ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Author's translation
Acta Orthop Traumatol Turc 2006;40(5):356-366

The results of calcaneal lengthening osteotomy for the treatment of flexible pes planovalgus and evaluation of alignment of the foot

Fleksibl pes planovalgusta kalkaneal uzatma osteotomisinin sonuçları ve ayak diziliminin değerlendirilmesi

Ahmet DOGAN,[1] Mehmet ALBAYRAK,[1] Y. Emre AKMAN,[1] Gazi ZORER[2]

[1]*Istanbul Education and Research Hospital, 1. Orthopaedy and Traumatology Department;*
[2]*Bezm-i Alem Valide Sultan Vakif Gureba Education and Research Hospital, 2. Orthopaedy and Traumatology Department*

Amaç: Fleksibl pes planovalgus (PPV) deformitesi olan hastalarda modifiye Evans osteotomisi tekniğiyle uygulanan kalkaneal uzatma ameliyatının sonuçları ve bu tekniğin ayak dizilimini sağlamadaki başarısı değerlendirildi.

Çalışma planı: Fleksibl PPV deformitesi olan 11 hastanın (6 erkek, 5 kız; takip sonu ort. yaş 10 yıl 10 ay; dağılım 5 yıl 6 ay-14 yıl 8 ay) 22 ayağına modifiye Evans osteotomisi tekniğiyle kalkaneal uzatma ameliyatı yapıldı. Etyoloji, beş olguda serebral felç, bir olguda miyelomeningosel sekeli, bir olguda herediter sensorimotor polinöropati iken, dört olgu idiyopatik olarak değerlendirildi. Olguların tümü ameliyat öncesinde uzun süreli konservatif tedavi görmüş, bir hasta dışında hiçbir olgu deformite nedeniyle ameliyat geçirmemişti. İki taraflı deformiteler, bir hasta hariç tüm hastalarda aynı seansta ameliyat edildi. Klinik değerlendirmede 10 parametre; standart ön-arka ve yan radyografiler üzerinden yapılan radyografik değerlendirmede yedi parametre göz önüne alındı. Ameliyat sonrası takip süresi ortalama 18 ay (dağılım 13-75 ay) idi.

Sonuçlar: Tüm olgularda ortalama 7 hafta (dağılım 6-8 hafta) içinde radyografik olarak kaynama sağlandı. Klinik değerlendirmede 17 ayakta (%77.3) mükemmel, üçünde (%13.6) iyi, birinde (%4.6) orta, birinde kötü sonuç elde edildi. Radyografik değerlendirmede beş ayakta (%22.7) mükemmel, 13'ünde (%59.1) iyi, dördünde (%18.2) orta sonuç elde edildi. Kalkaneusta ortalama 7.3 mm (dağılım 4-9 mm) uzama sağlandı ($p<0.05$). Hiçbir ayakta greftte pozisyon kaybı veya aşırı düzeltme gözlenmedi. Ameliyattan önce iki olgu desteksiz, üçü destekli olarak topukta yürüyebiliyorken, ameliyattan sonra, bir olgu hariç tüm olgular desteksiz olarak topukta yürüyebiliyordu.

Çıkarımlar: Kalkaneal uzatma osteotomisi semptomatik PPV'de ağrıyı ortadan kaldırmakta, klinik ve radyografik olarak arka ve ön ayakta anlamlı düzelme sağlamaktadır.

Anahtar sözcükler: Kemik uzatma/yöntem; kalkaneus/cerrahi/radyografi; düz ayak; ayak deformiteleri/cerrahi; osteotomi/yöntem.

Objectives: We evaluated the results of calcaneal lengthening using the modified Evans osteotomy technique in patients with flexible pes planovalgus and the effectiveness of this technique in restoring the alignment of the foot.

Methods: Calcaneal lengthening osteotomy was performed using the modified Evans technique in 22 feet of 11 patients (6 males, 5 females; mean age at the end of follow-up, 10 years 10 months; range 5 years 6 months to 14 years 8 months) with flexible pes planovalgus deformity. Etiologies were cerebral palsy (n=5), sequela of myelomeningocele (n=1), and sensorimotor polyneuropathy (n=1); four patients were evaluated as idiopathic. All the patients received long-term conservative therapy preoperatively, and, except one patient, none had undergone surgery for the deformity. All patients but one were operated on bilaterally at a single session. Clinical assessment was based on 10 parameters, and radiographic assessment was based on seven parameters on standard anteroposterior and lateral radiographs. The mean follow-up was 18 months (range 13 to 75 months).

Results: Radiographically, union was achieved in all the patients after a mean of 7 weeks (range 6 to 8 weeks). Clinical results were perfect in 17 feet (77.3%), good in three feet (13.6%), fair in one foot (4.6%), and poor in one foot. Radiographically, five feet (22.7%), 13 feet (59.1%), and four feet (18.2%) were assessed as perfect, good, and fair, respectively. An average of 7.3 mm (range 4 to 9 mm) of calcaneal lengthening was obtained ($p<0.05$). Malpositioning of the graft or overcorrection did not occur. Before surgery, five patients could walk on the heel with (n=3) or without (n=2) support; postoperatively, all the patients but one could perform this without support.

Conclusion: Calcaneal lengthening osteotomy for symptomatic pes planovalgus provides pain relief and significant clinical and radiographic correction in the hind foot and forefoot.

Key words: Bone lengthening/methods; calcaneus/surgery/radiography; flatfoot; foot deformities/surgery; osteotomy/methods.

