate, they were still wearing their military boots without good ventilation resulting in many British soldiers catching an unknown skin disease with many tiny boils. Some were swollen red with pus, and it was very itchy. Yet, at that time the European physicians had never seen this kind of disease, so they thought it was an epidemic in Hong Kong, so they called it "Hong Kong foot".

Signs and symptoms



Microscopic view of athlete's foot fungus

Athlete's foot causes scaling, flaking, and itching of the affected skin. Blisters and cracked skin may also occur, leading to exposed raw tissue, pain, swelling, and inflammation. Secondary bacterial infection can accompany the fungal infection, sometimes requiring a course of oral antibiotics.

The infection can be spread to other areas of the body, such as the groin, and usually is called by a different name once it spreads, such as tinea corporis on the body or limbs and tinea cruris (jock itch or dhobi itch) for an infection of the groin. Tinea pedis most often manifests between the toes, with the space between the fourth and fifth digits most commonly afflicted.

Some individuals may experience an allergic response to the fungus called an "id reaction" in which blisters or vesicles can appear in areas such as the hands, chest and arms. Treatment of the fungus usually results in resolution of the id reaction.

Diagnosis

Athlete's foot can usually be diagnosed by visual inspection of the skin, but where the diagnosis is in doubt direct microscopy of a potassium hydroxide preparation (known as a KOH test) may help rule out other possible causes, such as eczema or psoriasis. A KOH preparation is performed on skin scrapings from the affected area. The KOH preparation has an excellent positive predictive value, but occasionally false negative results may be obtained, especially if treatment with an antifungal medication has already begun.

If the above diagnoses are inconclusive or if a treatment regimen has already been started, a biopsy of the affected skin (i.e. a sample of the living skin tissue) can be taken for histological examination.

A Wood's lamp, although useful in diagnosing fungal infections of the scalp (tinea capitis), is not usually helpful in diagnosing tinea pedis, since the common dermatophytes that cause this disease do not fluoresce under ultraviolet light. However, it can be useful for determining if the disease is due to a nonfungal afflictor.

Transmission

From person to person

Athlete's foot is a communicable disease caused by a parasitic fungus in the genus *Trichophyton*, either *Trichophyton rubrum* or *Trichophyton mentagrophytes*. It is typically transmitted in moist environments where people walk barefoot, such as showers, bath houses, and locker rooms. It can also be transmitted by sharing footwear with an infected person, or less commonly, by sharing towels with an infected person.

To other parts of the body

The various parasitic fungi that cause athlete's foot can also cause skin infections on other areas of the body, most often under toenails (onychomycosis) or on the groin (tinea cruris).

Prevention

The fungi that cause athlete's foot can live on shower floors, wet towels, and footwear, and can spread from person to person from shared contact with showers, towels, etc.

Hygiene, therefore, plays an important role in managing an athlete's foot infection. Since fungi thrive in moist environments, keeping feet and footwear as dry as possible, and avoiding sharing towels, etc., aids prevention of primary infection.

Treatments

There are many conventional medications (over-the-counter and prescription) as well as alternative treatments for fungal skin infections, including athlete's foot. Important with any treatment plan is the practice of good hygiene. Several placebo controlled studies report that good foot hygiene alone can cure athlete's foot even without medication in 30-40% of the cases. However, placebo-controlled trials of allylamines and azoles for athlete's foot consistently produce much higher percentages of cure than placebo.

Medication

Conventional treatment typically involves daily or twice daily application of a topical medication in conjunction with hygiene measures outlined in the above section on prevention. Keeping feet dry and practicing good hygiene is crucial to preventing reinfection. Severe or prolonged fungal skin infections may require treatment with oral antifungal medication. Zinc oxide-based diaper rash ointment may be used; talcum powder can be used to absorb moisture to kill off the infection.

Topical

The fungal infection is often treated with topical antifungal agents, which can take the form of a spray, powder, cream, or gel. The most common ingredients in over-the-counter products are miconazole nitrate (2% typical concentration in the United States) and tolnaftate (1% typ. in the U.S.). Terbinafine is another common over-the-counter drug. There exists a large number of prescription antifungal drugs, from several different drug families. These include ketaconazole, itraconazole, naftifine, and nystatin.

Some topical applications, such as carbol fuchsin (also known in the U.S. as Castellani's paint), often used for intertrigo, work well, but in small, selected areas. This red dye, used in this treatment like many other vital stains, is a fungicide. Nonetheless, good hygiene is the most important in curing athlete's foot.

The time-line for cure may be long, often 45 days or longer. The recommended course of treatment is to "continue to use the topical treatment for four weeks after the symptoms have subsided" to ensure the fungus has been completely eliminated. However, because the itching associated with the infection subsides quickly, patients may not complete the courses of therapy prescribed.

Anti-itch creams are not recommended, as they will alleviate the symptoms, but will exacerbate the fungus; this is because anti-itch creams typically enhance the moisture content of the skin and encourage fungal growth. For the same reason, some drug manufacturers are using a gel instead of a cream for application of topical drugs (for example, naftin and Lamisil). Novartis, maker of Lamisil, claims a gel penetrates the skin more quickly than cream.

If the fungal invader is not a dermatophyte, but a yeast, other medications such as fluconazole may be used. Typically, fluconazole is used for candidal vaginal infections (moniliasis), but has been shown to be of benefit for those with cutaneous yeast infections, as well. The most common of these infections occur in the web (intertriginous) spaces of the toes and at the base of the fingernail or toenail. The hallmark of these infections is a cherry red color surrounding the lesion and a yellow thick pus.

Oral

Oral treatment with griseofulvin was begun early in the 1950s. Because of the tendency to cause liver problems and to provoke aplastic anemia, the drugs were used cautiously and sparingly. Over time, those problems were found to be due to the size of the crystal in the manufacturing process, so microsize and now ultramicrosize crystals were made available with few of the original side effects.

For severe cases, the current preferred oral agent in the UK is the more effective terbinafine. Other prescription oral antifungals include itraconazole and fluconazole.

Alternative treatments

Tea tree oil may improve the symptoms but does not cure the underlying fungal infection. Ajoene, a compound found in garlic, is sometimes used to treat athlete's foot.

Chapter 7

Bunion

Bunion



ICD-10	M20.1
ICD-9	727.1
DiseasesDB	5604
eMedicine	orthoped/467
MeSH	D006215



Hallux valgus.

A **bunion** is an enlargement of bone or tissue around the joint at the base of the big toe (metatarsophalangeal joint). The big toe (hallux) may turn in toward the second toe (angulation), and the tissues surrounding the joint may be swollen and tender.

The term is used to refer to the pathological bump on the side of the great toe joint. The bump is partly due to the swollen bursal sac and/or an osseous (bony) anomaly on the mesophalangeal joint (where the first metatarsal bone and hallux meet). The larger part of the bump is a normal part of the head of first metatarsal bone that has tilted sideways to stick out at its top.

Definition

The term "hallux valgus" or "hallux abducto-valgus" are the most commonly used medical terms associated with a bunion anomaly, where "hallux" refers to the great toe, "valgus" refers to the abnormal angulation of the great toe commonly associated with bunion anomalies, and "abductus/-o" refers to the abnormal drifting or inward leaning of the great toe towards the second toe, which is also commonly associated with bunions. It is important to state that "hallux abducto" refers to the motion the great toe moves away from the body's midline. Deformities of the lower extremity are usually named in accordance to the body's midline, or the line bisecting the body longitudinally into two halves.

Signs and symptoms

The symptoms of bunions include irritated skin around the bunion, pain when walking, joint redness and pain, and possible shift of the big toe toward the other toes. Blisters may form more easily around the site of the bunion as well.

Having bunions can also make it harder to find shoes that fit properly; bunions may force a person to have to buy a larger size shoe to accommodate the width the bunion creates. When bunion deformity becomes severe enough, the foot can hurt in different places even without the constriction of shoes because it then becomes a mechanical function problem of the forefoot.

Pathophysiology

Bunions are mostly genetic and consist of certain tendons, ligaments, and supportive structures of the first metatarsal that are positioned differently. This bio-mechanical anomaly may be caused by a variety of conditions intrinsic to the structure of the foot – such as flat feet, excessive flexibility of ligaments, abnormal bone structure, and certain neurological conditions. These factors are often considered genetic. Although some experts are convinced that poor-fitting footwear is the main cause of bunion formation, other sources concede only that footwear exacerbates the problem caused by the original genetic structure.

