Chapter

Perspective Chapter: Podological Deformities and Its Management

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Abstract

The ankle and foot complex plays on important role in gait and weight bearing of the body weight. The deformity of the ankle and foot affects and alters the biomechanics of the body and normal gait pattern, and this consequently affects the other parts and joints of the lower limb and also trunk.

Keywords: podiatry, deformity, congenital disorder, gait abnormality, pes cavus, pes planus, vertical talus, CTEV, hammer toe, bunion deformity

1. Introduction

Podological deformities are the deformities that occur in the Ankle and foot complex. Deformity is any disfigurement or change in shape of the body part example in the foot. The deformities may be congenital or acquired. Congenital deformities that is present from the birth itself, acquired deformities are developed later in life occurs due to trauma, injuries or any pathology in the Ankle and Foot.

The commonest deformities in the Ankle and foot are Congenital Talipes Equino Varus (CTEV), Congenital vertical talus, Foot drop, Hallux valgus, Claw toe, pes planus and pes cavus. There are various surgical, conservative managements and post-operative managements are given to correct the deformities, improve biomechanical aspect and the gait pattern.

2. Ankle and foot—anatomy & biomechanics

The foot and ankle are a complex joint made up of twenty six individual bones of the foot and it has subtalar joint, talocrural joint, tarsometatarsal joint, talocalcaneonavicular joint and other inter tarsal joints. The ankle joint is one high stability role joint due to the presence of the structure called ankle mortise. The motions that take place in the ankle complex are dorsiflexion 20°/plantarflexion 55° in the sagittal plane and inversion 30°/eversion 20° in the frontal plane. When these motions occur as

coupled motions to produce another movement which is known as supination and pronation. The range of motion that is available for dorsiflexion will be 10–20° and plantar flexion will be around 40–55°. The forces acting on the ankle joint bears approximately five times the body weight during stance in a normal walking phase and up to 13 times body weight during running activities.

The motions of ankle joint are produced by extrinsic muscles which has its attachment within the leg and the foot. These muscles are present within the various compartments like anterior, posterior and lateral compartment muscles. The tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius forms the anterior compartment. The peroneus longus and brevis forms the lateral compartment. The gastrocnemius, soleus, plantaris forms the posterior compartment. The deep posterior compartment comprises of tibialis posterior, flexor digitorum longus and flexor hallucis longus. The tibialis anterior and extensor hallucis longus produces dorsiflexion and inversion of the foot. The peroneus tertius produces dorsiflexion and eversion of the foot. The extensor digitorum longus assists in dorsiflexion. The peronei muscles on the lateral compartment produces plantar flexion and eversion of the foot. The calf muscles on the posterior compartment produces plantarflexion of the foot. The tibialis posterior, flexor digitorum longus and flexor hallucis longus produces plantarflexion and inversion of the foot (**Figure 1**).

The ankle joint possesses high congruency during the activity of daily living as the load bearing area is larger and has high stability role. The larger contact area in the ankle joint occurs mostly in the stance phase during normal gait. The maximum power of the ankle complex is generated around 50% in gait cycle during the forefoot rocker phase correspondingly with the force production of the plantar flexors which is required for the lower extremity to propel the body forward towards toe-off. The other form of stability for foot as a whole is provided by the presence of plantar Aponeurosis which takes up to 60% of the weight bearing and the action tie beam around 25% from the metatarsals. The toe extension during the normal gait cycle makes the plantar Aponeurosis to become taut thereby increases the ability to withstand larger amount of stress. This mechanism by several authors have been depicted as Windlass mechanism of the foot.

Figure 1.
Ankle and foot anatomy.

3. CTEV

3.1 Definition

The CTEV is also known as Clubfoot. It is one of the most common congenital musculoskeletal deformity occurs in children. CTEV is characterized by the fixation of the foot in adduction, supination and varus (**Figure 2**).

3.2 Etiology

The cause is idiopathic. But combination of genetics and environmental factors contribute to this condition.

