Symposium

POSI
IJPO

Lever Arm Disorders of the Feet in Cerebral Palsy

Atul Bhaskar MS Ortho, FRCS Ortho, MCH, DNB [1,2,3]

Abstract

The key for optimum management for progressive musculoskeletal deformities in cerebral palsy patients is understanding the causative mechanisms. The impact of muscle shortening and contracture on the long bones and joints leads to lever arm problems in the foot and ankle and the associated deformities.

Management of each deformity is considered separately although many of these can occur concurrently and the severity my vary in an individual.

Keywords: Lever, Cerebral palsy, Foot & Ankle

Dr. Atul Bhaskar

Address of Correspondence
Dr. Atul Bhaskar,
Paediatric Orthopaedic Surgeon, Department of Orthopaedics, Apollo Hospital, SRCC NH Hospital, Bombay Hospital Institute of Medical Sciences, Mumbai, Maharashtra, India.
E-mail: arb_25@yahoo.com

[1]Department of Orthopaedics, Apollo Hospital, Mumbai, Maharashtra, India.
[2]Department of Orthopaedics, SRCC NH Hospital, Mumbai, Maharashtra, India.
[3]Department of Orthopaedics, Bombay Hospital Institute of Medical Sciences, Mumbai, Maharashtra, India.

DOI- https://doi.org/10.13107/ijpo.2024.v10i01.175
www.ijpoonline.com

Introduction

Lever arm dysfunction in children with cerebral palsy refers to abnormal joint moment due to abnormal skeletal development [1].

Segmental foot and ankle malalignments are seen in almost all types of CP tone disorders– spastic, dystonic athetoid and hypotonic. Joints that have large excursions, such as ankle, subtalar, talonavicular and first metatarsophalangeal joints usually bear the brunt of deforming forces in CP.

The foot is well adapted for load bearing due to the intricate binding of 26 bones and ligaments controlled by both intrinsic and extrinsic muscles. Specific foot segments are active in different phases of the gait cycle. The ankle rockers in motion analysis illustrate the fine balance between foot levers controlled by muscles and ground reaction force. After heel strike the foot gradually dorsiflexes due to eccentric muscle activity of ankle dorsiflexors and unlocks in pronation for shock absorption. As the foot moves from mid-stance to push-off, there is supination and inversion of the midfoot and hindfoot. This locks the foot into a rigid lever and allows the gastro-soleus to generate maximum concentric power at terminal stance.

Almost all foot malalignments are supple at the beginning and as weight bearing forces, the foot shape adapts to the muscle imbalance based on type of cerebral palsy. If the ankle invertors are stronger then the foot deviates into varus and equinus causing lateral pressure, conversely if the evertors overpower the invertors (diplegics) then the foot drifts into valgus and equinus. As the weight bearing axis in valgus feet shifts medially, there is secondary arch collapse and progressive weakening of the tendoachilles complex.

The foot and ankle joints are also subjected to increasing loads with higher body mass index (BMI), proximal knee and hip malalignments and influence of orthotics. As the mechanical levers that optimize foot muscle function get compromised, there is progression of deformities. The typical gait abnormalities seen in diplegic and hemiplegics is a manifestation of the morphological change in foot shape, altered tone, muscle contracture and weakness.

The goal of any intervention in foot deformities is to restore both static and dynamic foot and ankle alignment. This may be with external aids such as custom fabricated orthotics, tone management with systemic medication or local treatment with botulinum toxin. With advancing age, soft tissue surgery and dynamic tendon transfers correct muscle imbalance provided the lever arms are intact. During early

Submitted: 11/02/2024; Reviewed: 26/02/2024; Accepted: 13/03/2024; Published: 10/04/2024

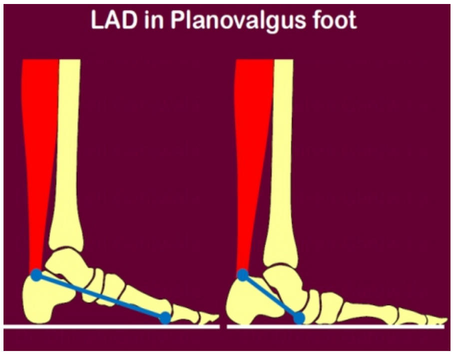

Figure 1: In planovalgus deformity, the lever arm of the foot is reduced from the metatarsal head to the head of the navicular bone