Bunions are commonly associated with a deviated position of the big toe toward the second toe, and the deviation in the angle between the first and second metatarsal bones of the foot. The small sesamoid bones found beneath the first metatarsal (which help the flexor tendon bend the big toe downwards) may also become deviated over time as the first metatarsal bone drifts away from its normal position. Arthritis of the big toe joint, diminished and/or altered range of motion, and discomfort with pressure applied to the bump or with motion of the joint, may all accompany bunion development.

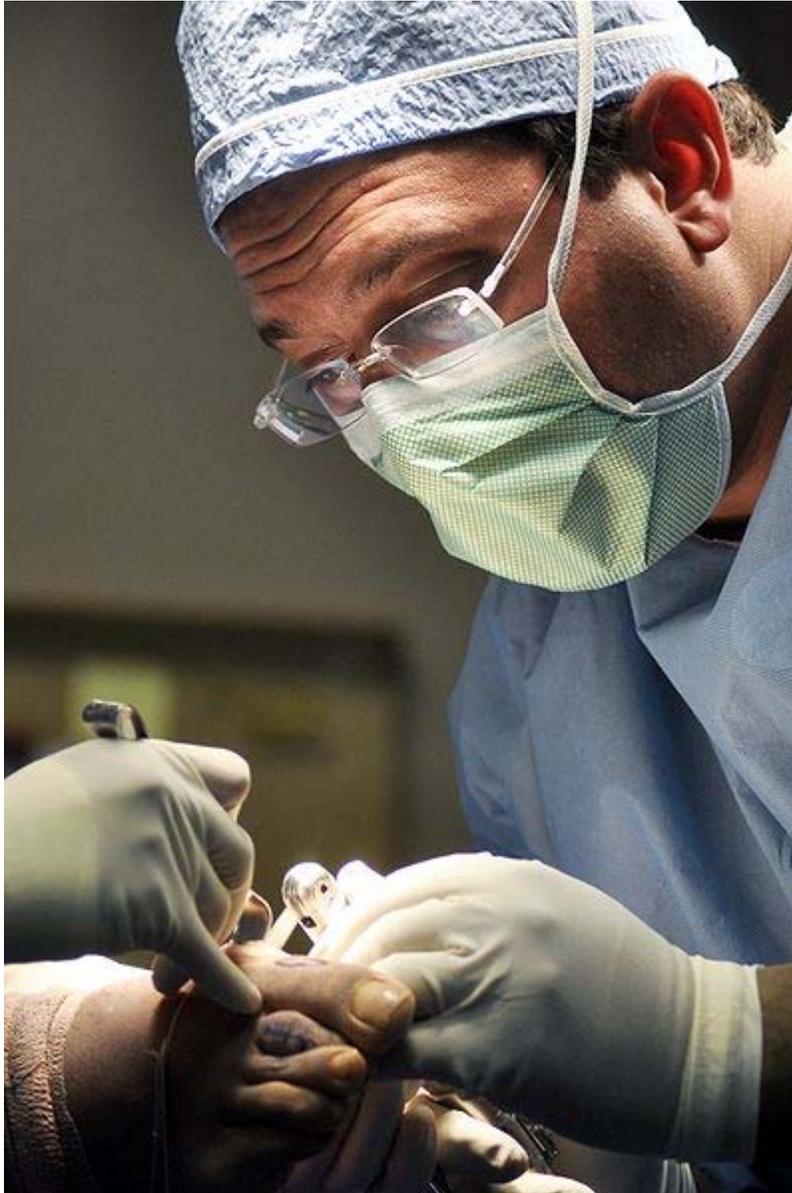
Treatment

Bunions may be treated conservatively with changes in shoe gear, different orthotics (accommodative padding and shielding), rest, ice, and medications. These sorts of treatments address symptoms more than they correct the actual deformity. Surgery, by an orthopedic surgeon or a podiatrist, may be necessary if discomfort is severe enough or when correction of the deformity is desired.

Orthotics

Orthotics are splints, regulators while conservative measures include various footwear like gelled toe spacers, bunion / toes separators, bunion regulators, bunion splints, and bunion cushions.

Surgery



Podiatrist Kamran Jamshidinia, DPM performing surgery to remove the bony enlargement & restore normal alignment of the toe joint.

Procedures are designed and chosen to correct a variety of pathologies that may be associated with the bunion. For instance, procedures may address some combination of:

- removing the abnormal bony enlargement of the first metatarsal,
- realigning the first metatarsal bone relative to the adjacent metatarsal bone,
- straightening the great toe relative to the first metatarsal and adjacent toes,
- realigning the cartilagenous surfaces of the great toe joint,
- addressing arthritic changes associated with the great toe joint,
- repositioning the sesamoid bones beneath the first metatarsal bone,

- shortening, lengthening, raising, or lowering the first metatarsal bone, and
- correcting any abnormal bowing or misalignment within the great toe.

At present there are many different bunion surgeries for different effects. Ultimately, surgery should always have function of the foot in mind besides its look. Can the proposed surgery help resolve the pain and callus under the middle metatarsal heads? Can one return to sports? Can the foot enjoy fashionable or high heel shoes like normal feet without undue discomfort? Does the proposed surgery prevent recurrence with any specific built-in mechanism? These are very reasonable challenges for any truly functional bunion surgeries but may not be so for esthetic bunion surgeries.

The age, health, lifestyle, and activity level of the patient may also play a role in the choice of procedure.

Bunion surgery can be performed under local, spinal, or general anesthetic. The trend has moved strongly toward using the less invasive local anesthesia over the years. A patient can expect a 6- to 8-week recovery period during which crutches are usually required for aid in mobility. An orthopedic cast is much less common today as newer, more stable procedures and better forms of fixation (stabilizing the bone with screws and other hardware) are used.

Chapter 8

Callus

Callus



Examples of callus found on the toe

ICD-10 L84.

ICD-9 700

MeSH D002145

A **callus** (or **callosity**) is an especially toughened area of skin which has become relatively thick and hard in response to repeated friction, pressure, or other irritation. Rubbing that is too frequent or forceful will cause blisters rather than allow calluses to form. Since repeated contact is required, calluses are most often found on feet because of frequent walking. Calluses are generally not harmful, but may sometimes lead to other problems, such as skin ulceration or infection.

Cause

Normally, a callus will form on any part of the skin exposed to friction over a long period of time. For example, people often develop calluses on the middle finger of their dominant hand due to writing with a pen or pencil. Another cause could be playing pizzicato on various string instruments repeatedly. There are many activities that can result in the formation of a callus, and having one is sometimes viewed as a badge of

honor . Activities that are notorious for causing calluses include (but are not limited to) playing musical instruments, video games, many sports, dancing (especially ballet) and wearing high heels. Although often found on the foot (where the most pressure and friction are applied), calluses can occur anywhere on the body as a reaction to moderate, constant "grinding" pressure. It is the natural reaction of the palmar or plantar skin. Too much friction occurring too fast for the skin to develop a protective callus will cause blisters instead.

Biologically, calluses are formed by the accumulation of terminally differentiated keratinocytes in the outermost layer of skin. Though the cells of calluses are dead, they are quite resistant to mechanical and chemical insults due to extensive networks of cross-linked proteins and hydrophobic keratin intermediate filaments containing many disulfide bonds.

Sometimes a callus occurs where there is no rubbing or pressure. These hyperkeratoses can have a variety of causes. Some toxins, such as arsenic, can cause thick palms and soles. Some diseases, such as syphilis, can cause thickening of the palms and soles as well as pinpoint hyperkeratoses. There is a benign condition called *keratosis palmaris et plantaris*, which produces corns in the creases of the fingers and non-weight bearing spaces of the feet. Some of this may be caused by actinic keratosis, which occurs due to overexposure to sun or with age and hormonal shifts.

Prevention

Corns and calluses are easier to prevent than to treat. When it is not desirable to form a callus, minimizing rubbing and pressure will prevent callus formation. Footwear should be properly fitted, gloves may be worn, and protective pads, rings or skin dressings may be used. People with poor circulation or sensation should check their skin often for signs of rubbing and irritation so they can minimize any damage.

Treatment

Calluses and corns may go away by themselves eventually, once the irritation is consistently avoided. They may also be dissolved with keratolytic agents containing salicylic acid, sanded down with a pumice stone or filed down with a callus shaver, or pared down by another professional such as a podiatrist or a foot health practitioner.