Correspondence to: Dr. Ahmet Dogan. Tesvikiye Mah., Hasan Cevdet Pasa Sok., Ihlamur Sitesi, A Blok D: 2, 34365 Sisli, Istanbul-Turkey.
Phone: +90212 - 588 44 00 / 1532 Fax: +90212 - 230 54 56 e-mail: orthopaedy@hotmail.com

Received: 05.06.2006 **Accepted:** 29.10.2006

Pes planus is a term implying that longitudinal arc of the foot is fallen or doesn't exist.If valgus of the heel is also present then it's called pes planovalgus (PPV).In these patients deformity is characterized by plantar flexion and medially deviation of talus, dorsiflexion and external rotation of calcaneus according to talus, severe subtalar evertion, naviculari's' laterally and dorsally shifting and supination of forefoot upon hindfoot.[1-7] In a patient with pes planovalgus normal dorsiflexion of the ankle is limited in the midstance phase of walking by the effect of contracted achilles tendon and dorsiflexor forces shift upon talonavicular joint. Therefore axial loading and shearing forces center directly under the head of plantar flexed talus.[1,2,4,8]

Patients with pes planovalgus differ by means of etiology, patology, severity of the deformity, prognosis and treatment.Pes planovalgus is an often deformity in the patients with neuromuscular disorders such as cerebral palsy, poliomyelitis, myelomeningocele and muscular dystrophy. Muscular spasticity or imbalance causes planovalgus deformity in these patients, but rarely deformity may also be seen in normal children.[1,3,4,9]

Flexible PPV is usually asymptomatic in children.Disorder is usually identified when parents are disturbed of the shape of child's foot and notice the problems in wearing shoes.In untreated patients, by the beginning of puberty, ulcerations on skin, difficulties in wearing shoes or braces and serious walking problems and as the most important severe pains occur.The aim of the treatment is to relieve the skin and pain, overcome difficulties in shoe and brace wearing and restore the normal alignment of the foot.[2,10,13] First conservative methods should be applied and when these methods are insufficient then surgical procedures should be tried.Surgical options vary from simple soft tissue procedures to calcaneal osteotomy, subtalar extra-articular arthrodesis and triple arthrodesis.[1,8,9,14] Because of the problems associated with limited arthrodesises, common opinion is to correct children's foot deformities without arthrodesis.[3,11,14,15]

Calcaneal lengthening osteotomy was described for the first time by Evans in 1975 and then modified and introduced by Mosca.[2] In our study we evaluated mid-term results of calcaneal lengthening operations performed using modified Evans osteotomy technique in patients with flexible PPV and inspected how foot alignment was effected when hindfoot was corrected by this technique.

Patients and method

Calcaneal lengthening operation was performed using modified Evans osteotomy technique in 22 feet of 11 patients (6 boys, 5 girls,mean age at the end of follow-up 10 years 10 months, range 5 years 6 months to 14 years 8 months) with flexible PPV. All of the bilateral deformities were operated at the same time except for one in which the second operation was performed 7 months later the first one.Mean age during the time of the surgery was 9 years 4 months (range 4 years 4 months- 13 years 3 months)Post-operative follow-up period was 18 months (range 13 months-75 months)Etiology was cerebral palsy in 5, myelomeningocele sequel in 1, hereditary sensorymotor polineuropathy in 1 and idiopatic in 4 cases.All of the patients were treated conservatively for a long time before surgery.The patient with hereditary sensorymotor polineuropathy was underwent an operation for tendon transfers in both feet and except for this one none of the patients were operated for their deformities.

Operation technique

Patients are positioned supine under general anesthesia and a pneumatic tourniquet is applied on thigh.A modified lateral longitudinal Ollier incision of 3 cm that extends 1 cm proximal of anterior calcaneal process is made over sinus tarsi.[8]Sural and superficial branches of peroneal nerve are preserved and inferior extansor retinaculum is released from calcaneus' superolateral border. Extensor digitorum brevis and other soft tissue contents of the sinus tarsi is elevated from the dorsal surface of the anterior aspect of the calcaneus. Peroneus longus and brevis tendons are released from their tendon sheaths sufficiently for them to be retracted dorsally and plantarward. Calcaneocuboid joint was identified but the the capsule was not damaged. The interval between medial and anterior fascets of calcaneus was identified and through this interval 2 Hohmann retractors are placed around medial and lateral aspects of calcaneus extraperiosteally.Periosteum is incised in line with the planned osteotomy starting laterally approximatelly 1.5 cm proximal to the calca-

neocuboid joint. A slightly oblique osteotomy which is neither perpendicular to the lateral side of the foot nor parallel to the calcaneocuboid joint is made from proximal-lateral to distal-medial.

Because the center of rotation for correction of the deformity is near the center of the talar head and not at the medial cortex of the calcaneus, this is not a simple opening-wedge osteotomy, but rather a lengthening-distraction wedge osteotomy, and it requires a trapezoid graft (figure-1). A laminar sprader is placed into the osteotomy side temporarily to determine the size of the graft necessary to reduce the talonavicular joint and entire subtalar complex to normal anatomical alignment. Correction was evaluated at this time either clinically or with roentgenograms. The size of the graft is dependent on the severity of the deformity but it is typically 10 to 12 mm long medially. During distraction of the osteotomy, the calcaneocuboid joint is watched carefully for dorsal subluxation. If subluxation occurs the laminar sprader is removed to allow the osteotomy to close. A large, smooth Steinmann pin is inserted longitudinally from the dorsal distal aspect of the cuboid through the center of the calcaneocuboid joint into the center of the osteotomy surface of the distal calcaneal fragment. Distraction is tried again. After the graft was placed, the pin was inserted to the proximal calcaneal fragment and the graft was fixed. When the size of the graft increases the risk of subluxation also becomes greater.[16] A tricortical, trapezoid shaped, autogenous bone graft derived from the iliac crest was used. In children in whom the apophyses have not closed, bicortical grafts are adequate alternatives.[2,4] The graft is impacted from lateral to medial in the most plantar portion of the osteotomy.

