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Management of Flexible Flat Foot Deformity

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Abstract

Flexible flatfoot is a common foot form that may be seen in the majority of neonates and many adults. In the first ten years of life, the arch rises on its own in the majority of children. There is no proof that any external forces or equipment may develop a longitudinal arch in a child's foot. Some teenagers and adults have discomfort and incapacity as a result of flexible flatfoot with a short Achilles tendon, which is different from basic flexible flatfoot. When conservative measures do not reduce discomfort behind the head of the plantar flexed talus or in the sinus tarsi region, surgery that preserves the joint and corrects deformities is considered for flexible flatfeet with short Achilles tendons. The first and most important technique of choice is osteotomy. In almost all situations, extending the Achilles tendon is necessary. In certain situations, the forefoot has a hard supination deformity, which must be identified and treated at the same time.

Key words: Flexible flatfoot, Achilles tendon, arch development, osteotomy, foot deformity.

What is flexible flat foot?

Pes planus, also name for flexible flatfoot, is a condition in which the medial longitudinal arch of the foot flattens while the foot is bearing weight and then returns when the foot is not. This condition is referred to be "flexible" since the arch collapses while standing but is visible when the foot is off the ground (1).

There are notable differences in the incidence of flexible flatfoot across age groups and populations. According to estimates, up to 90% of toddlers have flatfoot, making it quite common in early infancy. As the arch grows with maturity, its frequency declines; research suggests that between 15 and 25 percent of teenagers have flatfoot. The continuation of flexible flatfoot throughout adolescence may be influenced by a number of factors, including neuromuscular disorders, obesity, heredity, and ligamentous laxity (1).

Flexible flatfoot is common among teenagers, according to many extensive investigations. For example, according to a research by Harris and Beath, between 14 and 20 percent of kids between the ages of 7 and 15 had flexible flatfoot. According to another research, 14% of youngsters between the ages of 7 and 12 had it. Different diagnosis criteria, methods, and population demographics are sometimes blamed for these disparities in prevalence (2).

The pathogenesis of flexible flat foot

The development of flexible flatfoot is significantly influenced by genetic predisposition. Studies on families have shown a genetic component, indicating that flatfoot may run in families. The development of flatfoot is likely influenced by genetic variables that affect muscle function, bone shape, and ligamentous laxity. According to Harris and Beath's, for example, children who have a family history of flatfoot are more likely to have the ailment themselves. The significance of genetic variables in the pathophysiology of flexible flatfoot is highlighted by this hereditary component. Bones, ligaments, and muscles work together to maintain the medial longitudinal arch. Arch collapse may result from any interference with this synchronization (2).

One prevalent biomechanical aspect in flexible flatfoot is ligamentous laxity. Excessively loose ligaments are unable to hold the arch enough, causing it to collapse when weight is applied. There are two types of laxity: congenital and acquired. Genetic factors are often associated with congenital laxity (3).

Flatfoot may be caused by weakness in the foot's extrinsic and intrinsic muscles. In particular, the tibialis posterior muscle is essential for preserving the arch. This muscle's weakness or dysfunction may result in insufficient arch support and flattening (3).

People who have generalized joint hypermobility, which is frequently observed in diseases like Ehlers-Danlos syndrome, may be more susceptible to flatfoot. Arch collapse and instability may result from the increased range of motion in joints, including the foot. People may be more susceptible to flatfoot due to differences in bone structure, such as a low calcaneal inclination angle or higher talar head uncovering. A flattened arch may result from several structural variations that alter the foot's alignment and mechanics. Flexible flatfoot development may be strongly impacted by neuromuscular disorders. An failure to maintain the arch may result from conditions that impact muscular tone, strength, and coordination (4).

Flatfoot is one of the abnormalities that may result from muscular imbalances and stiffness in cerebral palsy. Arch collapse results from the decreased muscular tone and coordination, which alters the foot's natural mechanics (4).

Conditions that damage peripheral nerves, such as Charcot-Marie-Tooth disease, may lead to muscular weakness and atrophy in the feet, leading to the development of flatfoot. The pathophysiology of flexible flatfoot is also influenced by lifestyle and environmental variables. These variables may worsen the disease or contribute to its persistence. In those with flexible flatfoot, obesity may worsen the collapse of the arch because it increases the weight on the foot. Research has shown a relationship between the occurrence of flatfoot in children and adolescents and a higher body mass index (BMI). The onset and duration of flatfoot may be attributed to inadequate footwear that does not provide appropriate arch support. Normal foot mechanics might be hampered by shoes that are excessively tight or don't provide enough support. The degree and kind of physical exercise may affect how flatfoot develops. Excessive foot straining activities, including heavy lifting or extended standing, might make the problem worse (5).