Risk factors:

- Family history: Parents and siblings with same condition can have higher chance of developing disease to the new born.
- Congenital deformities: Spina bifida, cerebral palsy, or connective tissue disorders, could develop clubfoot later stages of life.
- Environment: Smoking and intake of recreational drugs during pregnancy, oligohydramnios.
- Gender: Males are like to be affected by the condition.

Epidemiology: It is more common in firstborn children and males. Incidence rate is 1:1000

3.3 Clinical features

- Heel is in equinus and small.

Figure 2.
CTEV.

- Foot inverted.
- Deep creases on medial and posterior aspect of foot.

3.4 Pathology

It involves four components. These component are cavus, adductus, varus and equinus where cavus and adductus deformities occurs in midfoot and varus and equinus occurs in hindfoot.

Pathomechanics: Cavus is caused due to the arch in the foot is higher than usual which causes first metatarsal being plantarflexed. The second part of the CTEV is adductus, here the navicular bone moves medially and gets dislocated from the talus. Varus is the third part of the deformity where heel is in varus in relation to tibia finally equinus causes increase in plantar flexion which leads to foot pointing downward.

Diagnosis: Antenatal diagnosis during 2nd trimester using ultrasonography.

3.5 Management

3.5.1 Conservative management

1. **At birth**: Mother of the baby is advised to manipulate the foot during every feed for 1–2 weeks before the casting begins.

2. **Infancy**: Ponseti method consists of two equally important phases: the corrective phase and the maintenance phase. *Corrective phase*: During the corrective phase the position of the foot is gradually corrected using a series of manual correction first cavus then adduction with varus followed by equinus and plaster of Paris casts, then finally a small outpatient procedure is performed to cut the Achilles tendon (tenotomy). The corrective phase usually takes 4–8 weeks. *Maintenance phase*: Following the corrective phase, the foot position should be retained in the same position. The maintenance phase involves keeping the corrected position of foot for the next 4–5 years using denis brown splint for 23 ho a day for the first 12 weeks. Then at night-time until 4–5 years old (**Figure 3**).

3. **Bracing protocol**: The brace consists of pair of CTEV SHOES: it will have straight inner border, outer shoe rise and no heel.

4. **Recurrent/Relapse CTEV**: Manipulations and casts are applied weekly followed by Re – tenotomy.

5. **Nonoperative treatment**: It includes the Stretching and adhesive strapping. French technique: sequential correction of forefoot adduction, hindfoot varus and equinus of calcaneum.

3.5.2 Surgical management

Neglected CTEV who do not respond for nonoperative method surgery is indicated surgical treatment are as follows:

Figure 3.
Dennis brown splint.

- Turco's operation: Subtalar release along with calcaneo-fibular ligament.
- Caroll's incision: Plantarfascia release and capsulotomy of calcaneo cuboid joint.
- Cincinatti incision: It is done for posteromedial and posterolateral soft tissue release.
- Tendo achilles tendon release with posterior capsulotomy: To correct residual hind foot equinus.
- Tendon transfer.
- Triple arthrodesis.
- Talectomy.

4. Hallux valgus

Hallux valgus, commonly known as a bunion, is a deformity of the big toe joint that causes the big toe to angle in toward the second toe and protrude outward from the foot. It is caused by an abnormal balance of muscles and ligaments around the joint, which pulls it out of alignment.

4.1 Definition

The hallux valgus is a most common deformity occurs in great toe, in which the first metatarsophalangeal (MTP) joint is malpositioned, lateral deviation of great toe along with the medial deviation of first metatarsal bone (**Figure 4**).

The hallux valgus angle (HVA) is defined as the angle between the shaft axis of the first metatarsal and the proximal phalanx of the hallux (standard 15° angle).

Figure 4.
Hallux valgus.

4.2 Risk factors

The various intrinsic and extrinsic risk factors causes the development of hallux valgus deformity.

- The intrinsic factors are Genetic predisposition, family history, anatomical and biomechanical factor like long first metatarsal bone, cerebral palsy, hyper mobility of the joint, severe flat foot.

