ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Author's translation
Acta Orthop Traumatol Turc 2008;42(1):44-52

Long-term results of extensive surgical dissection in the treatment of congenital clubfoot

Doğuştan çarpık ayak tedavisinde geniş cerrahi diseksiyonun uzun dönem sonuçları

Gokmen DENIZ, Hasan BOMBACI, Hakan TUYGUN, Mucahit GORGEC, Ozkan KOSE,[1] H.Serhat YANIK

Haydarpasa Numune Training and Research Hospital, 1st. Orthopedics and Traumatology Clinic,[1] 2nd Orthopedy and Traumatology Clinic

Amaç: Doğuştan çarpık ayak nedeniyle geniş cerrahi diseksiyon ile tedavi edilen hastaların geç dönem fonksiyonel ve radyografik sonuçları değerlendirildi.

Çalışma planı: Çalışmada, doğuştan çarpık ayak için geniş cerrahi diseksiyon uygulanan 30 çocuğun (6 kız, 24 erkek; ort. yaş 9.8 ay) 47 ayağı incelendi. On yedi hastanın her iki ayağında deformite vardı. Otuz beş ayağa komplet subtalar gevşetme (KSTG), 12'sine posteromedial gevşetme (PMG) uygulandı. Ameliyat sırasında ortalama yaş KSTG grubunda 9.6 ay (dağılım 6-23 ay), PMG grubunda 10.6 ay (dağılım 5-23 ay) idi. Hastalar Laaveg-Ponseti fonksiyon değerlendirme skoru, ayak bimalleolar açısı ve radyografik ölçümlerle değerlendirildi. Ortalama takip süresi 117.3 ay (KSTG grubunda 106.6 ay, PMG grubunda 150.6 ay) idi.

Sonuçlar: Fonksiyon değerlendirmesinde, 47 ayağın 24'ünde mükemmel, 12'sinde iyi, altısında orta, beşinde kötü sonuç alındı. Kötü sonuç alınan beş ayağın hepsi KSTG grubunda idi. Bu ayakların ikisinde nüks gelişirken, iki ayakta kavus ve metatarsus adduktus deformiteleri, bir ayakta kavus deformitesi vardı. Ayak bimalleolar açısına göre değerlendirildiğinde, PMG uygulanan ayakların %83.4'ü, KSTG uygulananların %85.7'si tip 1-2 grubu içinde yer aldı. Ayak bimalleolar açısı, ön-arka ve yan grafilerde talus-birinci metatars açısı ve ön-arka grafide talokalkaneal açı ile ayak fonksiyon skoru arasında anlamlı ilişki saptandı ($p<0.05$). İki cerrahi yöntem arasında fonksiyonel skorlar ve radyografik ölçümler açısından anlamlı fark bulunmadı ($p>0.05$).

Çıkarımlar: Geniş cerrahi diseksiyon deformitenin tüm bileşenlerinin bir seansta düzeltilmesini sağlayan, sonuçları erken dönemde olduğu gibi uzun dönemde de başarılı olan bir yöntemdir.

Anahtar sözcükler: Çocuk; çarpık ayak/radyografi/cerrahi.

Objectives: We evaluated the long-term functional and radiographic results of patients who underwent extensive soft tissue dissection for the treatment of congenital club foot.

Methods: We retrospectively evaluated 47 feet of 30 patients (6 girls, 24 boys; mean age 9.8 months) who underwent extensive surgical dissection for congenital clubfoot. Involvement was bilateral in 17 patients. Surgical dissection included complete subtalar release (CSTR) in 35 feet, and posteromedial release (PMR) in 12 feet. The mean age was 9.6 months (range 6 to 23 months) in CSTR-, and 10.6 months (range 5 to 23 months) in PMR-treated patients. The patients were assessed with the Laaveg-Ponseti functional score, foot bimalleolar angle, and other radiographic measurements. The mean follow-up was 117.3 months (106.6 months in the CSTR, and 150.6 months in the PMR group).

Results: Functional results were excellent in 24 feet, good in 12 feet, fair in six feet, and poor in five feet. All the poor results were seen in the CSTR group. Of these five feet, two developed recurrences, two had both pes cavus and metatarsus adductus deformities, and one had pes cavus deformity. Considering the foot bimalleolar angle, 83.4% of PMR-treated feet, and 85.7% of CSTR-treated feet were rated as type 1 or 2. Functional scores were significantly correlated with the foot bimalleolar angle, talus-first metatarsus angle on anteroposterior and lateral radiographs, and with the talocalcaneal angle on anteroposterior radiographs ($p<0.05$). There were no significant differences between the two surgical procedures with respect to functional scores and radiographic measurements ($p>0.05$).