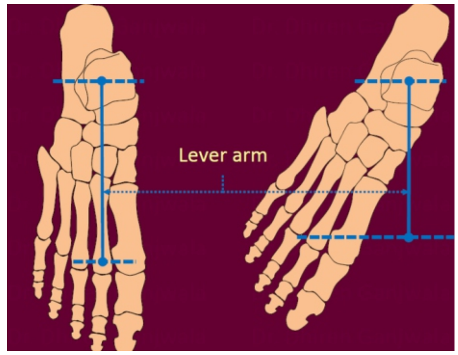

Figure 2: External tibial torsion reduces the perpendicular distance from the centre of the ankle to the head of the metatarsal (plantar flexion lever arm)

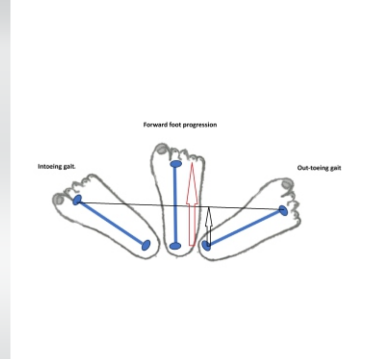

Figure 3: Reduction in the plantar flexion lever arms due to intoeing and out-toeing gait (blue arrow) compared to forward foot progression (red arrow).

adolescence the lever arm alterations are paramount and must be corrected for any dynamic muscle transfers to work.

The common foot deformities seen in cerebral palsy are listed below and the levers that are important in the feet are shown in the illustrations (Fig. 1-3).

Four most common segmental malalignments seen in foot and ankle due to lever arm disturbance[2]. (Fig. 4-6)

Planovalgus Foot: Diplegics, inadvertent tendoachilles surgery, repeat botulium toxim injections in the calf.

Equinovalgus foot: similar to planovalgus with tendoachilles contracture more signigficant.

Equinovarus foot: common in hemiplegic type of CP due to gastrocnemius and tibialis anterior contracture.

Tibial torsion: external tibial torsion can impact foot and ankle alignment akin to pes valgus.

Secondary deformities: Mid-foot collapse, hallux valgus, ankle valgus and forefoot abduction.

The cause of these deformities is multifactorial: severity of neurological impairment, muscle spasticity or weakness, ligamentous laxity, external forces. The deformities can be supple / flexible or rigid.

Planovalgoid foot

The most common lever arm dysfunction seen in CP, especially diplegics. It starts of as an uniaxial contracture due to calf spasticity and weakness of foot invertors and ankle dorsiflexors. There is progressive midfoot collapse with hindfoot eversion and forefoot abduction. These deformities are compounded by increased weight gain and secondary contractures during the adolescent growth spurt [3]. Further worsening is seen by using ill-fitting orthosis, on an already deformed foot, to try and maintain plantigrade posture.

The segmental malalignments are severe in the midfoot but there is associated hallux valgus, hindfoot valgus and ankle valgus. The line of pull or moment arm of the tibialis anterior and peroneal muscles are altered causing shortening of the lateral border of the foot. The moment arm of tendoachilles is shortened with loss of plantarflexion-knee extension couple. This can lead to crouch gait and associated knee flexion [4, 5].

The ground reaction force is concentrated medially and the line of progression of foot progression pressure is disturbed causing foot

Figure 4: Bilateral equinovarus feet

Figure 5: Bilateral planovalgoid feet with midfoot collapse and hallux valgus

Figure 6: Planovalgus feet is often associated with internal femoral rotation and external tibial rotation (ETT)