Pathomechanics and biomechanics

After the early stance phase of gait, the foot provides a sturdy but flexible platform that adjusts to the ground; after push-off, it transforms into a stiff lever. Although that image is obviously oversimplified, a number of writers have shown the intricate interactions between the midfoot and hindfoot bones as a mitered hinge. To fully comprehend the biomechanics of the foot, one needs add a detailed knowledge of the form, structure, connections, and movements of the subtalar joint complex, which should be used as a first approximation or fundamental foundation (3).

The subtalar joint complex is made up of three bones (or maybe four if the cuboid is included), a number of crucial ligaments (such as the calcaneo-navicular ligament or spring), and various joint capsules that work as a single unit. Scarpa observed parallels between the hip joint and the subtalar joint complex about 200 years ago. He likened the femoral head to the talar head and the pelvic acetabulum to the so-called "acetabulum pedis," which is a cup-shaped structure composed of the front end of the calcaneus and its facets, the navicular, and the spring ligament. Although the comparison is not flawless, there are certain similarities between the two anatomical regions that appear to make it both legitimate and valuable. Two bones, one intra-articular ligament, and a joint capsule make up the hip, a pure ball-and-socket joint with a central rotation point (6).

Although the combined movements of the subtalar joint and the ankle joint next to it give the appearance that it is a ball and socket joint, the subtalar joint is not. Not frontal, sagittal, or coronal, its axis of motion is in an oblique plane. This results in movements that are best represented by the special phrases “inversion” and “eversion.” The talus (the ball) is the stable structure in the subtalar joint complex, and the acetabulum (the socket) is the stable structure in the hip joint. According to Saxena and Nguyen, inversion involves the acetabulum pedis's internal rotation, supination, and plantar flexion around the talus head (6).

Clubfeet and cavovarus feet both exhibit hindfoot varus, a static condition of inversion of the subtalar joint. Dorsiflexion, pronation, and external rotation of the acetabulum pedis around the talar head are all components of eversion. Both flatfeet and skewfeet exhibit hindfoot valgus, which is the static position of the everted subtalar joint. During the initial part of the gait cycle's stance phase, the subtalar joint complex everts as the tibia and talus internally rotate. Due to the loss of acetabulum pedis support, the talar head plantar flexes. The foot flattens and becomes very pliable, or freed. The tibia and talus externally rotate during the later portion of the stance phase, and the subtalar joint complex inverts, allowing the acetabulum pedis to support the talus head once again. The whole foot stiffens, or locks, when the talus dorsiflexes. As a result, the muscles and ligaments experience less strain during push-off (7).

The flexible flatfoot does not fully transform into a stiff, inverted lever until the later part of stance; it starts stance in an unlocked, everted state. Foot tiredness and soreness may result from this, since Mann and Inman's research revealed that a flatfooted person needs more intrinsic muscle activity to support the transverse tarsal and subtalar joints than a person with an average arch height. Thankfully, only a small percentage of people with flat feet seem to experience foot weariness and discomfort (8).

Although pronation is a component of the hindfoot deformity in this condition, the forefoot is supinated in relation to the hindfoot, the midfoot is abducted, and the subtalar joint is dorsiflexed and externally rotated. As such, the orthopedist is advised to refrain from using the term "pronated" in place of "flatfoot." A preferable phrase to use is "flatfoot," which includes all of these multi-site three-dimensional abnormalities (9).

Does flat foot cause foot pain?

In addition to the particular foot and ankle examination, a general musculoskeletal examination should be part of the clinical evaluation of a kid with flatfoot. The purpose of the general examination is to evaluate the walking pattern and torsional and rotational variations of the lower extremities. Check for signs of generalized ligamentous laxity in the patient, such as touching the thumb to the volar forearm, hyperextending the fingers' metacarpo-phalangeal joints to 90 degrees, hyperextending the elbows and/or knees into recurvatum, and touching the palms to the ground while the knees are extended. Inquiring about family flat feet and examining the feet of other family members in the examination room are frequently fruitful. It is important to evaluate the child's shoes since flexible flatfeet may lead to quick and uneven shoe wear in older children and adolescents (10).