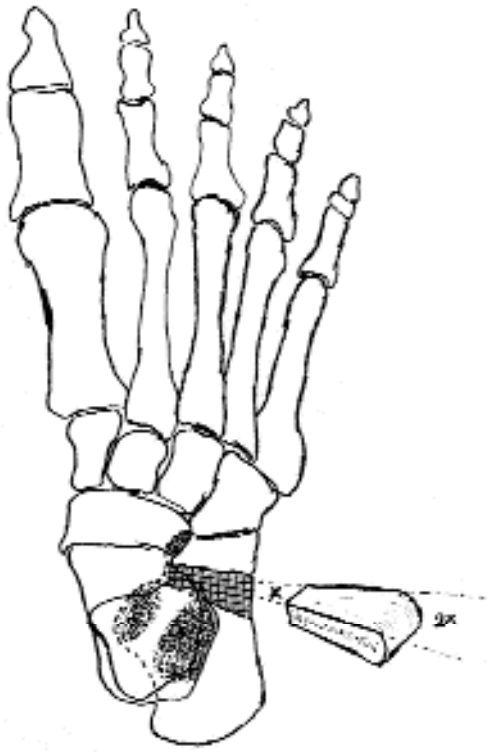

Figure 1. Schematic drawing of the osteotomy and the trapezoid graft.

In the cases in which the osteotomy site was not thought to be stabile enough after the impaction of the graft Kirschner wires were used for internal fixation. The wires were bended at the surface of the skin and left long for easy retrieval after the bone has healed. In children with cerebral palsy and in the cases that the tendons were observed to limit the distraction of the osteotomy site peroneus longus tendon was lengthened by Z-plasty addition to these procedures. After the impaction of the graft (after the heel valgus was corrected) dorsiflexion degree of the ankle was evaluated when the knee was extended. In the cases in which equinus or limitation of ankle dorsiflexion was observed aschilles tendon was lengthened by Z-plasty. The operation was terminated by application of a long leg cast.This cast was removed after 6 weeks and a short leg walking cast was applied to be used for 4 weeks.

Except for the cases in which temporary internal fixation was applied in none of the cases a window was opened for wound care.In 10 feet of 5 cases with cerebral palsy and in 2 feet of an idiopatic case achilles tendon was primarily lengthened and in 2 feet of another idiopatic case Vulpius' gastrocnemius lenghtening technique was performed.In 8 feet of 4 cases temporary internal fixation was applied by Kirschner wires. At the end of the 6th week Kirschner wires were removed and a below leg walking cast was made.Because the calcaneus was very osteoporotic, in 2 feet of a patient with myelomeningocele, in return to the risk of graft to sink deep into the main fragments, two similar sized grafts were put on each other and were together impacted in the osteotomy site. In all of the other patients for both feet only one iliac crest was used as donor but in this patients both iliac crests were used to derive grafts. In 5 cases with cerebral palsy peroneus longus tendon was lengthened by Z-plasty.

Table 1. Clinical evaluation scale

Parameters	2 points	1 point	0 point
Pain	No	Mild	Severe
Family satisfaction (over 10 points)	10-8	6-7	<6
Subtalar motion	Moving	Limited	Rigid
Hindfoot (varus/valgus in frontal plan)	0°-5°	5°-10°	>10°
Hindfoot (sagittal plan)	Neutral	In mild equinus	In significant equinus
Forefoot (frontal plan)	Neutral	In mild supination/pronation	In significant supination/pronation
Forefoot (transverse plan)	Neutral	<5° abduction/adduction	>5° abduction/adduction
Medial longitudinal arc	Normal	Mild planus	Planus
Ability to walk on heels	Yes	With support	No
Improvement in standing/walking	Adequate	Fair	Inadequate

20-17 points: perfect, 16-14 points: good, 13-10 points: fair, <10 points: poor.

To evaluate patients post-operatively clinical and radiological evaluation scales were formed.Clinical evaluation was made over 10 parameter and 20 points according to forefoot alignment (neutral, adductus, abductus, supination, pronation), hindfoot alignment (neutral, varus, valgus, equinus), presence of pain pre and post-operatively, improvement in walking and standing, formation of medial longitudinal arc, subtalar motion, family satisfaction and ability to walk on heels.Results were classified as perfect, good, fair and poor (Table 1). Radiological evaluation was made by assessment of standart AP and lateral radiographies obtained in standing position.All of the radiographies were obtained with the companionship of the same orthopaedic crew and were also assessed by the same crew. Radiological assessment was consisted of 7 parameters which were directly associated with the deformity. These were AP and lateral talocalcaneal angle (the angle between the long axis of talus and the long axis of calcaneus), AP and lateral talus-first metatars angle (angle between the long axis of talus and the long axis of first metatars), calcaneal slope angle (in lateral plan, the angle between the line that is drawn along inferior cortex of calcaneus and the line that is drawn from lowermost point of calcaneus to the lowermost point of fifth metatars head), medial longitudinal arc angle (in lateral plan, the angle between the line that is drawn from the lowermost point of talar head to the lowermost point of the first metatars head and the line that is drawn from the lowermost point of talar head to the lowermost point of calcaneus), lateral talo-horizontal angle (The angle between the long axis of talus and the horizontal plan).[7,17,18] Calcaneal length (in lateral plan the length of calcaneus along its long axis in milimeters) was evaluated on pre and post-operatively obtained lateral radiographies. While the radiological evaluation scale was composed, Vanderwilde's statistical study on normal feet 17 was taken as a base and average values of the parameters and standart deviations were calculated for the age group of 5-10 years old children in which surgical procedure was applied the most. Remnant deformity and over correction were considered in the same clinical importance. Radiological evaluation was made according to 7 parameters and 21 points.Results were classified as perfect, good, fair and poor (Table 2). While the radiological evaluation was made the cases whose parameters were in 1 standart deviation (SD) were given 3 points, whose parameters were in 2 SD were given 2 points, whose parameters were in 3 SD were given 1 points.The cases whose parameters were outside 3 SD were given 0 point.Mann-Whitney U test was used to evaluate the results.$p<0.05$ value was considered meaningful in interpretation of the statistics.