- The extrinsic factors are wearing tight and pointed footwear, incorrect footwear.

4.3 Symptoms

- Pain over the medial eminence.

- Local skin or bursa irritation.

- Medial deviation of the first ray.

- Lateral deviation and pronation of the great toe.

- Pain and swelling at or near the affected joint.

- Difficulty walking or standing for long periods due to discomfort and redness or irritation around the area.

4.4 Pathology

The pathology associated with this condition includes bony enlargement at the base of the first metatarsal bone, displacement of soft tissues such as tendons and ligaments, and cartilage degeneration due to repetitive stress on these structures.

Pathomechanics: It is characterized as a combined deformity with a malpositioning of the first MTP joint caused by a lateral deviation of the great toe and

a medial deviation of the first metatarsal bone. It is a deformity of the big toe joint that results from an imbalance in forces around the MTP joint. This imbalance causes the great toe to drift away from its normal position and towards the smaller toes. The main cause of this condition is over pronation of the foot, which leads to an increase in pressure on the MTP joint during walking or running activities. In addition, tight calf muscles, high heels, bunions, arthritis and genetic factors can all contribute to hallux valgus formation.

Diagnosis:

- Physical examination of the foot
- X-ray

4.5 Treatment

4.5.1 Conservative management

The HVA 20° to 45° are treated with conservatively.

- Wearing wider shoes with a lower heel.
- Using orthotic devices to support the foot.
- Taking pain medication to manage discomfort {NAIDS}.
- Physical therapy to strengthen the foot muscles.
- Steroid injection for inflamed joints.
- Physiotherapy management—These include stretching exercises, orthoses (special insoles), manual therapy techniques such as soft tissue massage or joint mobilization, and taping techniques.

4.5.2 Surgical management

The HVA more than 45° is considered severe deformity and its corrected with surgical management.

Surgical techniques includes modified McBride procedure, distal metatarsal osteotomies, metatarsal shaft osteotomies, the Akin osteotomy, proximal metatarsal osteotomies, the modified Lapidus fusion and the hallux joint fusion.

The scarf osteotomy, is a versatile diaphyseal osteotomy of the first metatarsal and is frequently used for correction of moderate to severe hallux valgus deformity.

The combination of soft tissue surgery and bony surgery followed by correct dressing and splint advised to correct the deformity.

4.5.3 Prevention

There are several ways to prevent Hallux Valgus, including:

- Wearing comfortable shoes that fit properly.

- Avoiding high heels and narrow shoes.
- Maintaining a healthy weight.
- Stretching and exercising the feet regularly.

5. Congenital vertical talus

It's the dorsal dislocation of navicular bone on the talus, the head of talus points vertically downwards and it produce rigid flatfoot deformity. Congenital vertical talus also known as Rocker bottom foot or convex pes valgus deformity.

5.1 Epidemiology

Rocker-bottom foot affects about 1 in 10,000 births and occurs equally in boys and girls. In about half of the cases the both feet are affected.

5.2 Etiology

The cause of vertical talus is unknown, however, it is often associated with a neuromuscular disease or other disorders such as:

- Arthrogryposis
- Spina bifida
- Neurofibromatosis

5.3 Pathology

The navicular bone is dislocated dorsolaterally, vertical orientation of talus bone, the calcaneum is everted and contracture of Tendo Achilles tendon. This leads to fixed hindfoot equinovalgus, rigid midfoot dorsiflexion, forefoot is abducted and dorsiflexed (**Figure 5**).

5.4 Signs and symptoms

- Rocker bottom deformity
- Equinovalgus
- Convex plantar surface of the foot
- Talar head is prominent
- Peg-leg gait

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Figure 5.
Congenital vertical talus.