The first unambiguous statement made by Mosca is that "the foot is not a joint." This straightforward and apparently obvious truth serves as the basis for the proper examination and treatment of foot abnormalities in infants. All congenital and developmental malformations of the child's foot include at least two segmental defects, sometimes pointing in opposing directions. For instance, a flatfoot is a conglomeration of abnormalities, such as the forefoot's supination deformity and the hindfoot's valgus deformity. According to Mosca, these deformities are rotationally opposite directions and give the appearance that the foot has been "wrung out like a towel." In a symptomatic flatfoot, the gastrocnemius alone or the entire triceps surae (Achilles tendon) may also be contractured (3).

A flatfoot's clinical presentation is more complex than just a longitudinal arch's absence or depression. The foot's plantar-medial border is either convex or straight. The lateral margin is straight or concave. When bearing weight, the midfoot sags and makes contact with the ground. The weight-bearing axis of the lower extremities passes medially to the hindfoot's mid-axis, and the foot looks externally rotated with respect to the leg (11).

More significant than the flatfoot's static form is its flexibility. The motion of the subtalar joint complex is referred to as flexibility, and it needs to be carefully evaluated. A flexible flatfoot hanging in midair while the person is sitting will exhibit a longitudinal arch and the subtalar joint will invert from valgus to neutral. Dorsiflexion of the great toe may also produce a longitudinal arch (12).

Assessment of real ankle dorsiflexion and Achilles tendon excursion are vital, although challenging, to quantify precisely. To isolate and evaluate the motion of the talus in the ankle joint, the subtalar joint complex has to be inverted to neutral and kept locked in that position. While keeping the subtalar joint in a neutral posture, the knee is flexed and the ankle is dorsiflexed (7).

Although they are not required for diagnosis, radiographs of the flexible flatfoot may be useful for surgical planning, evaluating unusual discomfort, and assessing reduced flexibility. In most cases, lateral and weight-bearing anteroposterior (AP) views of the foot are enough to assess the flexible flatfoot. The radiographic correlations between the bones will not accurately depict the actual clinical abnormalities if there is no weight-bearing, or at least simulated weight-bearing (5).

The calcaneal pitch, which measures the plantar flexion of the calcaneus, and the talo-horizontal angle, which measures the even larger degree of plantar flexion of the talus, are both visible on the lateral radiograph of a flatfoot. On a standing lateral radiograph, described a normal longitudinal arch as having a continuous straight line made up of the lines that pass through the mid-axis of the talus and the mid-axis of the first metatarsal. Although there is a range of typical values that encompasses a few degrees of plantar sag, he classified a flatfoot as one with a plantar sag where the two lines connect (13).

Management of flat foot

Depending on how the discomfort manifests, flexbile flatfoot deformity may be treated conservatively or surgically (14).

`To treat flexible flatfoot, orthotic devices like arch supports and specially designed insoles are often used. According to studies, these devices may aid in foot realignment, support, and symptom relief, including pain and discomfort. Effectiveness: Studies show that in teenagers with flexible flatfoot, orthotics may reduce discomfort and enhance functional results. Because custom orthotics are built to fit each person's unique foot shape, they are often more effective than over-the-counter insoles (15).

Physical Therapy: Strengthening the foot and lower leg muscles to support the arch is the main goal of physical therapy. Exercise to develop the foot's intrinsic and extrinsic muscles, common workouts include toe curls, heel lifts, and resistance band usage. It has been shown that regular physical therapy helps teenagers with flexible flatfoot by increasing arch height and lowering symptoms (5).

In order to manage flexible flatfoot, appropriate footwear is essential. Supportive Shoes: Shoes with a strong heel counter and adequate arch support may provide extra stability and support. Activity Modification: Reducing high-impact activities and opting for less foot-stressing sports, like cycling or swimming, can help control symptoms (16).

Surgical Care

Adolescents with severe symptoms who do not improve with conservative measures may be candidates for surgery.

1.Arthroereisis

This minimally invasive surgery, which is mostly utilized before the age of ten, involves placing a tiny implant into the sinus tarsi to realign the foot.

• Effectiveness: Research has shown positive results in terms of reduced pain and enhanced functionality.