Conclusion: Extensive surgical dissection enables simultaneous correction of all components of deformity and provides satisfactory results not only in the short-term but also in the long-term follow-up.

Key words: Child; clubfoot/radiography/surgery.

Correspondence / *Yazışma adresi:* Dr. Gokmen Deniz. Haydarpasa Numune Training and Research Hospital, 1st Orthopedy and Traumatology Clinic, 34717 Uskudar, Istanbul. Phone: +90216 - 414 45 02 / 1595 Fax: +90216 - 345 61 81 e-mail: drgokmendeniz@yahoo.com

Submitted / *Başburu tarihi:* 08.03.2007 **Accepted / *Kabul tarihi:*** 26.01.2008

Clubfoot is a congenital foot deformity with an incidence of 1-5/1000. The goals of treatment are to obtain a plantigrade, pain-free, flexible foot that does not require the use of orthotics. Widely accepted approach is to start a conservative clubfoot treatment as early as possible[1] It is widely accepted that , clubfoot treatment should start as early as possible with a conservative method.

Successful results between 20% to 95% have been reported with conservative treatment.[1-4] In case of failure of initial approach or if there is recurrence, the conservative tretament can either be repeated or surgical treatment can directly be performed. Surgical treatment includes simple procedures such as posterior release and selective tendon transfers or extensive procedures such as complete subtalar release (CSTR) or posteromedial release (PMR) depending on the patient's condition.

Coronal, sagittal and horizontal plane deformities are present in congenital clubfoot. These deformities are inter-related. Simultaneouscorrection of all deformities is a preffered property of the surgical technique. Extensive surgical procedures, such as complete subtalar release, aimed to correct this three-planar deformity in one session. While correction can be achieved with these types of procedures, serious complications such as wound necrosis, extensive scarring, and avascular necrosis of tarsal bones may arise. Several studies have evaluated short-term results of extensive surgical procedures in the treatment of congenital clubfoot, While some refer successful outcomes, others describe serious complications. Excellent to good short-term results have been reported in 63% to 83% of congenital clubfoot cases treated with extensive surgical dissection.[5-8] Nonetheless, Dobbs et al.[9] obtained moderate and poor long-term results by extensive surgical dissection in 67% of 60 feet Moreover, he had to re-oprate 55 feet.

Despite numerous short-term reports of cases treated with extensive dissection, few studies regarding long-term results have been published. Long-term functional and radiographic outcomes of patients treated with posteromedial and complete subtalar releases have been evaluated in this

Patients and method

A total of 50 patients with congenital clubfoot that failed to respond to conservative treatment by plaster casting were operated between September 1990 and March 1998 in our clinic. Patients were retrospectively evaluated. Preoperative treatment method, preoperative condition of the foot, surgery, and follow-up information until discharge were obtained from patient files in the hospital records. Since 11 of them were older than 2 years at time of operation and 2 had meningomyelocele, they were excluded from the study. The common features of the remaining 37 patients were idiopathic congenital clubfoot, age below 2 years at the time of surgery, and a minimum 4-year follow-up. Positive response to our request was acquired for 30 of these patients (6 girls, 24 boys; mean age of 9.8 months), who were included in the study (Table 1). The number of evaluated feet was 47.

Bilateral deformity was present on 17 patients while right and left deformities were present on 9 and 4 patients, respectively. CSTR was performed on 35 feet and PMR on 12. Mean age at time of operation was 9.6 months (range: 6-23 months) in the CSTR group, and 10.6 months (range: 5-23 months) in the PMR group. Age distribution at time of operation was similar in two groups.

PM incision and release method was used as described by Turko.[4] Cincinnati incision and the method described by Simons was performed on patients operated by CSTR (Figure 1).[10] Prophylactic first generation cephalosporins were administered to all patients from 30 minutes prior to surgery until 2nd postoperative day. Antero-posterior and lateral foot x-rays were also obtained postoperatively. No window was placed in casting after PMR. First cast change was performed at postoperative 3rd week under general anesthesia and sutures were removed. Second cast change took place on the 6th week at the outpatient clinic and wires were withdrawn. Casting was maintained for two months. It was performed above-knee, with 90 degrees of knee flexion, 0-10 degrees of ankle dorsiflexion and without forcing any varus or valgus angulation.