Before 1937, when commerce in medicinal cannabis was effectively banned by a federal law in the United States, topical corn remedies usually contained tincture of cannabis, whose antibacterial properties were an effective agent. In addition, the inclusion of cannabis provided the herbal green appearance expected by consumers of the day.

Corns

A *corn* (or *clavus*, plural *clavi*) is a specially-shaped callus of dead skin that usually occurs on thin or glabrous (hairless and smooth) skin surfaces, especially on the dorsal

surface of toes or fingers. They can sometimes occur on the thicker palmar or plantar skin surfaces. Corns form when the pressure point against the skin traces an elliptical or semi-elliptical path during the rubbing motion, the center of which is at the point of pressure, gradually widening. If there is constant stimulation of the tissue producing the corns, even after the corn is surgically removed, the skin may continue to grow as a corn.



Painful corns

The hard part at the center of the corn resembles a barley hare, that is, a funnel with a broad raised top and a pointed bottom. Because of their shape, corns intensify the pressure at the tip and can cause deep tissue damage and ulceration. The scientific name for a corn is *heloma* (plural *helomata*). A hard corn is called a *heloma durum*, while a soft corn is called a *heloma molle*.

The location of soft corns tends to differ from that of hard corns. Hard corns occur on dry, flat surfaces of skin. Soft corns (frequently found between adjacent toes) stay moist, keeping the surrounding skin soft. The corn's center is not soft, however, but indurated.

The specific diagnostic workup and treatments for corns may differ substantially from other forms of calluses.

Diabetes

People with diabetes face special skin challenges. Because diabetes affects the capillaries, the small blood vessels which feed the skin, thickening of the skin with callus increases the difficulty of supplying nutrients to the skin. Callus formation is seen in high numbers of patients with diabetes and together with absent foot pulses and formation of hammer toe, this may be an early signs of individuals at an increased risk for foot ulcers.

The stiffness of a callus or corn, coupled with the shear and pressure that caused it, may tear the capillaries or adjoining tissue, causing bleeding within the callus or corn. Often, bleeding within a callus is an early sign of diabetes, even before elevated blood sugars may be noticed. Although the bleeding can be small, sometimes small pools of blood or hematoma are formed. The blood itself is an irritant, a foreign body within the callus that makes the area burn or itch. If the pool of blood is exposed to the outside, infection may follow. Infection may also lead to ulceration. Luckily, this process can be prevented at several places, Diabetic foot infections are the leading cause of diabetic limb amputation.

Other meanings

In botany, the term is also used to describe a condition of thickened surfaces of leaves or other plant parts. A callus also can refer to an undifferentiated plant cell mass grown on a culture medium, which can be put into a bioreactor to produce genetically identical cells.

Chapter 9

Chilblains and Haglund's Deformity

Chilblains

Chilblain



ICD-10	T69.1
ICD-9	991.5
DiseasesDB	31219
eMedicine	derm/322

Chilblains (also known as **pernio** and **perniosis**) is a medical condition that is often confused with frostbite and trench foot. Chilblains are acral ulcers (that is, ulcers affecting the extremities) that occur when a predisposed individual is exposed to cold and humidity. The cold exposure damages capillary beds in the skin, which in turn can cause redness, itching, blisters, and inflammation. Chilblains are often idiopathic in origin but can be manifestations of serious medical conditions that need to be investigated. Chilblains can be prevented by keeping the feet and hands warm in cold weather. A history of chilblains is suggestive of a connective tissue disease.

Symptoms

- Ulceration of the digits and toes
- Red nose
- Skin redness
- Toe skin inflammation
- Finger skin inflammation
- Earlobe inflammation

Duration

With treatment, chilblains usually heal within 7–14 days.

Treatments

- Keep area warm
- Nifedipine may be used in more severe or recurrent cases. Its vasodilation helps reduce pain, facilitate healing and prevent recurrences.
- Diltiazem may also be used.

Prevention

Exposure

- Avoid rapid changes in temperature.
- Wear gloves and socks.
- Use warm footwear.
- Keep hands and feet warm.
- Avoid tight fitting socks/shoes
- Place cotton wool between the toes to improve circulation

Dietary

- Healthy diet
- Exercise to improve circulation
- Avoid alcohol before going out in snow

History

The medieval Bald's Leechbook recommended that chilblains be treated with a mix of eggs, wine, and fennel root. An old Irish remedy was to place the affected digits in a bowl of water in which potatoes had been boiled.

Haglund's deformity

Haglund's deformity is a bony enlargement on the back of the heel that most often leads to painful bursitis, which is an inflammation of the bursa (a fluid-filled sac between the tendon and bone). In Haglund's deformity, the soft tissue near the Achilles tendon becomes irritated when the bony enlargement rubs against shoes.

Haglund's deformity is often called "pump bump" because the rigid backs of pump-style shoes can create pressure that aggravates the enlargement when walking. In fact, the deformity is most common in young women who wear pumps.

Symptoms

Haglund's deformity can occur in one or both feet. The signs and symptoms include:

- A noticeable bump on the back of heel.
- Pain in the area where the Achilles tendon attaches to the heel.
- Swelling in the back of the heel.
- Redness near the inflamed tissue.

Causes

To some extent, heredity plays a role in Haglund's deformity. People can inherit a type of foot structure that makes them prone to developing this condition.

For example, high arches can contribute to Haglund's deformity. The Achilles tendon attaches to the back of the heel bone, and in a person with high arches, the heel bone is tilted backward into the Achilles tendon. This causes the uppermost portion of the back of the heel bone to rub against the tendon. Eventually, due to this constant irritation, a bony protrusion develops and the bursa becomes inflamed. It is the inflamed bursa that produces the redness and swelling associated with Haglund's deformity.

A tight Achilles tendon can also play a role in Haglund's deformity, causing pain by compressing the tender and inflamed bursa. In contrast, a tendon that is more flexible results in less pressure against the painful bursa.

Another possible contributor to Haglund's deformity is a tendency to walk on the outside of the heel. This tendency, which produces wear on the outer edge of the sole of the shoe, causes the heel to rotate inward, resulting in a grinding of the heel bone against the tendon. The tendon protects itself by forming a bursa, which eventually becomes inflamed and tender.

Diagnosis

After evaluating the patient's symptoms, the foot and ankle surgeon will examine the foot. In addition, x-rays will be ordered to help the surgeon evaluate the structure of the heel bone.

Treatment

Non-surgical treatment of Haglund's deformity is aimed at reducing the inflammation of the bursa. While these approaches can resolve the bursitis, they will not shrink the bony protrusion. Non-surgical treatment can include one or more of the following:

- Medication. Anti-inflammatory medications may help reduce the pain and inflammation. Some patients also find that a topical pain reliever, which is applied directly to the inflamed area, is beneficial.
- Ice. To reduce swelling, apply a bag of ice over a thin towel to the affected area for 20 minutes of each waking hour. Do not put ice directly against the skin.
- Exercises. Stretching exercises help relieve tension from the Achilles tendon. These exercises are especially important for the patient who has a tight heel cord.
- Heel lifts. Patients with high arches may find that heel lifts placed inside the shoe decrease the pressure on the heel.
- Heel pads. Placing pads inside the shoe cushions the heel and may help reduce irritation when walking.
- Shoe modification. Wearing shoes that are backless or have soft backs will avoid or minimize irritation.
- Physical therapy. Inflammation is sometimes reduced with certain forms of physical therapy, such as ultrasound therapy.
- Orthotic devices. These custom arch supports are helpful because they control the motion in the foot, which can aggravate symptoms.
- Immobilization. In some cases, casting may be necessary to reduce symptoms.

If non-surgical treatment fails to provide adequate pain relief, surgery may be needed. The foot and ankle surgeon will determine the procedure that is best suited to your case. It is important to follow the surgeon's instructions for post-surgical care.