- Calcaneal gait
- Improper weight distribution during walking
- Balance is affected

Complications: Vertical talus can cause various complications. Following are a few of them:

- Wound necrosis
- Talar necrosis
- Under correction of the deformity
- Stiffness of the ankle
- Subtalar joint

5.5 Diagnosis

Early detection of congenital vertical talus is important for successful treatment. X-ray shows the vertically positioned talus, dorsal dislocation of navicular bone and the talocalcaneal angle is more than 40°.

5.6 Treatments

5.6.1 Nonsurgical treatment

- Manipulation
- Stretching exercises for the forefoot and hindfoot

- Casting the foot to increase flexibility
- Physical therapy exercises to stretch the foot
- Casting, bracing or stretching programs to correct the deformity

5.6.2 Surgery

Surgery is recommended at 9–12 months of age. Surgery is necessary to correct problems with the foot bones, ligaments and tendons. During the operation, pins are used to keep hones in the correct position.

The surgical procedures are:

- Soft tissue release—Lengthening of peroneal and Achilles tendon
- Reduction of talonavicular joint
- Triple arthrodesis
- Talectomy

5.6.3 Safety in surgery

Surgery can dramatically improve the long-term outcomes for your child with congenital vertical talus, but it can also be a stressful experience for you and your child. Treatment is similar to that for a congenital club-foot. Management principle are to re-establish normal relationship between bones of feet and hold them there.

6. Claw toe

A claw toe is defined or characterized as "hyperextension at the metatarsal phalangeal joints and, flexion of interphalangeal joint" [1, 2] both proximal and distal, "a foot with exaggerated arch, prominent metatarsals" [3].

6.1 Etiology

The cause of this claw foot includes either a limitation to dorsiflexion or intrinsic foot muscle paralysis or both together [3]. The exact mechanism is not known but it may occur due to the hyperextension of the MTPJ. The claw foot is seen in the following conditions. Poliomyelitis (paralysis of extensor muscle group in leg), [4], spastic spinocerebellar atrophy, hereditary spastic paraplegia, myeloneningocele, spastic spianl cord injury, multiple scelrosis (Manuel Rivera-Dominguez).

6.2 Pathology

The most common reported cause of claw toe deformity is atrophy and weakness of the intrinsic muscles caused by motor neuropathy. This causes an "imbalance between the intrinsic muscles and the extrinsic muscles that cross the MTP

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and interphalangeal joints. At the interphalangeal joints, the long extrinsic flexors have a greater mechanical advantage over the extensors, whereas at the MTP joint, the extensors have a greater mechanical advantage over the flexors". If the intrinsic muscles (also known as the lumbricals and interossei) are working properly, they will be able to compensate for this mechanical advantage by flexing the MTP joint while simultaneously extending the interphalangeal joints. This stabilizing action, however, is lost when the intrinsic muscles become atrophic and the extrinsic muscles become dominant. This can eventually lead to clawing of the toes (**Figure 6**).

6.2.1 Pathomechanics

"When the MTPJ becomes chronically hyperextended, the intrinsic shorten and the axis of pull shifts dorsal to the center of rotation of the MTPJ". The intrinsic are no longer able to produce a flexion moment at the MTPJ, which means that the extensors act unopposed. When the flexors are pulled to their full length, the IPJs are flexed. This clawing might be dynamic at first, and you might only notice it when you're walking. The deformity will further lead to the plantar plate tears and a subluxation develops at the MTPJ leading to the permanent deformity. The mechanism for the reverse windlass eventually breaks down, and when this happens, the toes are unable to make contact with the ground while walking, the MT heads are subjected to a greater amount of force, which ultimately leads to metatarsalgia.

6.3 Management

It is essential to have a solid understanding of, and strategy for dealing with, the underlying pathology in order to effectively lower the risk of recurrence.

6.3.1 Conservative

First and foremost, a more conservative treatment approach consisting of digital pads and footwear modification should be attempted. They are using "wide and high toe box with soft insole shoes or using an orthotic device like doughnut-shaped cushion, foamed toe cap, viscoelastic toe sleeves or toe splint".

Figure 6.
Claw toe.