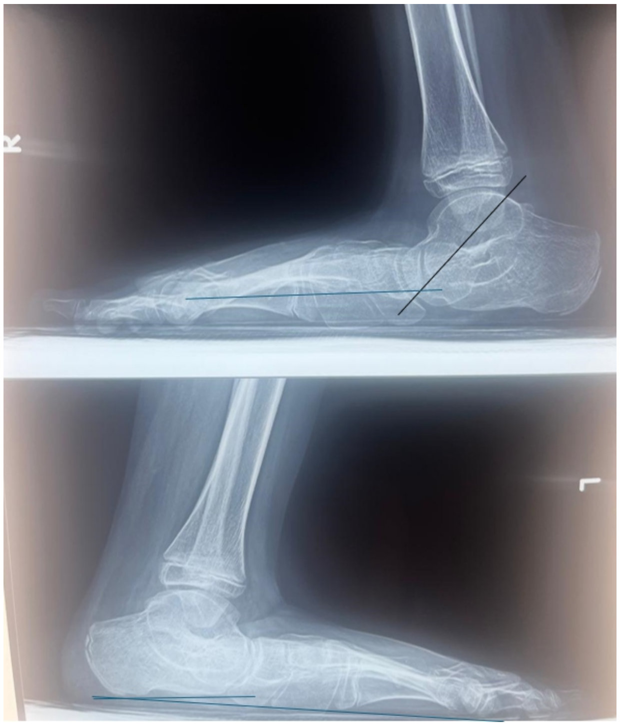

Figure 7: Weight bearing radiographs showing the increased Talo-1st metatarsal angle on lateral view (< 45degrees is normal) and calcaneal pitch angle less than 15 degrees.

Figure 8: AP view showing increased talo-navicular angle in AP view and talus uncovering.

Figure 11: Severe planovalgoid feet in 13 year old girl

Figure 9: illustration of planovalgoid foot with shortened lateral border.

Figure 10: Lateral column lengthening with insertion of bone graft. Plates and K wires can be used to secure graft in position depending on age of child.

callosities and pain in the mid-tarsal and metatarsophalangeal joints.

Equinovalgus foot

This deformity is similar to planovalgoid feet except there is more rigid ankle equinus with secondary midfoot break. The main culprit is a tight tendoachilles tendon or calf contracture In the supple foot the mid-foot can be supinated to see the magnitude of equinus contracture. There is also tautness of the peroneal tendons on foot inversion. Over time the peronei muscle shortening exaggerates the midfoot deformity. As the tendoachilles lever arm is disturbed, push-off is reduced and the foot appears more dorsiflexed.

Equinovarus foot

This is commonly seen in hemiplegic type CP. Spasticity and contracture of tendoachilles causes ankle inversion and foot inversion with pressure on the lateral border of the foot. Here the lateral column of the foot lengthens with increasing contracture of the plantar fascia and intrinsic foot muscles. There is spasticity and contracture of the invertor muscles – tibialis posterior and tibialis anterior. The evertors are weak (peroneal group) and the midfoot supinates due to the multiple attachments of tibials posterior muscle and there is forefoot adduction and rotation due to insertion of tibialis anterior on the first metatarsal.

External tibial torsion

Excessive femoral anteversion in CP diplegics is often associated with ETT. This ETT alters the weight-bearing line of tibia and ankle/foot segment. This impacts the lever arm of the gastro-solues complex resulting in an inefficient push-off force required for forward propulsion.

ETT is almost always occurs as secondary torsional problem in conjunction with excessive adductor thrust and excessive femoral anteversion. The foot malalignment that follows ETT

Figure 12: Subtalar fusion with Talo-navicular fixation to protect medial soft tissue plication and hallux valgus fusion

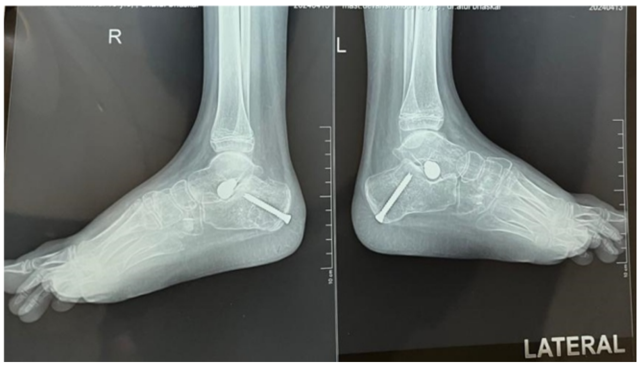

Figure 14: Subtalar arthroereisis with Calcaneal slide osteotomy and medial soft tissue plication with tibialis posterior advancement.

Figure 15-17: Severe rigid plano-valgoid feet in marginal ambulator (GMFCS 4). Painful callosities on the dorsum and pain on weight bearing. Both medial and lateral column stabilization (talo-navicular fusion), Cuboid lengthening and subtalar fusion.

is a planovalgoid deformity due to medial shift of weight bearing axis. ETT is assessed by measuring the thigh foot angle (TFA) in prone position. Typically the thigh-bimalleolar axis is about 10- 15 degrees external [7].