Results

Clinical results were perfect in 17 feet (77.3%), good in three feet (13.6%), fair in one foot (4.6%),

Table 2. Radiographical values and statistical analysis.

Angular parameters	Normal population (average±SD)[14]	Pre-op Average	Pre-op Distribution	Post-op Average	Post-op Distribution	*p*
AP talocalcaneal angle (°)	39±6	34.1	18/46	23.1	15/34	<0.05
Lateral talocalcaneal angle (°)	44.5±5.5	53	33/66	42.8	28/62	<0.05
AP talus-first metatars angle (°)	15.5±6.5	-28.5	-11/-46	-6.2	0/-23	<0.05
Lateral talus-first metatars angle (°)	12±8.5	-32	-62/-5	-6.5	0/-30	<0.05
Calcaneal slope (°)	25±2	5.9	-6/16	21.1	11/35	<0.05
Talo-horizontal angle (°)	26.5±4	48.5	29/66	22.7	12/39	<0.05
Medial longitudinal arc (°)	127±3	154.9	144/168	133.9	115/146	<0.05
Calcaneal length (mm)	–	58.6	46/80	65.9	54/88	<0.05

(-) shows abduction in AP plan, dorsiflexion in lateral plan: (+) shows adduction in AP plan, plantarflexion in lateral plan.

and poor in one foot (Figure 2). Radiographically, five feet (22.7%), 13 feet (59.1%), and four feet (18.2%) were assessed as perfect, good, and fair, respectively (Figure 3).

An average of 7.3 mm (range 4 to 9 mm) of calcaneal lengthening was obtained.Over correction wasn't observed in any foot. Radiographically, union was achieved in all the patients after a mean of 7 weeks (range 6 to 8 weeks). Malpositioning of the