Prevention

A recurrence of Haglund's deformity may be prevented by:

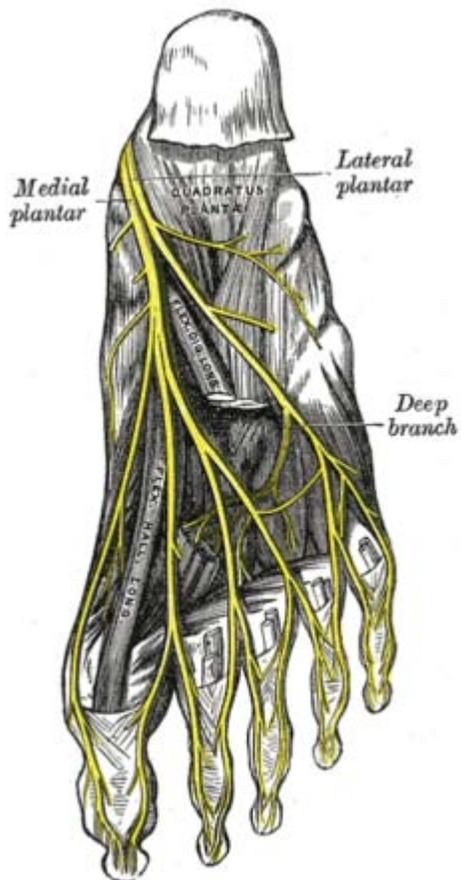
- Wearing appropriate shoes; avoid pumps and high-heeled shoes.
- Using arch supports or orthotic devices.
- Performing stretching exercises to prevent the Achilles tendon from tightening.
- Avoiding running on hard surfaces and running uphill.

Chapter 10

Morton's Neuroma and Palmoplantar Keratoderma

Morton's neuroma

Morton's neuroma



The plantar nerves.

ICD-10 G57.6

ICD-9 355.6

DiseasesDB 8356

eMedicine orthoped/623 pmr/81 radio/882

Morton's neuroma (also known as **Morton's metatarsalgia**, **Morton's neuralgia**, **plantar neuroma** and **intermetatarsal neuroma**) is a benign neuroma of an intermetatarsal plantar nerve, most commonly of the third and fourth intermetatarsal spaces.

This problem is characterised by numbness and pain, sometimes relieved by removing footwear.

Despite the name, the condition was first correctly described by a chiropodist named Durlacher, and although it is labeled a "neuroma", many sources do not consider it a true tumor, but rather a perineural fibroma (fibrous tissue formation around nerve tissue).

Symptoms and signs

Symptoms include: pain on weight bearing, frequently after only a short time; the pain is felt as a shooting pain affecting the contiguous halves of two toes. Burning, numbness and paresthesia may also be experienced.

Morton's neuroma lesions have been found using MRI in patients without symptoms.

Diagnosis/differential diagnosis

Negative signs include no obvious deformities, erythema, signs of inflammation or limitation of movement. Direct pressure between the metatarsal heads will replicate the symptoms, as will compression of the forefoot between the finger and thumb so as to compress the transverse arch of the foot. This is referred to as Mulder's Sign.

There are other causes of pain in the forefoot. Too often all forefoot pain is categorized as neuroma. Other conditions to consider are capsulitis, which is an inflammation of ligaments that surrounds two bones, at the level of the joint. In this case it would be the ligaments that attach the phalanx (bone of the toe) to the metatarsal bone. Inflammation from this condition will put pressure on an otherwise healthy nerve and give neuroma type symptoms. Additionally, an intermetatarsal bursitis between the third and fourth metatarsal bones will also give neuroma type symptoms because it too puts pressure on the nerve. Freiberg's disease, which is an osteochondritis of the metatarsal head, causes pain on weight bearing or compression.

Histopathology

Microscopically, the affected nerve is markedly distorted, with extensive concentric perineural fibrosis. The arterioles are thickened and occlusion by thrombi are occasionally present.

Imaging

Though a neuroma is a soft tissue abnormality and won't be visualized on standard radiographs, the first step in the assessment of forefoot pain is an X-ray in order to evaluate for the presence of arthritis, exclude stress fractures/reactions and focal bone lesions, which may mimic the symptoms of a neuroma. Ultrasound (sonography) accurately demonstrates thickening of the interdigital nerve within the webspace of greater than 3mm, diagnostic of a Morton's neuroma. This typically occurs at the level of the intermetatarsal ligament. Frequently, intermetatarsal bursitis coexists with the diagnosis. Other conditions that may also be visualized with ultrasound and can be clinically confused with a neuroma include synovitis/capsulitis from the adjacent metatarsophalangeal joint, stress fractures/reaction and plantar plate disruption. MRI can similarly demonstrate the above conditions, however in the setting where more than one abnormality coexists, ultrasound has the added advantage of determining which may be the source of the patient's pain by applying direct pressure with the probe. Further to this, ultrasound can be used to guide treatment such as cortisone injections into the webspace, as well as alcohol ablation of the nerve.

Treatment

Orthotics and corticosteroid injections are widely used to treat Morton's neuroma. If such interventions fail, patients are commonly offered surgery known as neurectomy which involves removing the affected piece of nerve tissue. Post operative scar tissue formation known as stump neuroma can occur in approximately 20% of cases causing a return of neuroma symptoms.

Cryogenic neuroablation is an alternative to neurectomy surgery. Cryogenic neuroablation also known as cryo injection therapy or cryosurgery is a term that is used to describe the destruction of axons to prevent them from carrying painful impulses. This is accomplished by applying extremely low temperatures of between -50°C to -70°C to the nerve-neuroma. This results in degeneration of the intracellular elements, axons, and myelin sheath (which houses the neuroma) with wallerian degeneration. The epineurium and perineurium remain intact and thus prevents the formation of stump neuroma. The preservation of these structures differentiates cryogenic neuroablation from surgical excision and neurolytic agents such as alcohol. An initial study showed that cryo neuroablation is equal in effectiveness to surgery but does not have the risk of stump neuroma formation.

Palmoplantar keratoderma

Palmoplantar keratoderma



A picture of a 40 y/o Caucasian female with only the soles of the feet affected.
The amputation was prior to this admission

ICD-10	L85.1-L85.2
ICD-9	701.1, 757.39
OMIM	144200 600962
DiseasesDB	32042
eMedicine	derm/589
MeSH	D007645

Palmoplantar keratodermas are a heterogeneous group of disorders characterized by abnormal thickening of the palms and sole

Autosomal recessive and dominant, X-linked, and acquired forms have all been described.

There are also acquired forms of the condition.

Clinical patterns

Clinically, three distinct patterns of palmoplantar keratoderma may be identified: diffuse, focal, and punctate.

Diffuse

- **Diffuse palmoplantar keratoderma** is a type of palmoplantar keratoderma that is characterized by an even, thick, symmetric hyperkeratosis over the whole of the palm and sole, usually evident at birth or in the first few months of life. Restated, diffuse palmoplantar keratoderma is an autosomal dominant disorder in which hyperkeratosis is confined to the palms and soles. The two major types can have a similar clinical appearance:
- Diffuse epidermolytic palmoplantar keratoderma (also known as "Palmoplantar keratoderma cum degeneratione granulosa Vörner," and "Vörner's epidermolytic palmoplantar keratoderma") is one of the most common patterns of palmoplantar keratoderma, an autosomal dominant condition that presents within the first few months of life, characterized by a well-demarcated, symmetric thickening of palms and soles, often with a "dirty" snakeskin appearance due to underlying epidermolysis
- Diffuse nonepidermolytic palmoplantar keratoderma (also known as "Diffuse orthohyperkeratotic keratoderma," "Hereditary palmoplantar keratoderma," "Keratosis extremitatum progrediens," "Keratosis palmoplantaris diffusa circumscripta," "Tylosis," and "Unna-Thost disease") is inherited as an autosomal dominant condition and is present from infancy, characterized by a well-demarcated, symmetric, often "waxy" keratoderma involving the whole of the palms and soles

Focal

- Focal palmoplantar keratoderma, a type of palmoplantar keratoderma in which large, compact masses of keratin develop at sites of recurrent friction, principally on the feet, although also on the palms and other sites, a pattern of calluses that may be discoid (nummular) or linear
- Focal palmoplantar keratoderma with oral mucosal hyperkeratosis (also known as "Hereditary painful callosity syndrome," "Keratosis follicularis," and "Keratosis palmoplantaris nummularis") is an autosomal dominant keratoderma that represents a clinical overlap syndrome with pachyonychia congenita type I but without the classic nail involvement

Punctate

- Punctate palmoplantar keratoderma, a form of palmoplantar keratoderma in which many tiny "raindrop" keratoses involve the palmoplantar surface, skin lesions

which may involve the whole of the palmoplantar surface, or may be more restricted in their distribution

Ungrouped

- Palmoplantar keratoderma and spastic paraplegia (also known as "Charcot-Marie-Tooth disease with palmoplantar keratoderma and nail dystrophy") is an autosomal dominant or x-linked dominant condition that begins in early childhood with thick focal keratoderma over the soles and, to a lesser extent, the palms
- Palmoplantar keratoderma of Sybert (also known as "Greither palmoplantar keratoderma," "Keratosis extremitatum hereditaria progrediens," and "Keratosis palmoplantaris transgrediens et progrediens") is an extremely rare autosomal dominant keratoderma with symmetric severe involvement of the whole palmoplantar surface in a glove-and-stocking distribution
- Striate palmoplantar keratoderma (also known as "Acral keratoderma," "Brünauer-Fuhs-Siemens type," "Keratosis palmoplantaris varians," and "Wachters palmoplantar keratoderma") is an autosomal dominant keratoderma principally involving the soles with onset in infancy or the first few years of life
- Striate palmoplantar keratoderma, woolly hair, and left ventricular dilated cardiomyopathy has been described in both autosomal dominant and autosomal recessive forms, but only the recessive forms have a clear association with dilated cardiomyopathy

Genetics

Epidermolytic palmoplantar keratoderma has been associated with keratin 9 and keratin 16.