The exact magnitude of torsional deformities in femur and tibia

Figure 13: 2year follow up. Correction is well maintained with plantigrade feet.

Figure 18-20: Equinovarus rigid foot treated with triple arthrodesis

that need correction depends on detailed visual and 3D gait analysis and CT measurements of the torsional profile. Excessive ETT > 25 degrees and femoral anteversion > 30-45 degrees with deterioration in gait and reduction in functional mobility scale will merit a surgical intervention. A proximal femur osteotomy to correction anteversion will exaggerate the ETT and this needs correction with a distal tibial supramalleolar osteotomy [8]. Often the ETT is secondary to the long standing planovalgoid foot deformity and can be corrected at the time of foot surgery.

Hallux valgus (HV)

Forefoot deformities commonly afflict the great toe and proximal interphanlangeal joint of hallux and lesser toes. HV occurs with planovalgoid foot deformity due to loss of proximal foot lever function. As the midfoot collapse and rolls into

pronation, the hallux rotates and deviates at the metatarsophalangeal joint (MTP). As the sesamoids on the plantar aspect of foot displace laterally, they act as a taut checkrein and further exaggerate the deformity. There is gradual loss of MTP joint congruency and in severe cases subluxation and dorsal dislocation of the MTP joint.
The interphalangeal joint contracture can accompany the HV due to the abnormal pull of flexor hallucis and digitorum longus.

Assessment of foot deformities

The application of diagnostic matrix is useful for assessment of segmental foot deformities in CP [6].
A good clinical history of the onset of foot deformities based on neurological involvement helps in planning treatment. A thorough physical examination of the feet from all sides allows the assessment of foot deformities and associated pressure changes. Examination of footwear and orthosis also can reveal the weight-bearing pattern.
Radiological assessment to see the severity of foot deformity helps in the planning of the treatment. The various angles used in foot radiology are shown in Figure 7 & 8.
Observational gait analysis is an integral part of foot and ankle examination. The foot position at heel strike, mid-stance and swing phase can be easily discerned with slow motion image capture.
A more refined 3D instrumented gait analysis is useful to see the kinematics of hip, knee, ankle and foot segments along with kinetic or force data to assess the impact of ground reaction force on foot and ankle malalignment.
Dynamic EMG has a role in understanding abnormal muscle firing during various phases of the gait cycle.
Dynamic pedobarography gives quantitative information about the foot contact pressure, temporal and spatial distribution of pressure and the center of pressure progression. In valgus feet the pressure is distributed medially and vice versa in varus feet.

Management of lever arm problems in CP.

Is based on three pre-requisites
• Is the foot flexible, semi-rigid or rigid
• Age of the child
• Ambulatory status based on Gross Motor Function Classification System (GMFCS).

The progression for foot deformity based on flexibility of joints depends on age of presentation and type of CP. Myostatic contractures follow persistent spasticity, leading to secondary adaptations in bones (torsion, coronal or axial deviations) and later joint subluxation or dislocation.
These segmental malalignments can cause use pain and instability seen as compromised gait, early fatigue and discomfort at abnormal pressure sites. Callosities near joints indicate abnormal loading or pressure due to orthotic wear.

• Treatment of Flexible foot deformities in ambulatory children

The principle of foot correction in CP is to restore foot alignment and shape. In children less than 6 years, this can be achieved with a well-fitting orthosis. Often tone reduction with botulinum toxin may be required to weaken a spastic muscle and allow proper orthotic support.
Supple plano-valgoid feet are treated with botulinum toxin in the peronei and calf muscles followed by well-moulded arch based orthotic support.

• Treatment of semi-rigid foot deformities in ambulatory children

Between ages 7 – 10, muscle fibrosis induces contracture in the extrinsic muscles controlling foot and ankle motion.
Equinovarus attitude can be due to both tibialis anterior and tibialis posterior muscle contracture. This reduces the lateral or evertor excursion in coronal plane and with time the entire foot inverts into supination and adduction.
To restore foot alignment, soft tissues release on medial side with tendon transfers to correct invertor-evertor imbalance are required. A split tibialis anterior transfer (SPLATT) with tibialis posterior and calf recession suffices in most semi-rigid equinovarus feet.
For the planovalgoid feet the stiffness or rigidity of subtalar and midfoot joints determines the correct management. There is relentless progression of planovalgoid deformities from supple to rigid based on the ambulatory status of the child. GMFCS 3 and 4 show the worst progression in deformities during adolescence.