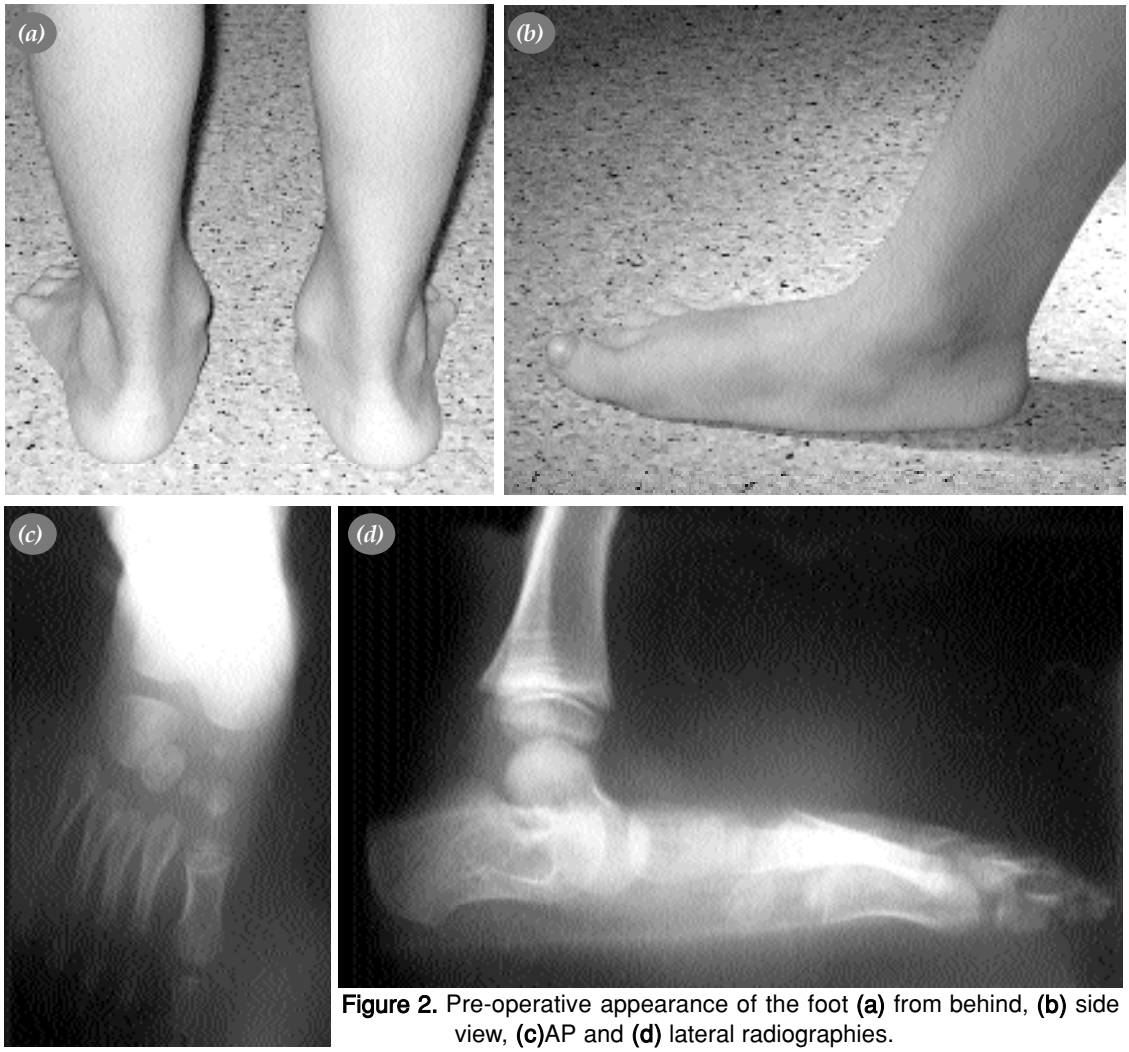

Figure 2. Pre-operative appearance of the foot **(a)** from behind, **(b)** side view, **(c)**AP and **(d)** lateral radiographies.

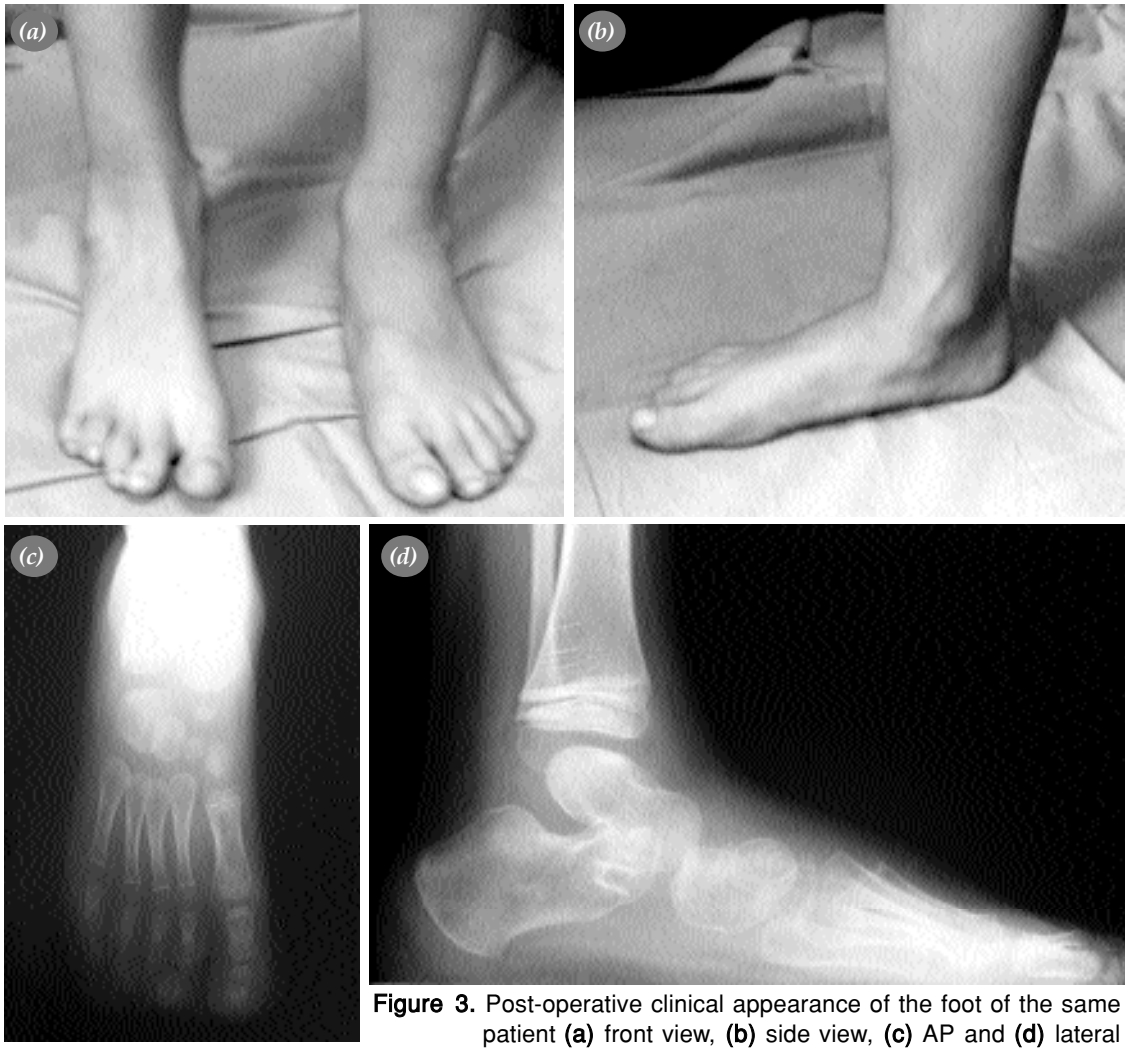

Figure 3. Post-operative clinical appearance of the foot of the same patient **(a)** front view, **(b)** side view, **(c)** AP and **(d)** lateral radiographies

graft did not occur.In any feet arthrosis in the adjacent joint wasn't observed, but in one feet of a 13 years old patient calcaneocuboid joint incongruity was noticed in early pre-operative period (Figure 4) A patient with triplegic cerebral palsy who was operated when she was 11 years old and who became able to walk supported when she was 9 years old was classified as good in both clinical and radiological evaluations but his gait was not satisfying and he could walk supported when one of his hands was held.Before surgery only 2 of 11 cases could walk unsupported and 3 of them could walk supported on their heels when their hands were held, After surgery, all of the patients except for the one with hereditary sensorymotor polineuropathy could walk on their heels unsupported.