• Complications: Sinus tarsi discomfort and implant dislocation are potential side effects (17).

2.Osteotomy

• Types: Common operations include cotton osteotomy, lateral column lengthening, and medial sliding calcaneal osteotomy.

• Results: These treatments have been successful in lowering symptoms and improving foot alignment (3).

3.Transfer of Tendons

By moving tendons to better locations, tendon transfer treatments seek to enhance foot function.

• Technique: The posterior tibial tendon is often transferred to the lateral side of the foot.

• Effectiveness: Tendon transfers can enhance foot stability and produce positive functional results (18).

Evans Calcaneal Osteotomy

A strong and effective treatment for pediatric flexible flatfoot is the Evans calcaneal osteotomy. The operation, which was first reported by Dr. Evans as a wedge osteotomy at the calcaneal neck with tibial cortical graft, has been improved and its indications broadened to cure flatfoot abnormalities in both adults and children. The best method for extending the lateral column is now the Evans calcaneal osteotomy. The technique does have certain risks and contraindications, however. For this technique to be effective, choosing the right patients is essential (19).

The incision is made to the calcaneocuboid (c-c) joint, beginning 1 cm distal to the lateral malleolus. According to Giannini et al. (19) this offers superior exposure without endangering the sural and intermediate dorsal cutaneous nerves. The peroneal tendons and extensor digitorum brevis (EDB) are dissected. The peroneal tendons are reflected plantarly and the EDB dorsally after an incision is made between the two structures. Care is taken to protect the soft tissue attachments at the level of the c-c joint. Failure to do so can result in avascular necrosis or subluxation of the distal fragment of the calcaneus. The osteotomy is positioned between 1 and 1.5 centimeters from the c-c joint. This is generally where the anterior superior section of the calcaneus meets the floor of the sinus tarsi. The writers regard this as their anatomical marker for the placement of the osteotomy. Making the osteotomy at this level enables for the anterior and middle facet to be bisected (19).

In order to avoid the distal piece of the calcaneus from subluxing, a.062 k-wire is temporarily fixed across the c-c joint by passing it percutaneously from distal to proximal prior to the osteotomy. The osteotomy is positioned through-and-through, from lateral to medial. Typically, the authors use a saw to start the osteotomy and an osteotome to complete. By doing this, the surgeon may utilize the osteotome as a lever arm to release the osseous structures from their soft tissue adhesions, reducing the chance of harm to medial structures. The osteotome is moved from side to side inside the osteotomy to release the soft tissue structures from their osseous adhesions (19).

A small distractor or a smooth, straight laminar spreader is used to distract the osteotomy to the required degree of correction. Intraoperative fluoroscopy with the foot loaded is used to ascertain this. Until the lateral column is straight and the talonavicular joint is rearticulated, the surgeon should divert the osteotomy (19).

The size of the bone transplant required depends on how much distraction is required to repair the deformity. A calcanceal cross-section allograft is used. The iliac crest and fibula are two of the numerous feasible choices for bone grafting material. After the graft is positioned, the osteotomy is fixed. Stabilization may be used, or a percutaneous Kirschner wire or screw may be used (19).

After surgery, for the first two weeks till the sutures are taken out, the patient is kept non-weight bearing in a comfortable splint. Then, for six weeks or until the graft exhibits early integration on radiographs, a short-leg non-weight-bearing cast is placed (19). After that, the patient is kept weight bearing for four to six weeks in a short-leg cast or fracture walker boot. After that, the patient progressively starts to bear weight while wearing sports shoes. For six months, the patient must abstain from sports or high-impact activities (19).

Although the Evans calcaneal osteotomy has a low overall complication risk, problems may still arise with any surgery. Malunion, nonunion, and delayed union are some of the most frequent side effects of the treatment. Avascular necrosis, dislocation of the distal segment of the calcaneus, nerve damage, and c-c joint impaction are less severe problems (which may result in higher morbidity). Stress fractures of the fifth metatarsal have been documented, notwithstanding their rarity (20).

Medial sliding calcaneal osteotomy

Patients with flexible flatfoot who continue to have discomfort and dysfunction after conservative therapy are usually candidates for a medial sliding calcaneal osteotomy. By realigning the hindfoot, the operation seeks to improve foot biomechanics and restore the medial longitudinal arch (21).