Lateral column lengthening: In children with mild to moderate heel valgus and mid-foot abduction, where the lateral column appears shortened, a LCL procedure is preferred. This may be combined with medial soft tissue plication and tibialis posterior advancement [7].
Several types of LCL have been described based on the site of the calcaneal cut. Typically, the cut starts 10 -15 mm proximal to the calcaneocuboid joint, between the anterior and middle facets of the os calcis. Evans described a transverse osteotomy and Mosca modified it by using a more obliquely directed osteotomy from proximal-lateral to distal-medial [9, 10]. This was an open wedge type of osteotomy with a trapezoidal shaped bone block inserted to lengthen the lateral border of the foot. This is a powerful technique to correct heel valgus and midfoot in the coronal plane. (Fig. 9 & 10)

Subtalar arthrodesis (Grice Green or Batchelor procedure): The concept of bone block in the extra-articular space of sinus tarsi to block eversion was first described for poliomyelitis. This procedure can be used in flexible and semi-rigid planovalgoid feet where heel valgus is correctable [11,12]. Only a bone block may suffice or the sinus tarsi can be fixed with a compression cannulated screw across the sinus tarsi to prevent graft slippage. However, this procedure doesn't correct forefoot abduction and midfoot collapse. (Fig. 11, 12 & 13)

Graft resorption, displacement and mal-positioning are the commonest complications of this procedure. The key for successful result is to place the graft perpendicular to the floor and in line with weight bearing axis of the tibia, and slightly posterior in the sinus tarsi. One can use fibula graft, iliac crest or allograft.

"Triple C" procedure: (Rathjen & Mubarak) This is reserved for moderate to severe deformity where the heel valgus cannot be corrected to neutral and there is a fixed forefoot abduction and midfoot collapse. This procedure entails an os calcis sliding osteotomy for hindfoot valgus, an open cuboid osteotomy to correct the short lateral column and realign the talonavicular joint [13]. The third "C" is a plantar closing wedge osteotomy of the medal cuneiform to allow plantar-flexion and pronation of the forefoot.

Subtalar arthoereisis: There is renewed interest in the use of an extra-articular implant in the sinus tarsi for flexible pes planovalgus feet in cerebral palsy [14, 15]. It can be used in isolation for flexible feet and in combination with a lateral column lengthening and medial soft tissue plication for the more moderately involved feet [17]. (Fig 14)

Salvage procedure in severe foot deformities: Limited bony fusions or triple arthrodesis have been described in cases of rigid foot deformities that present late or in cases of revision surgeries where previous described technique has left a sub-optimal, mal-aligned symptomatic foot. Often these are used in combination with other procedures on the os calcis or soft tissue plication. (Fig. 15- 17) and (Fig. 18-20)

Talo-navicular fusion, naviculectomy with mid-foot arthrodesis have been used for rigid equinovalgus [18, 19, 20]. Triple arthrodesis is used for the rigid equinovarus feet where a large wedge in removed from the lateral column and appropriate wedges are fashion in talo-navicular joint and subtalar joint to allow large bone surface for fusion. Special foot plates and cannulated screws can be used to hasten the bone healing.

The aim is to get a stiff but plantigrade foot to avoid abnormal pressure points. An orthotic support is often required to maintain correction.

External tibial Torsion

This requires correction as part of multi-level surgery in CP. The ETT occurs due to the adductor thrust and medial femoral rotation in walking diplegics. The compensatory external tibial rotation allows the child unobstructed ambulation. Also, with severe planovalgoid feet, the mechanical forces along with taut foot evertors and lateral pull of the gastrosoleus causes the external rotation to the tibia.

If the ETT is greater than 30 degrees, a tibial derotation osteotomy is required to improve the lever arm of calf muscles and foot invertors and also to bring the ankle and foot in alignment with the tibia [21, 22].

The osteotomy is performed at the supramalleolar level, 4-5 cms proximal to the ankle joint. An oblique or transverse osteotomy using 2 parallel K wires as guides helps to determine the angular correction. If more than 20 degrees internal rotation is required, then a fibular osteotomy is required to prevent proximal tibio-fibular joint subluxation [23]. Fixation of osteotomy is done by cross "K"wires or with plate osteosynthesis.