This patient who was operated when he was 12 years old was the only patient which we were not satisfied on the results and who couldn't walk on his heels.At the end of the 15 months follow-up both feet was evaluated as fair radiologically, the right foot was evaluated as poor clinically and the left foot was evaluated as fair clinically.In this case planovalgus relapsed and deformity became rigid by time.Before surgery both feet were painful and after surgery pain relief was provided in the left foot. Although the other foot's results were fair both clinically and radiologically the patient was about to be evaluated as poor (clinical score 12, radiological score 17). Bilateral triple arthrodesis was planned in this patient.

Figure 4. Post-operative incongruity in calcaneocuboid joint in early post-operative period.

Discussion

Flexible PPV is a common deformity in children with neuromuscular disorders.It may be also present in normal children in lower grades.[1-4] Equinus, ligamentous laxity, presence of os tibiale externum, calcaneal valgus, femoral anteversion, internal tibial torsion, ankle valgus and extremity length discrepancy are the risk factors or the reasons of nonparalitic planovalgus deformities.[1,9]

M. triceps surae's or peroneal muscles' increased spasticity versus dorsiflexor muscle group's strength is typical in flexible PPV.Calcaneus shifts under talus by the shearing effect of M. triceps surae and forefoot abducts. In conclusion, deformity appears with plantar flexed talus, externally rotated and dorsiflexed calcaneus.[1-3,8,11,13] Forefoot is supinated according to hindfoot.Lateral column is shorter than the medial column.But also lateral column may be relatively short due to inappropriate talonavicular joint alignmen.[2,8] Prolonged extreme pronator forces result with insufficiency and a possible rupture in M. tibialis posterior tendon.This situation is termed as "posterior tibial tendon disfunction syndrome".[19]

For differential diagnose of skewfoot deformity hindfoot valgus, forefoot adduction and plantar flexion should be examined.[2,8,12]

In pes planovalgus, a wide spectrum of treatment options varying from application of a simple orthesis to artrodesis is possible.[1-3,8,10] First of all conservative methods should be applied, if this is insufficient then surgical treatment may be tried. Options for surgical treatment varies from simple soft tissue procedures to calcaneal osteotomy, subtalar extra-articular arthrodesis and triple arthrodesis.[1] Some techniques are identified for correction of planovalgus deformity but indications are not certainly determined.About many techniques good results in short term but poor results in long term are reported.[2,20]

Although results were successfull for the procedures applied to support medial longitudinal arc, high relapse rates of deformity and symptoms caused this procedures to be given up.[9,19] Isolated calcaneal deplacement osteotomies are successfull in correcting hindfoot valgus but in severe cases they are not sufficient to restore medial longitudinal arc.[14] Problems associated with limited arthrodesises in literature are widely reviewed and a common opinion to correct children foot deformities without application of arthrodesis is constituted.[2-4,11-13,18,21]

In our study we inspected the success of calcaneal lenghthening operations that we applied in 22 feet of 11 children with flexible PPV deformity due to various etiologies.

Calcaneal lenghthening operation was first identified by Evans and was introduced as an option for calcaneovalgus deformities due to various etiologies,instead of triple arthrodesis. This procedure clinically corrects both hind and midfoot and forms medial longitudinal arc. But it's not clear that with which mechanism this procedure achieved correction. Evans suggested that ideal age group for this technique was between 8 and 12 years old but that if the deformity was severe then

it could be applied in younger ages. In our cases the average age was between the limits that Evans suggested (10 years 10 months) Evans also claimed that when the procedure was applied in younger ages in severe cases sufficient correction might not be achieved and that the procedure might be needed to be repeated in older ages. In our study we didn't find any deformity that required to be reoperated in the follow-up period in any of our patients.

Evans, 3 claimed that extreme correction was not possible with this technique in patients with poliomyelitis and he added that it would be difficult to achieve adequate correction in the cases in which the lateral side of the food, included peroneal tendons couldn't be adequately released. We also stand for optimum soft tissue release and if needed lengthening of the peroneal tendons.But with this technique over correction is in direct proportion with the bulk of the graft and theoretically it is possible.We think that to avoid inadequate and over correction radiologic checkover should be done per-operatively.

Evans3 reported that this technique was contraindicated in neurological disorders like cerebral palsy and spina bifida, that overcorrection was often in spastic disorders and that the graft is prodisposed to be sunk into the main fragment in spina bifida because of the abnormal softness of the os calcanei. In present time this techique became possible to be applied successfully in neurological disorders. But Evans' warning on the graft's affinity to sink, in the cases like spina bifida in which os calcanei is too soft should be noticed. We think that osteotomy site shouldn't be retracted without adequate soft tissue release and that we may achieve the graft sinking by incresing the contact surface putting two seperate grafts on another as we did in a case with myelomeningocele.

Evans3 claimed that it was possible even in the cases with calcaneonavicular bar to achieve correction by soft tissue release. He reported that despite of poor correction, pain relief was gained and the patients felt their feet more comfortable compared with the cases that arthrodesis was performed. But he didn't inform about the long term results. Mosca used this technique in a case with talocalcanotarsal coalition and he reported that the pain and the callus under the talar head remained. He also reported that in only 6 of the 31 cases complete passive correction was gained pre-operatively, with this technique successful results were gained without taking into consideration of etology and the rigidity of the foot. 2 We cannot deliver an opinion on this subject because we atand for triple arthrodesis in rigid foot deformities. But we think that to use this technique in a rigid foot it was against the basic principles of the technique bcause theoretically it was impossible to achieve reduction in talonavicular joint.