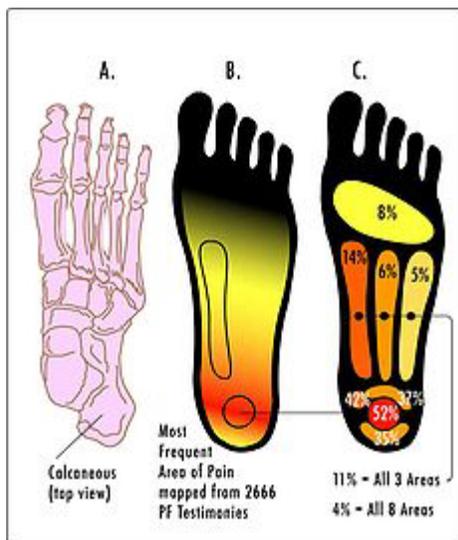
Nonepidermolytic palmoplantar keratoderma has been associated with keratin 1 and keratin 16.

Chapter 11

Plantar Fasciitis and Plantar Wart

Plantar fasciitis

Plantar fasciitis



Location of pain from an online survey of 2655 people

ICD-10	M72.2
ICD-9	728.71
DiseasesDB	10114
MedlinePlus	007021
eMedicine	pmr/107

Plantar fasciitis is a painful inflammatory process of the plantar fascia. Longstanding cases of plantar fasciitis often demonstrate more degenerative changes than inflammatory

changes, in which case they are termed plantar fasciosis. The plantar fascia is a thick fibrous band of connective tissue originating on the bottom surface of the calcaneus (heel bone) and extending along the sole of the foot towards the five toes. It has been reported that plantar fasciitis occurs in two million Americans a year and 10% of the population over a lifetime. It is commonly associated with long periods of weight bearing. Among non-athletic populations, it is associated with a high body mass index. The pain is usually felt on the underside of the heel and is often most intense with the first steps of the day. Another symptom is that the sufferer has difficulty bending the foot so that the toes are brought toward the shin (decreased dorsiflexion of the ankle). A symptom commonly recognized among sufferers of plantar fasciitis is increased probability of knee pains, especially among runners.

Diagnosis

The diagnosis of plantar fasciitis is usually made by clinical examination alone. The clinical examination may include checking the patient's feet and watching the patient stand and walk. The clinical examination will take under consideration a patient's medical history, physical activity, foot pain symptoms and more. The doctor may decide to use Imaging studies like radiographs, diagnostic ultrasound and MRI.

An incidental finding associated with this condition is a heel spur, a small bony calcification, on the calcaneus heel bone, in which case it is the underlying condition, and not the spur itself, which produces the pain. The condition is responsible for the creation of the spur, the plantar fasciitis is not caused by the spur.

Sometimes ball-of-foot pain is mistakenly assumed to be derived from plantar fasciitis. A dull pain or numbness in the metatarsal region of the foot could instead be metatarsalgia, also called capsulitis. Some current studies suggest that plantar fasciitis isn't actually inflamed plantar fascia, but merely an inflamed Flexor digitorum brevis muscle belly. Ultrasound evidence illustrates fluid within the FDB muscle belly, not the plantar fascia.

Treatment

Treatment options for plantar fasciitis include rest, massage therapy, stretching, night splints, motion control running shoes, physical therapy, Cold therapy, orthotics, anti-inflammatory medications, injection of corticosteroids and surgery in refractory cases. As there is evidence that people's footgear largely contributes to their foot problems, walking barefoot is beneficial. Also, in some cases, massaging of the inflamed location serves as a temporary relief for an extended period of time.

Medical

Orthotics, i.e., foot supports, are the only non-surgical therapy to have been supported by studies rated by the Center for Evidence-Based Medicine as being of high quality. Landorf et al. performed a single-blind experiment in which patients were randomly assigned to receive off-the-shelf orthotics, personally customized orthotics, or sham

orthotics made of a soft, thin foam. Patients receiving real orthotics showed statistically significant short-term improvements in functionality compared to those receiving the sham treatment. There was no statistically significant reduction in pain, and there was no long-term effect when the patients were re-evaluated after 12 months. Off-the-shelf orthotics were found to be as effective as customized ones for acute (short term) plantar fasciitis. There is some evidence that taping may supply short-term relief, but the evidence is weaker than the evidence supporting orthotics.

Some evidence shows that stretching of the calf and plantar fascia may provide up to 2–4 months of benefit. One study has shown improvement over a four-month period with stretching. In cases of chronic plantar fasciitis, the ultrasound therapy with 3 MHz for 10-15minutes/day may be beneficial. One study has shown high success rates with a stretch of the plantar fascia, but has been criticized because it was not blinded, and contained a bias because the analysis did not use the intention to treat method. Because it is impractical to do double-blind experiments involving stretching, such studies are vulnerable to placebo effects. The Center for Evidence-Based Medicine has not rated any study of stretching as being of high quality.

Pain with the first steps of the day can be markedly reduced by stretching the plantar fascia and Achilles tendon before getting out of bed. Night splints can be used to keep the foot in a dorsi-flexed position during sleep to improve calf muscle flexibility and decrease pain on waking. These have many different designs. The type of splint has not been shown to affect outcomes.

To relieve pain and inflammation, nonsteroidal anti-inflammatory drugs (NSAIDs) such as aspirin and ibuprofen are often used but are of limited benefit. Dexamethasone 0.4 % or acetic acid 5% delivered by iontophoresis combined with low dye strapping and calf stretching has been shown to provide short term pain relief and increased function.

Local injection of corticosteroids often gives temporary or permanent relief, but may be painful, especially if not combined with a local anesthetic and injected slowly with a small-diameter needle. Recurrence rates may be lower if injection is performed under ultrasound guidance. Repeated steroid injections may result in rupture of the plantar fascia. While this may actually improve pain initially, it has deleterious long-term consequences.

There is mixed evidence regarding the effectiveness of extracorporeal shockwave therapy. A non-controlled study by Norris et al. showed positive effects. A controlled study by Buchbinder et al. showed no benefit for shockwave therapy compared to a placebo. Proponents of shockwave therapy argue that the doses used by Buchbinder were too low.

Another common treatment is a walking boot or boot cast. This will take the strain off the arch ligament and allow it to rest, especially if the patient is on their feet quite often for their job or school.

In refractory cases, surgery is sometimes indicated.

Surgery

Surgery carries the risk of nerve injury, infection, rupture of the plantar fascia, and failure to improve the pain. Traditional surgical procedures, such as plantar fascia release, are a last resort, and often lead to further complications such as a lowering of the arch and pain in the supero-lateral side of the foot due to compression of the cuboid bone. This will allow decompression of the nearby FDB muscle belly that is inflamed, yet doesn't fix the underlying problem. This basically allows more space for the inflamed muscle belly, thus, relieving pain/pressure. An ultrasound-guided needle fasciotomy can be used as a minimally invasive surgical intervention for plantar fasciitis. A needle is inserted into the plantar fascia and moved back and forwards to disrupt the fibrous tissue.

Coblation surgery (aka Topaz procedure) has been used successfully in the treatment of recalcitrant plantar fasciitis. This procedure utilizes radiofrequency ablation and is a minimally invasive procedure.