6.3.2 Surgical

The mild flexible form of claw toe is amenable to correction through an FDB tenotomy. A flexor-to-extensor transfer is recommended in case of hyperextension of toes at the MTPJ due to unopposed pull by the extensors and intrinsic muscle group. The Girdlestone-Taylor procedure has been used to treat claw toe deformities that can be caused by a variety of conditions. Taylor detailed the process of dividing the FDS and FDL tendons and then re-routing those tendons to the extensor aspect so that they could be sutured to the extensor expansion using a technique known as the "buttonhole" method.

7. Flat foot

Flat foot is refers to loss of the medial longitudinal arch of the foot (**Figure** 7). The flat foot is also called as pes planus. It occur either congenitally or acquired.

7.1 Pathology

The foot has the two longitudinal arches (Medial and lateral), two transverse arches (Anterior and posterior). The function of arches are shock absorption, equal distribution of body weight and propulsion of foot during gait cycle. The obliteration of medial longitudinal arch lead to flatfoot, the weight bearing area is increased, navicular bone is more prominent. Uneven weight distribution causes excessive loading on bones, soft tissues and affect walking pattern.

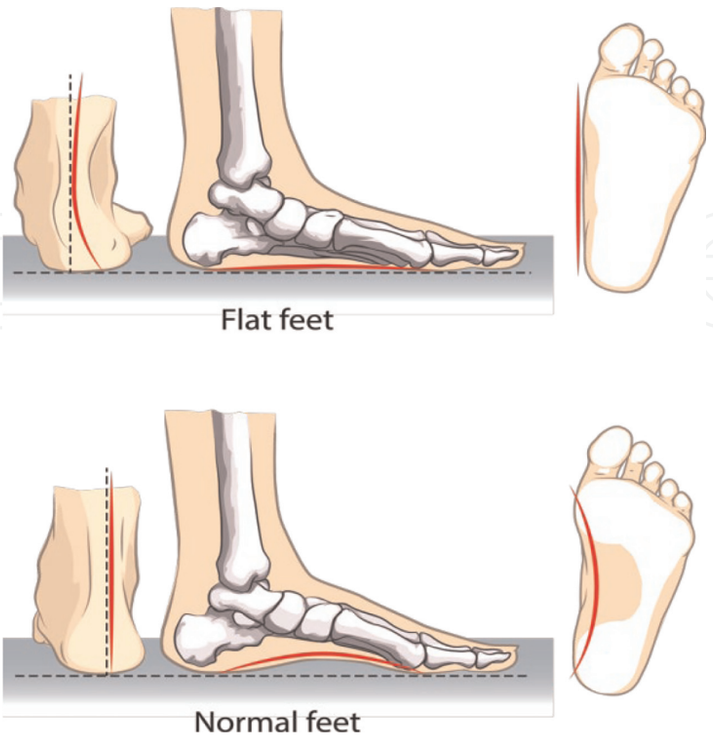

Figure 7.
Flat foot.

7.2 Types of flat foot

1. **Flexible flat foot**: During toe standing the longitudinal arches of the foot is present. During full weight bearing the arches are absent.

2. **Rigid flat foot**: During toe standing the longitudinal arches of the foot is absent.

3. **Congenital flat foot**: Present from the birth itself.

4. **Acquired flat foot:** The flat foot developed after birth.

7.3 Management

7.3.1 Conservative management

- The pain management for flat foot includes to provide the rest, activity modification, cryotherapy, massage, and ultrasound therapy used for pain relief.

- Strengthening, stretching and proprioceptive exercises.

- Footwear modification (Medial heel wedges & navicular pads).

7.3.2 Surgical management

Flat foot are corrected by reconstructive surgery. The surgeries are:

- Tendon lengthening—The Tendo Achilles tendon is lengthened.

- Tenosynovectomy—The inflamed tissues are removed.

- Tendon transfer—The affected tendon is removed and replaced by the healthy tendon from another part of foot.

- Ostetomy—It's the removing and reconstructing the bone to correct the arches.