Hallux Valgus Correction

The HV correction is always secondary after the foot correction. The optimal treatment of this deformity is still unclear. Surgery is often required for painful subluxation of the first metatarsophalangeal (MTP) joint or if there is any hindrance in fitting of an orthosis. A recent meta-analysis suggested MTP fusion surgery for GMFCS 4 & 5 and meta-tarsal osteotomy with soft tissue balancing procedures for ambulatory children [24].

Conclusion

Dynamics of growth and progressive muscle contracture leads to Lever arm dysfunction in foot and ankle, that is unique to cerebral palsy. The magnitude of deformities varies, based on the severity and type of Cerebral Palsy (GMFCS Grade). Classical patterns of foot deformities are seen in hemiplegics (equinovarus) and diplegics (planovalgus).

The initial deformities are supple, but the brunt of increasing weight during adolescence, and muscle imbalance leads to progressive lever arm problems around the ankle and foot. Tone management and orthotic can help to counter the abnormal muscle forces to preserve bony levers and optimize gait.

Lever arm correction surgery is undertaken when there is functional impairment and symptomatic disturbance during weight-bearing. To improve or enhance gait, tendon transfers around foot and ankle are useful to correct muscle imbalance. This may be combined with osteotomy and fusion surgery to obtain a plantigrade foot.

References

1. Theologis T. Lever arm dysfunction in cerebral palsy gait. J Child Orthop. 2013 Nov;7(5):379-82. doi: 10.1007/s11832-013-0510-y. Epub 2013 Aug 14. PMID: 24432098; PMCID: PMC3838510.

2. Dudeney, S. and Stephens, M., 1998. Foot deformities in children with cerebral palsy. Journal of Pediatric Orthopaedics, 18(6), pp.743-747.

3. Min, J.J., Kwon, S.S., Sung, K.H., Lee, K.M., Chung, C.Y. and Park, M.S., 2020. Progression of planovalgus deformity in patients with cerebral palsy. BMC musculoskeletal disorders, 21(1), pp.1-8.

4. Bennet, G.C., Rang, M. and Jones, D., 1982. Varus and valgus deformities of the foot in cerebral palsy. Developmental Medicine & Child Neurology, 24(5), pp.499-503.

5. Kadhim M and Miller F. Pes planovalgus deformity in children with cerebral palsy: review article. J Pediatr Orthop B 2014; 23(5): 400–405.

6. MacInnes P, Lewis TL, Griffin C, et al. Surgical management of pes planus in children with cerebral palsy: a systematic review. PROSPERO2021 CRD42021239285, https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021239285 (2021, accessed 22 December 2021).

7. Lee SH, Chung CY, Park MS, Choi IH, Cho TJ. Tibial torsion in cerebral palsy: validity and reliability of measurement. Clin Orthop Relat Res. 2009 Aug;467(8):2098-104. doi: 10.1007/s11999-009-0705-1. Epub 2009 Jan 22. PMID: 19159112; PMCID: PMC2706340.

8. Andrisevic E, Westberry DE, Pugh LI, Bagley AM, Tanner S, Davids JR. Correction of Tibial Torsion in Children With Cerebral Palsy by Isolated Distal Tibia Rotation Osteotomy: A Short-term, In Vivo Anatomic Study. J Pediatr Orthop. 2016 Oct-Nov;36(7):743-8. doi: 10.1097/BPO.0000000000000525. PMID: 27603097.

9. Sung K.H., Chung C.Y., Lee K.M., Lee S.Y., Park M.S. Calcaneal lengthening for planovalgus foot deformity in patients with cerebral palsy. Clin Orthop Relat Res. 2013;471(5):1682–1690. [PMC free article] [PubMed] [Google Scholar]

10. Zeifang F, Breusch SJ and Döderlein L. Evans calcaneal lengthening procedure for spastic flexible flatfoot in 32 patients (46 feet) with a followup of 3 to 9 years. Foot Ankle Int 2006; 27(7): 500–507.

11. Mosca VS. Calcaneal lengthening for valgus deformity of the hindfoot. Results in children who had severe, symptomatic flatfoot and skewfoot. J Bone Joint Surg Am 1995; 77: 500–512.