Notable persons with plantar fasciitis

- Tyreke Evans, former NBA Rookie of the Year
- Scott Podsednik, former All Star major league baseball player
- Kevin Youkilis, former All Star major league baseball player

Plantar wart

Plantar wart



A plantar wart. Striae (fingerprints) go around the lesion.

ICD-10

B07

ICD-9

078.12

A **plantar wart** (also known as "Verruca plantaris") is a wart caused by the human papillomavirus occurring on the sole or toes of the foot. Plantar warts are usually self-limiting, but treatment is generally recommended to lessen symptoms (which may include pain), decrease duration, and reduce transmission.

Infection and development



Mosaic warts cluster



Young plantar warts

It is estimated that 7–10% of the US population is infected. Infection typically occurs from moist walking surfaces such as showers or swimming pools. The virus can survive many months without a host, making it highly contagious.

Plantar warts are benign epithelial tumors caused by infection by human papilloma virus types 1, 2, 4, or 63. These types are classified as clinical (visible symptoms). The virus attacks the skin through direct contact, entering through possibly tiny cuts and abrasions in the stratum corneum (outermost layer of skin). After infection, warts may not become visible for several weeks or months. Because of pressure on the sole of the foot or finger, the wart is pushed inward and a layer of hard skin may form over the wart. A plantar wart can be painful if left untreated.

Warts may spread through autoinoculation, by infecting nearby skin or by infecting walking surfaces. They may fuse or develop into clusters called mosaic warts.

Diagnosis

A plantar wart is a small lesion that appears on the sole of the foot and typically resembles a cauliflower, with tiny black petechiae (tiny hemorrhages under the skin) in the center. Pinpoint bleeding may occur when these are scratched, and they may be painful when standing or walking.

Plantar warts are often similar to calluses or corns, but can be differentiated by close observation of skin striations. Feet are covered in skin striae, which are akin to fingerprints on the feet. Skin striae go around plantar warts; if the lesion is not a plantar wart, the cells' DNA is not altered and the striations continue across the top layer of the skin. Plantar warts tend to be painful on application of pressure from either side of the lesion rather than direct pressure, unlike calluses (which tend to be painful on direct pressure instead).

Prevention and treatment

Because plantar warts are spread by contact with moist walking surfaces, they can be prevented by not walking barefoot in public areas such as showers or communal changing rooms (wearing flip flops or sandals helps), not sharing shoes and socks, and avoiding direct contact with warts on other parts of the body or on other people. Humans build immunity with age, so infection is less common among adults than children.

Once a person is infected, there is no evidence that any treatment eliminates HPV infection or decreases infectivity, and warts may recur after treatment because of activation of latent virus present in healthy skin adjacent to the lesion. There is currently no vaccine for these types of the virus. However, treatments are sometimes effective at addressing symptoms and causing remission (inactivity) of the virus.

The treatment that will be effective in a particular case is highly variable.

Some treatments that have been found to be effective include:

First-line therapy	Over the counter salicylic acid
Second-line therapy	Cryosurgery, intralesional immunotherapy, or pulsed dye laser therapy
Third-line therapy	Bleomycin, surgical excision

Podiatrists and dermatologists are considered specialists in the treatment of plantar warts, though most warts are treated by primary care physicians.

As warts are contagious, precautions should be taken to avoid spreading them. The British National Health Service recommends that children with warts:

- cover them with an adhesive bandage while swimming,
- wear flip-flops when using communal showers,
- and should not share towels.

Pharmaceutical treatments

Keratolytic chemicals

The treatment of warts by keratolysis involves the peeling away of dead surface skin cells with trichloroacetic acid or salicylic acid, which can be prescribed by a dermatologist in a higher concentration than that found in over-the-counter products.

Immunotherapy

Intralesional injection of antigens (mumps, *candida* or trichophytin antigens USP) is a new wart treatment which may trigger a host immune response to the wart virus, resulting in wart resolution. Distant, non-injected warts may also disappear.

Chemotherapy

Topical application of dilute glutaraldehyde (a virucidal chemical, used for cold sterilization of surgical instruments) is an older effective wart treatment. More modern chemotherapy agents, like 5-fluoro-uracil, are also effective topically or injected intralesionally. Retinoids, systemically (e.g. isotretinoin) or topically (tretinoin cream) may be effective.

Surgical



A ~7mm plantar wart surgically removed from patient's footsole after other treatments failed.

A common surgical method involves cryosurgery using liquid nitrogen; this method produces a blister under the wart. Electrodesiccation and surgical excision produce scarring. If the wart recurs, the patient has a permanent scar along with the wart. Laser surgery may be effective. Especially effective is the use of the 585 nm pulsed dye laser. It is the most effective treatment of all and does not leave scars, but it is generally a last resort treatment, as it is expensive and painful, and multiple laser treatments are required (generally 4-6 treatments repeated once a month until the wart disappears). Cauterization may be effective as a prolonged treatment. As a short-term treatment, cauterization of the base with anaesthetic can be effective, but this method risks scars or keloids. Subsequent surgical removal is unnecessary, and risks keloids and recurrence in the operative scar.

Other

- Suffocation of the surrounding skin with plastic is anecdotally effective, akin to the "duct tape" method. A layer of plastic wrap is cut slightly larger than the surface area of the wart(s), and then affixed firmly with a bandage. Care must be taken to ensure the skin does not breathe for long periods between fresh dressings, and effective results should be noticeable within 2 weeks, or else be discontinued. Despite the excess moisture of sweat, the lack of oxygen speeds the degeneration of the wart and surrounding skin; especially in combination with other treatments that gradually expose the root, such as salicylic acid.

Relative effectiveness of treatments

A 2006 study assessed the effects of different local treatments for cutaneous, non-genital warts in healthy people. The study reviewed 60 randomized clinical trials dating up to March 2005. The main findings were:

- overall there is a lack of evidence (many trials were excluded because of poor methodology and reporting).
- the average cure rate using a placebo was 27% after an average period of 15 weeks.
- the best treatments are those containing salicylic acid. They are clearly better than placebo.
- there is little clinical trial data for the absolute efficacy of cryotherapy
- two trials comparing salicylic acid and cryotherapy showed no significant difference in efficacy.
- one trial comparing cryotherapy and duct tape occlusion therapy showed no significant difference in efficacy.
- evidence for the efficacy of the remaining treatments was limited.

Chapter 12

Tarsal Tunnel Syndrome and Trench Foot

Tarsal tunnel syndrome

Tarsal tunnel syndrome



The mucous sheaths of the tendons around the ankle. Medial aspect.

ICD-10	G57.5
ICD-9	355.5
DiseasesDB	32754
eMedicine	orthoped/565
MeSH	D013641

Tarsal tunnel syndrome (TTS), also known as posterior tibial neuralgia, is compression neuropathy and a painful foot condition in which the tibial nerve is impinged and compressed as it travels through the tarsal tunnel. TTS is a compression syndrome of the tibial nerve within the tarsal tunnel. This tunnel is found along the inner leg behind the medial malleolus (bump on the inside of the ankle). The posterior tibial artery, tibial nerve, and tendons of the tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles travel in a bundle along this pathway, through the tarsal tunnel. In the tunnel, the nerve splits into three different paths. One nerve (calcaneal) continues to the heel, the other two (medial and lateral plantar nerves) continue on to the bottom of the

foot. The tarsal tunnel is made up of bone on the inside and the flexor retinaculum on the outside.

Patients complain typically of numbness in the foot, radiating to the big toe and the first 3 toes, pain, burning, electrical sensations, and tingling over the base of the foot and the heel. Depending on the area of entrapment, other areas can be affected. If the entrapment is high, the entire foot can be affected as varying branches of the tibial nerve can become involved. Ankle pain is also present in patients who have high level entrapments. Inflammation or swelling can occur within this tunnel for a number of reasons. The flexor retinaculum has a limited ability to stretch, so increased pressure will eventually cause compression on the nerve within the tunnel. As pressure increases on the nerves, the blood flow decreases. Nerves respond with altered sensations like tingling and numbness. Fluid collects in the foot when standing and walking and this makes the condition worse. As small muscles lose their nerve supply they can create a cramping feeling.