• Persistent Symptoms: Recommended for teenagers who have chronic discomfort, walking difficulties, or functional impairment.

• Conservative Management Failure: Used when activity changes, physical therapy, and orthotic devices don't provide the desired effects.

• Biomechanical Considerations: Realignment may greatly enhance foot mechanics in situations of hindfoot valgus deformity.

To make it easier to reach the lateral side of the foot, the patient is positioned either supine with a roll under the hemi pelvis or in the lateral decubitus posture on a bean bag. The foot and lower leg are cleaned and wrapped in sterile material (22).

For antibiotic prophylaxis, a single dosage of a first-generation cephalosporin is administered before to incision. They apply a tourniquet. The superior portion of the calcaneus, posterior to the sural nerve and the peroneal tendons, is where the surgical incision starts proximally. Parallel to the path of the peroneal tendons, the incision extends distally at a 45-degree angle with the foot's plantar surface (22).

The incision is made straight. The sural nerve, which may cross the proximal aspect of the incision, is carefully preserved during the deep dissection. For a distance of about 1 cm, the periosteum is cut and reflected dorsally and plantarly. In accordance with the skin incision, approximately 45 degrees from the foot's plantar surface, a transverse osteotomy of the calcaneus is performed using an oscillating saw. To avoid too much bone loss, the ideal saw blade is 3 cm wide and as thin as feasible. The surgeon grasps the heel to feel when the saw blade pierces the medial cortex of the calcaneus, making the incision from lateral to medial with great care to preserve the medial neurovascular systems. A smooth lamina spreader is placed as far across the osteotomy as feasible once it is finished, and it is then opened repeatedly (22).

The calcaneus may more easily translate medially as a result of the medial soft tissues being loosened. After removing the lamina spreader, the calcaneus' tuberosity is translated medially by about 1 cm. Preventing the calcaneus from migrating proximally during medial translation is crucial. The pull of the Achilles tendon is relaxed and proximal displacement of the calcaneal tuberosity is avoided when the knee is flexed during medial translation (22).

A partly threaded cannulated screw is used for fixation after the osteotomy has been correctly translated and positioned. A guiding pin from the cannulated screw set is placed immediately proximal to the intersection of the plantar and posterior portions of the calcaneus. During guide pin insertion, the foot is dorsiflexed to secure the osteotomy in place. The beginning position for guide pin insertion is critical because it is possible to miss the body of the calcaneus with the pin after appropriate medial translation has been performed. The insertion location should be on the posterior part of the heel, just lateral to the midline. The pin is introduced using a cannulated drill, aiming laterally to acquire optimal purchase in the body of the calcaneus. An image intensifier is used to verify the guidewire's location in both the axial and lateral planes. To make sure the guiding pin has located the calcaneus body, which is now lateral to the tuberosity, an axial radiograph is used. The alignment of the heel with respect to the knee is another way to evaluate the degree of translation axially (22).

A tiny stab incision is created over the guidewire after adequate medial translation has been verified, and the screw's length is determined using the depth gauge. In order to guarantee that all screw threads cross distal to the osteotomy site, the short threaded screw is often used. This process is made easier by self-drilling, self-tapping screws, albeit drilling a beginning hole for the screw may be required in hard bone. The foot is held in dorsiflexion while the cannulated screw is inserted over the guidewire. Care should be taken to prevent the screw from penetrating the subtalar joint. The osteotomy's stability is evaluated. To improve osteotomy fixation, a second screw may be used if required. The picture intensifier is used to validate the screws' position (23).

The incision is irrigated, the subcutaneous tissue is approximated using a 3–0 absorbable stitch, and the skin is closed. Use one or two staples to roughly mark the little incision where the screw will be inserted. For the tendon transfer part of the procedure, the patient lies supine on the operating table (22).

There are a number of hazards associated with medial sliding calcaneal osteotomy, however few complications have been documented. Since this treatment is carried out via a large area of cancellous bone, nonunion is quite uncommon; yet, it might happen if firm fixation is not obtained. Because the lateral incision is made so near to the sural nerve, damage to the nerve may result. If the shelf of bone created by medial translation is not well shaped with a crushplasty, peroneal tendon discomfort is often seen. If the saw pierces the medial cortex, damage to the medial neurovascular systems may result. If the hardware is positioned too plantarly or if the discomfort continues in this location, it is often essential to remove the screw (23).

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