12. Andreacchio A, Orellana C, Miller F, et al. Lateral column lengthening as treatment for planovalgus foot deformity in ambulatory children with spastic cerebral palsy. J Pediatr Orthop 2000; 20: 501–505.

13. Grice D.S. An extra-articular arthrodesis of the subastragalar joint for correction of paralytic flat feet in children. J Bone Joint Surg Am. 1952;34(1):927–940. [PubMed] [Google Scholar]

14. Güven M., Eren A., Akman B., Unay K., Ozkan N.K. The results of the Grice subtalar extra-articular arthrodesis for pes planovalgus deformity in patients with cerebral palsy. Acta Orthop Traumatol Turcica. 2008;42(1):31–37. Jan-Feb. [PubMed] [Google Scholar]

15. Rathjen K.E., Mubarak S.J. Calcaneal-cuboid-cuneiform osteotomy for the correction of valgus foot deformities in children. J Pediatr Orthop. 1998;18(6):775–782. [PubMed] [Google Scholar]

16. Ahmed AH, Hanna AA, Arafa AS, et al. Prospective comparison of subtalar arthroereisis with calcaneal lengthening in the management of planovalgus feet of ambulatory children with spastic cerebral palsy? Foot Ankle Spec. Epub ahead of print 3 December 2020. DOI: 10.1177/1938640020974886.

17. Suh DH, Park JH, Lee SH, et al. Lateral column lengthening versus subtalar arthroereisis for paediatric flatfeet: a systematic review. Int Orthop. 2019;43:1179-1192.

18. Turriago CA, Arbeláez MF and Becerra LC. Talonavicular joint arthrodesis for the treatment of pes planus valgus in older children and adolescents with cerebral palsy. J Child Orthop 2009; 3: 179–183.

19. Elbarbary HM, Arafa AS, Said ABZ, et al. Clinical and Radiological Outcomes of Subtalar Arthroereisis for Management of Planovalgus Foot in Children With Cerebral Palsy: 3-Year Follow-up. Foot & Ankle Specialist. 2022;15(6):536-544. doi:10.1177/1938640020980911

20. Vlachou M, Demetriades D and Hager I. Subtalar arthrodesis with the combined Batchelor–Grice technique. Foot Ankle Surg 2004; 10: 79–84.

21. Dussa CU, Döderlein L, Forst R, Böhm H, Fujak A. Management of Severe Equinovalgus in Patients With Cerebral Palsy by Naviculectomy in Combination With Midfoot Arthrodesis. Foot & Ankle International. 2017;38(9):1011-1019. doi:10.1177/1071100717709577

22. Ireland, M.L. and Hoffer, M., 1985. Triple arthrodesis for children with spastic cerebral palsy. Developmental Medicine & Child Neurology, 27(5), pp.623-627. O'Connell, P.A., D'Souza, L.

23. Aiona M, Calligeros K, Pierce R. Coronal plane knee moments improve after correcting external tibial torsion in patients with cerebral palsy. Clin Orthop Relat Res. 2012 May;470(5):1327-33.

24. Stefko RM, de Swart RJ, Dodgin DA, Wyatt MP, Kaufman KR, Sutherland DH, Chambers HG. Kinematic and kinetic analysis of distal derotational osteotomy of the leg in children with cerebral palsy. J Pediatr Orthop. 1998 Jan-Feb;18(1):81-7. PMID: 9449107.

25. Cidambi EO, Farnsworth CL, Jeffords ME, Hughes JL, Parvaresh KC, Sullivan TB, Yaszay B, Edmonds EW. Distal tibial osteotomy to address internal tibial torsion: Should the fibula be cut? Clin Biomech (Bristol, Avon). 2022 Jan;91:105536. doi: 10.1016/j.clinbiomech.2021.105536. Epub 2021 Nov 20. PMID: 34920237.

26. T.L. Lewis, K. Patel, K.L. Shepherd, P. MacInnes, R. Ray, M. Kokkinakis, Hallux valgus surgery in children with cerebral palsy: A systematic review, Foot and Ankle Surgery,Volume 28, Issue 4,

Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

How to Cite this Article

Bhaskar A | Lever Arm Disorders of the Feet in Cerebral Palsy | International Journal of Paediatric Orthopaedics | January-April 2024; 10(1): 26-33