- Arthrodesis—Fusion of the joint for better stability. Triple arthrodesis procedure commonly done to fuse all three joints in the hindfoot.

8. Pes cavus

Pes cavus is a deformity characterized by excessively high longitudinal arch of the foot (**Figure 8**).

Epidemiology: Higher in adult population.

8.1 Etiology

Factors considered influential in the development of pes cavus include:

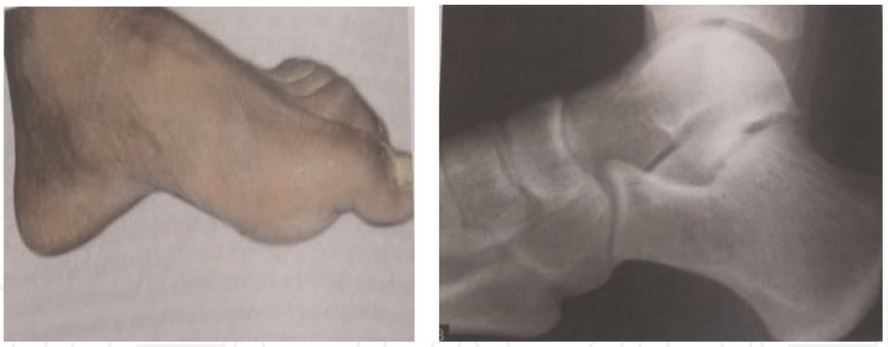

Figure 8.
Pes cavus.

- Muscle weakness and imbalance in neuromuscular disease
- Congenital clubfoot
- Posttraumatic bone malformations
- Peroneus longus tendon laceration
- Contracture of the plantar fascia
- Shortening of the Achilles tendon.

8.2 Pathology

- Weakness of intrinsic muscles of the foot.
- Muscle Imbalance—Weakness of anterior tibial muscle & calf muscle.

Pathologic anatomy:

- Dropping of the foot
- Contractures of the plantar fascia
- Varus of the heal
- Clawing of the toes.

Patho-mechanics: Pes cavus feet are often called supinated or high arched. The foot structured consists of either a high arch with a varus hind foot, a high with a valgus forefoot or both. In pes cavus, there is increased incident of ankle instability and stress fracture.

Kinematic studies of the gait demonstrated that covers feet in stance demonstrate less motion during loading response and midstance than planus or neutral foot.

This reduction in motion may result in reduced absorption of ground reaction forces and increased stress to the foot, ankle and lower limb.

8.3 Clinical features

- High medial longitudinal arch
- First metatarsal drop and pronation
- Tight plantar fascia
- Varus heel
- Clawing of toes (late feature).

Investigations/Radiography:

- Physical examination
- X-ray.

8.4 Treatment

8.4.1 Conservative management

Conservative management of patient with painful pes cavus involved strategies to reduce and re-distribute plantar pressure loading, with the use of foot orthoses and specialized cushioned footwear.

Physiotherapy management:

1. Stretching of tight muscles (peroneus longus, posterior tibialis) and strengthening of weak muscles (tibialis anterior, intrinsic foot muscles, peroneus brevis).
2. Daily manipulations, exercises, Night splints can be helpful.
3. Orthotics with depth shoes to offload bony prominences and prevent rubbing of the toes.

8.4.2 Surgical management

1. Soft tissue surgery: Tendon release in case of over pull from the muscles.
2. Jones transfer: Extensor hallucis longus is transferred to the neck of 1 metatarsal, with arthrodesis of the interphalangeal joint to improve dorsiflexion of the ankle and remove the deformity force at the MTP joint and hallux.
3. Osteotomy: Dwyer's osteotomy, Japa's V-shaped osteotomy, Anterior tarsal wedge osteotomy.
4. Bone wedge corrections of hindfoot and midfoot and triple arthrodesis.