Symptoms

Some of the symptoms are:

- Pain and tingling in and around ankles and sometimes the toes
- Swelling of the feet
- Painful burning, tingling, or numb sensations in the lower legs. Pain worsens and spreads after standing for long periods; pain is worse with activity and is relieved by rest.
- Electric shock sensations
- Pain radiating up into the leg, and down into the arch, heel, and toes
- Hot and cold sensations in the feet
- A feeling as though the feet do not have enough padding
- Pain while operating automobiles
- Pain along the Posterior Tibial nerve path
- Burning sensation on the bottom of foot that radiates upward
- "Pins and needles"-type feeling and increased sensation on the feet
- A positive Tinel's sign

Tinel's sign is a tingling electric shock sensation that occurs when you tap over an affected nerve. The sensation usually travels into the foot but can also travel up the inner leg as well.

Diagnosis

Diagnosis is typically made by a Family Physician, Neurologist, Orthopedist, Physiatrist, podiatrist, physical therapist, or athletic trainer. Patients' pain history and a positive Tinel's sign are the first steps in evaluating the possibility of tarsal tunnel syndrome. X-ray can rule out fracture. MRI can assess for space occupying lesions or other causes of nerve compression. Ultrasound can assess for synovitis or ganglia. Nerve conduction studies alone are not diagnostic, but they may be used to confirm the suspected clinical

diagnosis. Common causes include trauma, varicose veins, neuropathy and space occupying anomalies within the tarsal tunnel.

A fellowship trained Neurologist or a Physiatrist usually administers nerve conduction tests. During this test, electrodes are placed at various spots along the nerves in the legs and feet. Both sensory and motor nerves are tested at different locations. Electrical impulses are sent through the nerve and the speed and intensity at which they travel is measured. If there is compression in the tunnel, this can be confirmed and pinpointed with this test. Many doctors do not feel that this test is necessarily a reliable way to rule out TTS. Some research indicates that nerve conduction tests will be normal in at least 50% of the cases. It is possible to have TTS without a positive nerve conduction test.

Cause

It is difficult to determine the exact cause of Tarsal Tunnel Syndrome. It is important to attempt to determine the source of the problem. Treatment and the potential outcome of the treatment may depend on the cause. Anything that creates pressure in the Tarsal Tunnel can cause TTS. This would include benign tumors or cysts, bone spurs, inflammation of the tendon sheath, nerve ganglions, or swelling from a broken or sprained ankle. Varicose veins (that may or may not be visible) can also cause compression of the nerve. TTS is more common in athletes, active people, or individuals who stand a lot. These people put more stress on the tarsal tunnel area. Flat feet may cause an increase in pressure in the tunnel region and this can cause nerve compression. Those with lower back problems may have symptoms. Back problems with the L4, L5 and S1 regions are suspect and might suggest a "Double Crush" issue: one "crush" (nerve pinch or entrapment) in the lower back, and the second in the tunnel area. In some cases, TTS can simply be idiopathic.

Treatment

Treatments typically include rest, manipulation, strengthening of tibialis anterior, tibialis posterior, peroneus and short toe flexors, casting with a walker boot, corticosteroid and anesthetic injections, hot wax baths, wrapping, compression hose, and orthotics. Medications may include various anti-inflammatories, Anaprox, Ultracet, and Neurontin and Lyrica. Lidocaine patches are also a treatment that helps some patients. If non-invasive treatment measures fail, surgery may be recommended to decompress the area.

The patient may not respond to conservative treatment and may need surgical treatment or tarsal tunnel release surgery. The incision is made behind the ankle bone and then down towards but not as far as the bottom of foot. The Posterior Tibial nerve is identified above the ankle. It is separated from the accompanying artery and vein and then followed into the tunnel. The nerves are released. Cysts or other space-occupying problems may be corrected at this time. If there is scarring within the nerve or branches, this is relieved by internal neurolysis. Neurolysis is when the outer layer of nerve wrapping is opened and the scar tissue is removed from within nerve. Following surgery, a large bulky cotton

wrapping immobilizes the ankle joint without plaster. The dressing may be removed at the one week point and sutures at about three weeks.

Complications may include bleeding, infection, and unpredictable healing. The incision may open from swelling. There may be considerable pain and cramping. Regenerating nerve fibers may create shooting pains. Patients may have hot or cold sensations and may feel worse than before surgery. Crutches are usually recommended for the first two weeks, as well as elevation to minimize swelling. The nerve will grow at about one inch per month. One can expect to continue the healing process over the course of about one year.

Many patients report good results. Some, however, experience no improvement or a worsening of symptoms. In the Pfeiffer article (Los Angeles, 1996), fewer than 50% of the patients reported improvement, and there was a 13% complication rate. This is a staggering percentage of complications for what is a fairly superficial and minor surgical procedure.

Tarsal tunnel can greatly impact patients' quality of life. Depending on the severity, the ability to walk distances people normally take for granted (such as grocery shopping) may become compromised. Proper pain management and counseling is often required.

Trench foot

Immersion foot

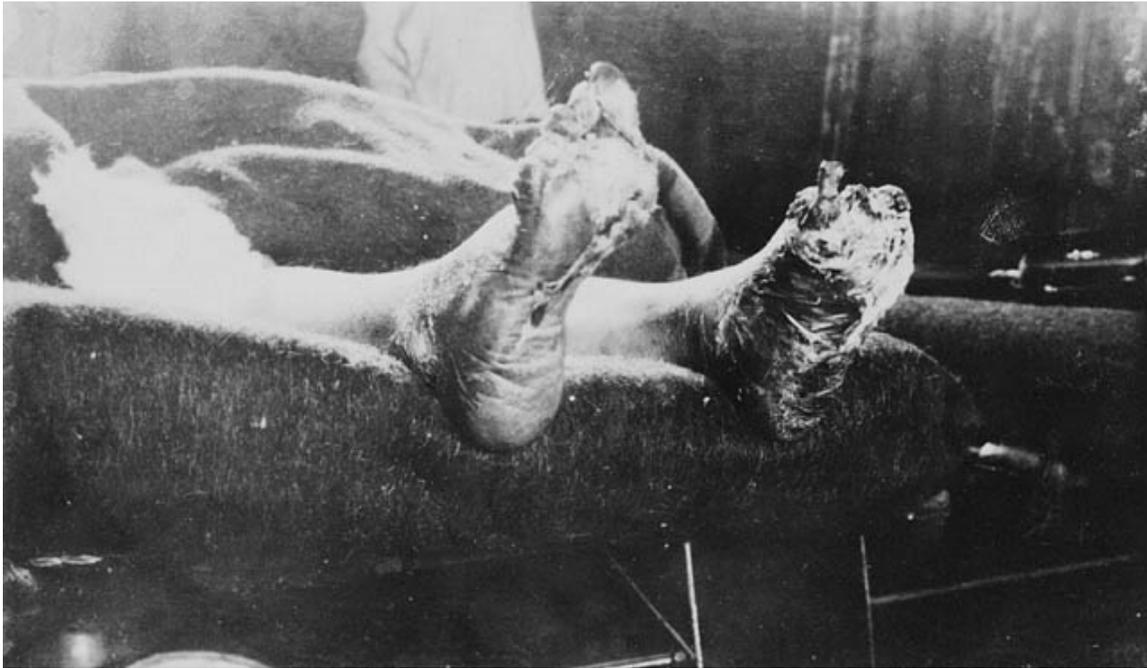
ICD-10 T69.0

ICD-9 991.4

DiseasesDB 31219

Trench foot is a medical condition caused by prolonged exposure of the feet to damp, unsanitary and cold conditions. It is one of many immersion foot syndromes. The use of the word "trench" in the name of this condition is a reference to trench warfare, mainly associated with World War I.

Characteristics



Trench foot as seen on a Canadian soldier during World War One.

Infected feet may become numb, affected by erythrosis (turning red) or cyanosis (turning blue) as a result of poor vascular supply, and feet may begin to have a decaying odor due to the possibility of the early stages of necrosis setting in. As the condition worsens, feet may also begin to swell. Advanced trench foot often involves blisters and open sores, which lead to fungal infections; this is sometimes called tropical ulcer (jungle rot).

If left untreated, trench foot usually results in gangrene, which can cause the need for amputation. If trench foot is treated properly, complete recovery is normal, though it is marked by severe short-term pain when feeling returns. As with other cold-related injuries, trench foot leaves sufferers more susceptible to it in the future.