Davitt et al 22 evaluated plantar pressure contribution and contact surface after calcaneal lengthening operation in children and adolescents and certifying the clinical correction they showed that contact surface in both hindfoot and forefoot and maximum mean pressure decreased in the medial side but increased in the lateral side and also that medial longitudinal arc was formed with all of the plantar pressure parameters that they have used.Because clinical and radiological datas are not always correlated and clinical appearance and function is usually subjectively evaluated in foot deformities maybe this study is the best one that reported the success of the technique with objective datas.

Ragab et al[10] showed anatomical variations in os calcaneus in their study on 1056 cadaver os calcanei based on the study that was made by Bunning ve Barnett in 1965 and they identified 5 different types of fascets.In this identification os calcanei were classified as type A (seperated anterior, mid and posterior fascets, 37%), type B (anterior and mid fascets are united, 46%), type C (all anterior, mid and posterior fascets are united, 0.2%, transitional type between type A and type B (12%), absence of anterior fascet (6%).

Authors suggested that this anatomical variation was not dependent on age and presence of the notch, that was seen in type A between anterior and mid fascets was not possible in typeB, in consequence this they sugeested that osteotomy may be performed intra-articularly and a relatively compatible joint would suffer.[10] In the same study

they claimed that calcaneal lengthening osteotomy was an effective method for the correction of the deformity but they couln't deliver an opinion on long term results.We think that several years period is needed for such an osteotomy to show alterations in subtalar joint both clinically and radiologically. Therefore patients should be selected carefully. Unique information about long term results of this technique is in Phillips' study in 1983, in which he reviewed the cases that were operated by Evans.In this study 23 cases were evaluated and the results were good in 15, fair in 3 and poor in 3. But evaluation was based on subjective parameters like patient satisfaction, relief of symptoms and clinical appearance and radiological evaluation was made classified as complete correction and acceptable partial correction instead of using angular parameters fo correction.

Clinical and radiological acceptability limits were not identified.It was reported that the poor results in 3 cases were not due to the technique but were due to progressive deformities dependent on different etiologies but no information was given about these etiologies. Also disorders like cerebral palsy and spina bifida were not included the study group.[23]

Yoo et al[5] classified clinical results as adequate and inadequate by assessing callus and pain comlaint, correction of forefoot abduction and hindfoot valgus, formation of medial longitudinal arc in a study that they evaluated 92 feet of 69 cases.In both groups a menaingful relation among preoperative correction degree and clinical results and radiological results. Meaningful inadequate result was obtained when talocalcaneal angle was less than 35 degrees, talus-first metatars angle was greater than 25 degrees and calcaneal slope angle was less than 5 degrees in standing lateral radiographies.

Our 1 poor, 1 fair, 2 good, 2 perfect cases were pre-operatively evaluated in similar values. Viegas[19] reported that he achieved meaningful correction in all clinical and radiological parameters after the combined surgery (Evans calcaneal lengthening osteotomy,achiloplasty, medial split tibialis anterior tendon transfer, calssical or modified Kidner procedure) he performed in 34 feet of 17 patients. When it is considered that medial soft tissue procedures might be performed solely in pes planovalgus it may be said that these procedures could increase the risk of relapse when performed together with evans osteotomy.

Cooper et al [24] suggested that risk of arthrosis in calcaneocuboid joint due to decreased pressure in the joint was a disadvantage for Evans osteotomy.But in a cadaver study no relation between calcaneal lengthening and decreased calcaneocuboid joint pressure was found.[19] In another cadaver study it was reported that graft size should be limited by 6 mm, and grafts with a size more than 6 mm had no additinal correction effect, and that bigger grafts caused pain in the lateral side of the foot by the strain effect over long plantar ligament.[16] Although all of the grafts we used in our study was bigger than 6 mm in size we experienced no pain complaint in any of the cases except for the one with the hereditary sensorymotor polineuropathy.Therefore we don't agree about the problems suggested[16] about the size of the graft. We also think that it is not possible to achieve adequate correction with a graft of 6 mm in size.However tis problem may cause a potential risk by means of arthrosis after calcaneocuboid joint subluxations that may occur during the distraction of the osteotomy site.

Mosca made modifications on skin incision, direction of the osteotomy, shape of the graft, application of internal fixation and soft tissue procedures respecting the main principles of the original technique and repoted successfull results in 29 of 31 cases that he performed modified Evans technique. He addressed technical fault (malposition of the the graft in early post-operative period and realisation of this after the union of the osteotomy site) in one case and extreme deformity in the other case as the reasons of the failure.

Since he considered ankle valgus alignment and external tibial torsion as the factors to increase deformity, Mosca[2] performed varus-derotation deformity in 8 of the 31 cases.However he didn't suggest the criterions for indication and that in which cases this procedure should be performed.We didn't need to perform varus-derotation osteotomy in any of our cases. Mosca[2] also

used allografts in 24 of 31 patients as prefered by the patient or his/her family and he reported that he didn't meet any problems in bone union in the osteotomy site. We used tricortical autograft derived from iliac crest in all of our cases.