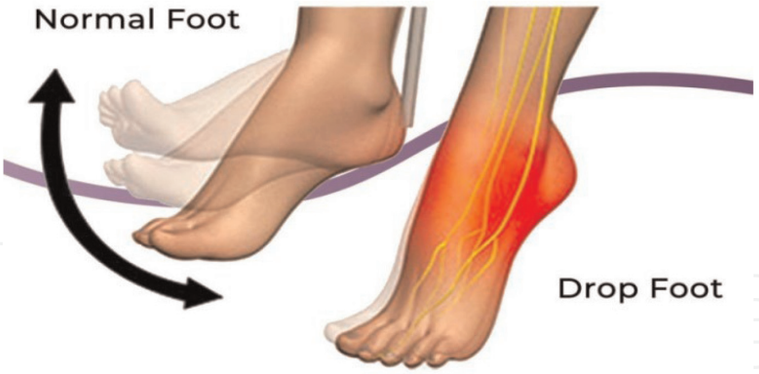

Figure 9.
Foot drop.

9. Drop foot

Drop foot is an inability to lift the forefoot due to the weakness of dorsiflexors of the foot. This, in turn, can lead to an unsafe antalgic gait, potentially resulting in falls (**Figure 9**).

9.1 Etiology

Compressive disorders: Entrapment syndromes of the fibular nerve at various locations along its anatomical pathway can lead to compressive neuropathy.

Traumatic injuries: Traumatic injuries often occur associated with orthopedic injuries as knee dislocations, fractures, blunt trauma, and musculoskeletal injuries.

Neurologic disorders: ALS (Amyotrophic lateral sclerosis).

Cerebrovascular disease (CVA).

Mononeuritis multiplex—The sciatic nerve is one of the commonly affected nerves in this condition.

Acute inflammatory demyelinating polyneuropathy (AIDP), also called Guillain-Barré syndrome.

Charcot-Marie Tooth (CMT) is a primary congenital demyelinating peripheral neuropathy and is one of the most common inherited neuropathy. It affects both motor and sensory nerves.

9.2 Pathology

The various causes lead to damage of the common peroneal nerve. The damage occur either the compression (Neuropraxia), axonotmesis, the axon is damaged, but the epineurium and perineurium remain intact. Neurotmesis is the most severe type of nerve injury. Myelin, axons, and supportive connective tissue are damaged. The injury of the common peroneal nerve leads to loss of motor supply to the dorsiflexor muscles of ankle and foot and the patient is unable to do the dorsiflexion of the foot this results foot drop.

9.3 Symptoms and sign

- Foot drop makes it difficult to lift the front part of the foot, so it might drag on the floor when you walk.

- To help the foot clear the floor, a person with foot drop may raise the thigh more than usual when walking, as though climbing stairs.

- This unusual kind of walking, called steppage gait, might cause the foot to slap down onto the floor with each step. In some cases, the skin on the top of the foot and toes feels numb.

9.4 Treatment

9.4.1 Conservative management

This includes physical therapy and or splinting and pharmacological therapy to manage pain. The goals of conservative management are to stabilize the gait, prevention of falls and contractures.

AFO (splinting): Splinting is utilized to minimize contractures. For complete nerve palsies with insufficient recovery, an ankle-foot orthosis (AFO) to prevent further plantarflexion should be ordered.

9.4.2 Surgery

The surgeries are to correct the deformity, improve the gait pattern and functional activity. The surgical treatments are:

- Nerve graft surgeries

- Triple arthrodesis

- Tendon transfer

10. Conclusion

This chapter gives us knowledge about the commonest deformities occur in the ankle and foot complex especially the congenital deformities. In this chapter discussed about the causes, incidence, pathology of the ankle and foot deformities and also the anatomical and biomechanical changes in the joint, changes in the weight distribution occur in the joints of ankle and foot due to the deformities. The various surgical procedure to correct the deformities are discussed. The conservative management like foot wear modification, positioning of the feet, orthosis and casting are discussed. Thus the chapter fully concentrated on the commonest deformities in the ankle and foot, its pathology surgical and conservative management for the deformity.

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