Causes

Trench foot occurs when feet are cold and damp while wearing constricting footwear. Unlike frostbite, trench foot does not require freezing temperatures and can occur in temperatures up to 60° Fahrenheit (about 16° Celsius). The condition can occur with as little as eleven hours exposure. The mechanism of tissue damage is not fully understood. Excessive sweating or hyperhidrosis has long been regarded as a contributory cause.

Prevention

Trench foot is easily prevented by keeping the feet warm and dry, and changing socks frequently when the feet cannot be kept dry. Soldiers often wrote home about their daily

lives living in the trenches, but also asked and pleaded for more socks, to help prevent things like trench foot. During World War I, trench soldiers were provided with whale grease and told to apply it to their feet, to reduce the prevalence of this condition; the idea was to make the feet waterproof. It was found, however, that this made the condition worse as it made the feet perspire and absorb even more water. It was also discovered that a key preventive measure was regular foot inspections by officers.

History

Trench foot was first noted in Napoleon's army in 1812. It was during the retreat from Russia that it became prevalent, and was first described by Larrey.

It was a particular problem for soldiers in trench warfare (hence the name) during the winters of World War I and World War II, and in the Vietnam War.

Trench foot made a reappearance in the British Army during the Falklands War, in 1982. The causes were the cold, wet conditions and insufficiently waterproof DMS boots.

Some people were even said to have developed trench foot at the 2007 Glastonbury Festival, as a result of the sustained cold and wet conditions at the event.

Chapter 13

Hanger Prosthetics and Orthotics

Hanger Prosthetics and Orthotics (a division of **Hanger Orthopedic Group** (NYSE: HGR) provides prosthetic and orthotic patient care services in the United States. The company has more than 640 patient care centers located in 45 states and the District of Columbia. About 650,000 patients visit these centers each year. Hanger Prosthetics and Orthotics operates under the corporate umbrella of Hanger Orthopedic Group, Inc., headquartered in Austin, TX (formerly Bethesda, MD). According to the company's 2007 annual report, the patient care market for prosthetic and orthotic services in the United States is estimated at \$2.5 billion annually. Hanger Prosthetics and Orthotics represents about 25 percent of this market. They employ about 3,500 people, including more than 1,080 prosthetic and orthotic practitioners.

Notable Hanger patients include: Jeremy Campbell, winner of two gold medals in the 2008 Paralympic Games, and world-record holder for the Pentathlon P44 ; Retired Staff Sgt. Heath Calhoun, veteran of the Iraq War, spokesperson for the Wounded Warrior Project, and key advocate in the passage of federal Traumatic Injury Protection (TSGLI) payments to assist wounded American soldiers and their families; and Aron Ralston a mountain climber who became famous in May 2003 when he amputated his lower right arm with a dull knife in order to free himself from a fallen boulder.

History

James Edward Hanger, the first documented amputee of the American Civil War, founded the company in Virginia in 1861.

A remark in Ambrose Bierce's postwar memoir that "We shot off a Confederate leg at Philippi" refers to Hanger. At 18 years of age, Hanger joined the Confederate cavalry at Philippi, Virginia, on June 2, 1861. One day later, during the Battle of Philippi, Hanger was sheltering inside a stable with the rest of the Churchville (Virginia) Cavalry when the "first solid Union cannon shot of the war" bounced into the stable and struck his leg. The injury required amputation of Hanger's leg above the knee, and he underwent the first battlefield amputation of the war, at the hands of Union surgeons. Hanger returned to his parent's home to recuperate wearing a prosthesis that was basically a wooden peg. His

dissatisfaction with the fit and function of the limb replacement led Hanger to design and construct a new prosthesis from whittled barrel staves, rubber and wood, with hinges at the knee and foot. The device worked well, and the state legislature commissioned him to manufacture the “Hanger Limb” for other wounded soldiers.

Manufacturing operations for J.E. Hanger, Inc., were established in the cities of Staunton and Richmond. Hanger was awarded his first patent for an artificial limb, number 155, from the United States Patent Office on March 23, 1863. Over the years Hanger developed and patented additional products for veterans and other amputees. In 1906, Hanger moved the company’s headquarters to Washington, DC. In 1915, he traveled to Europe to help World War I amputees and to learn from European prosthetists.

Hanger’s five sons were active in operating the family business. In 1915, they divided J.E. Hanger, Inc., into four separate companies, with each operating in a different region of the country. At the time of Hanger’s death in 1919, the companies had branches in Atlanta, St. Louis, Philadelphia, Pittsburgh, London and Paris.

Significant technological advances in the U.S. prosthetic industry were largely absent in the years leading up to World War II. The new wave of amputee veterans demanded better prosthetic options, and in 1946, the federal government began providing funds for research and development in prosthetics. J.E. Hanger, Inc., was able to introduce new prosthetic socket designs made from improved materials such as thermosetting resins.

Also around this time, the orthotics industry (braces /supports) sought to combine with the prosthetics industry. In 1950, the American Orthotics and Prosthetics Association was formed, and with that came a new emphasis on the education and certification of clinical practitioners. By the mid 1950s, J.E.Hanger, Inc., had added orthotic services to its business, and had expanded to 50 offices in the U.S. and 25 in Europe.

The 1960s and 70s held relatively few technological improvements, but the 1980s marked the beginning of a period of advanced technological development that continues to the present day. In 1986, Sequel Corporation, a Colorado-based communications company, sold off its cellular phone business and began investing in the orthotics and prosthetics industry. In 1989, Sequel bought J. E. Hanger, Inc., of Washington, DC. At the time of purchase, J. E. Hanger, Inc., was an \$8 million business with offices in 11 cities and eight states. Soon after, Sequel changed the name of the company to the Hanger Orthopedic Group. Ivan Sabel, president and chief operating officer, was focused on centralizing the design and manufacturing of the company's prosthetic and orthotic devices and distributing them nationally.

In 1996, the company bought J. E. Hanger, Inc., of Georgia. This acquisition doubled the size of the company, which now had 175 patient care centers, six distribution sites, four manufacturing plants and 1,000 employees in 30 states. Hanger continued purchasing small companies and by 1998, was operating 256 patient care centers. In 1999, Hanger Orthopedic Group bought its biggest competitor and the industry leader, the orthotics and prosthetics division of NovaCare. This added an additional 369 patient care centers. In

1999, Fortune Magazine ranked Hanger Orthopedic Group as 79th on its list of One Hundred Fastest-Growing Companies. Following the NovaCare acquisition, the company continued to expand its corporate holdings with related specialty businesses.

Subsidiaries

In 2009, Hanger Orthopedic Group is composed of four wholly-owned subsidiaries that serve different segments of the orthotics and prosthetics industry. In addition to Hanger Prosthetics and Orthotics, holdings include **Southern Prosthetic Supply**, **Innovative Neurotronics** and **Linkia**.

Southern Prosthetic Supply (SPS) is the largest distributor of orthotic and prosthetic materials in the world. SPS has four distribution centers and 270,000 products offerings.

Innovative Neurotronics, Inc., specializes in the development and commercialization of emerging neuromuscular technologies. Neuromuscular refers to the use of electrical stimulation to improve the functionality of an impaired extremity.

Linkia is a network management company that works exclusively with the orthotics and prosthetics industry.

Technologies

Hanger Orthopedic Group has several patented technologies including:

- **ComfortFlex Socket** for upper and lower extremity prosthetic users.
- **Insignia**, a handheld laser scanner that connects to a laptop computer and is used to scan the limb in order to create a prosthetic socket or an orthotic support and/or brace.
- **V-Hold Suspension**, a prosthetic socket with a vacuum pump, for below/above knee prosthetic patients.
- **WalkAide**, a medical device for people suffering from foot drop. (Foot drop can be caused by multiple sclerosis (MS), incomplete spinal cord injuries, traumatic brain injuries, cerebral palsy, stroke, and other neurological involvements.)

Research

Employees of the company are editors and contributing authors of textbooks such as *Prosthetics and patient management: a comprehensive clinical approach*, *Functional Restoration of Adults and Children with Upper Extremity Amputation*, and *Physical medicine and rehabilitation: principles and practice*.

Legal problems

In 2004, allegations of billing fraud were made against the company when an office administrator reported Hanger employees in New York for forging false prescriptions for

non-existent patients. A class action lawsuit was brought against Hanger for allegedly using the fraud to artificially raise stock prices. Although 14 offices were named in the lawsuit, Hanger said that only one location was involved in the fraud.