One of the most important stages of this operation technique is achilloplasty and should be applied nearly in all of the cases.Equinus position of the foot should be evaluated after the insertion of the graft and should be corrected when the knee joint is in ful extension as at least 10 degrees of dorsiflexion is let, by Z-plasty applied to achilles tendon.[2-3] The surgeon should pay attention to cut the lateral half of distal part and to remain the medial part attached on calcaneus during Z-plasty.

In conclusion, a successful calcaneal lengthening osteotomi removes pain in symptomatic PPV, provides meaningful correction clinically and radiographically in both hindfoot and forefoot.Plantar pressure distribution studies show that plantar contact are shifts from medial to lateral side confirming the correction.[22] It is possible to gain clinical improvement even when radiographic parameter are evaluated as poor. In the flexible cases in which complete reduxion may be gained, the surgical technique may be applied easier and both clinical and radiological results are better.

The advantages of calcaneal lengthening osteotomy are being easy to be applied technically, low risk of giving harm to neurovascular structure and low loss of blood due to opportunity to use a tourniquet. It shouldn't be ignored that this osteotomy may cause problems especially in subtalar joint and it's hard to predict long term results. However maybe the most important advantage of this technique is that it lets other procedures to be applied in the future in the operated foot contrary to subtalar or triple artrodesis. In the future when artrodesis is required to be performed in these feet it will be far more easy to do because of the corrected alignment of the foot.

References

1. Zorer G, Bagatur AE, Dogan A, Unlu T. Dennyson-Fulford subtalar extra-articular arthrodesis in the treatment of paralytic pes planovalgus and its value in the alignment of the foot. [Article in Turkish] Acta Orthop Traumato Turc 2003; 37:162-9.
2. 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; 77:500-12.
3. Evans D. Calcaneo-valgus deformity. J Bone Joint Surg [Br] 1975;57:270-8.
4. Andreacchio A, Orellana CA, Miller F, Bowen TR. Lateral column lengthening as treatment for planovalgus foot deformity in ambulatory children with spastic cerebral palsy. J Pediatr Orthop 2000;20:501-5.
5. Clark GC. A modified Kidner procedure for symptomatic flat feet. Clin Orthop Relat Res 1988;(228):258-60.
6. Ragab AA, Stewart SL, Cooperman DR. Implications of subtalar joint anatomic variation in calcaneal lengthening osteotomy. J Pediatr Orthop 2003;23:79-83.
7. Mosca VS. Flexible flatfoot and skewfoot. J Bone Joint Surg [Am] 1995;77:1937-45.
8. Flexible flatfoot (pes planovalgus). In: Herring JA. Tachdjian's pediatric orthopaedics. Vol. 2, 3rd ed. Philadelphia: W. B. Saunders; 2002. p. 908-17.
9. Ritterbusch JF. Pediatric foot. In: Mizel MS, Miller RA, Scioli MW, editors. Orthopaedic knowledge update. Foot-ankle. Illinois: American Academy of Orthopaedic Surgeons; 1998. p. 65-78.
10. Murphy GA. Pes planus. In: Canale ST, editor. Campbell's operative orthopaedics. Vol. 4, 10th ed. St. Louis: Mosby; 2003. p 4025-27.
11. Koutsogiannis E. Treatment of mobile flat foot by displacement osteotomy of the calcaneus. J Bone Joint Surg [Br] 1971; 53:96-100.
12. Rathjen KE, Mubarak SJ. Calcaneal-cuboid-cuneiform osteotomy for the correction of valgus foot deformities in children. J Pediatr Orthop 1998;18:775-82.
13. Dinucci KR, Christensen JC, Dinucci KA. Biomechanical consequences of lateral column lengthening of the calcaneus: Part I. Long plantar ligament strain. J Foot Ankle Surg 2004;43:10-5.
14. Vanderwilde R, Staheli LT, Chew DE, Malagon V. Measurements on radiographs of the foot in normal infants and children. J Bone Joint Surg [Am] 1988;70:407-15.
15. Viegas GV. Reconstruction of the pediatric flexible planovalgus foot by using an Evans calcaneal osteotomy and augmentative medial split tibialis anterior tendon transfer. J Foot Ankle Surg 2003;42:199-207.
16. Davitt JS, MacWilliams BA, Armstrong PF. Plantar pressure and radiographic changes after distal calcaneal lengthening in children and adolescents. J Pediatr Orthop 2001;21:70-5.
17. Yoo WJ, Chung CY, Choi IH, Cho TJ, Kim DH. Calcaneal lengthening for the planovalgus foot deformity in children with cerebral palsy. J Pediatr Orthop 2005;25:781-5.
18. Hadley N, Rahm M, Cain TE. Dennyson-Fulford subtalar arthrodesis. J Pediatr Orthop 1994;14:363-8.
19. Grace DL, Cracchiolo A 3rd. A method of evaluating the results of forefoot surgery. Clin Orthop Relat Res 1985; (198): 208-18.
20. Hensinger RN. Standards in pediatric orthopedics: tables, charts, and graphs illustrating growth. New York: Raven Press; 1986.
21. Mosca VS. Flexible flatfoot and tarsal coalition. In: Richards BS, editor. Orthopaedic knowledge update: pediatrics. Illinois: American Academy of Orthopaedic Surgeons; 1996. p. 211-17.
22. Cooper PS, Nowak MD, Shaer J. Calcaneocuboid joint pres-

sures with lateral column lengthening (Evans) procedure. Foot Ankle Int 1997;18:199-205.
23. Jones BS. Flat foot. A preliminary report of an operation for severe cases. J Bone Joint Surg [Br] 1975;57:279-82.
24. Phillips GE. A review of elongation of os calcis for flat feet. J Bone Joint Surg [Br] 1983;65:15-8.