Table 1. Distribution of patients' characteristics according to surgical procedures

	PMR	CSTR	Total
Number of feet involved	12	35	47
Bilateral involvement (patients)	4	13	17
Mean age at time of operation (months)	10.6	9.6	9.8
Mean follow-up duration (month)	150.6	106.6	117.3
Number of male patients	5	19	24
Number of female patients	3	3	6

PMR: Posteromedial release; CSTR: Complete subtalar release

Table 2. Functional assessment

Characteristic	Score
Ankle passive range of motion	
>20° from neutral	15
>10° from neutral	10
0°-10° from neutral	0
Subtalar joint motion	
>15°	10
<15°	5
Rigid, no motion	0
Position of heel while standing	
0° to 5° valgus	10
>5° valgus	5
Varus	0
Position of forefoot	
Neutral	10
<5° adduction or abduction	5
>5° adduction or abduction	0
Gait	
Ability to walk on heels and toes	10
Inability to walk on heels	6
Inability to walk on toes	6
Flat feet	5
Radiography	
Talocalcaneal index >40	5
Talocalcaneal index <40	0
Talus-first metatarsal angle <10°	5
Talus-first metatarsal angle >10°	0
Shoe	
Normal shoe (no problem)	5
Normal shoe (problem)	3
Orthopedic shoe, brace	0
Patient functions	
Unaffected	15
Rarely affected	8
Frequently affected	0
Pain	
Absent	10
Occasional	5
Always	0
Flexor tendons	
Full function	5
Partial function	2
No function	0

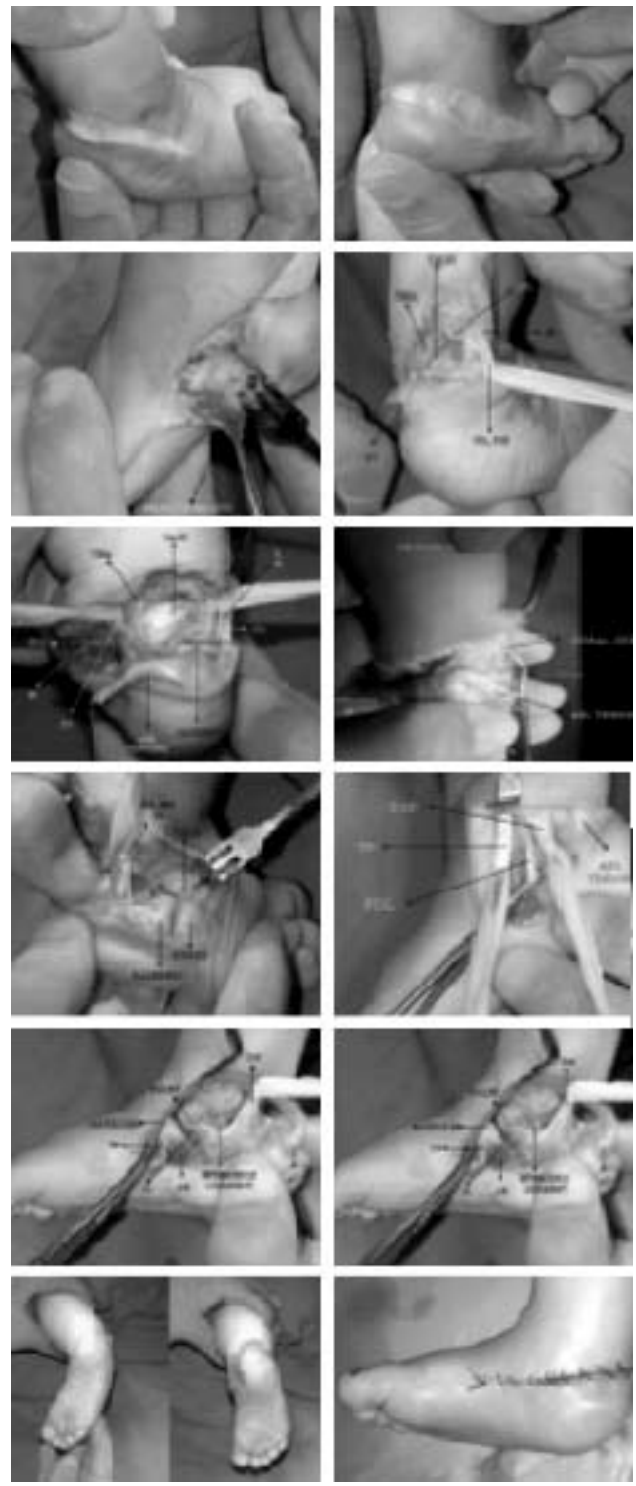

Figure 1. Incision, medial superficial, posterior, lateral, deep, superficial release and fixation by K-wire stages in patients for whom complete subtalar release was performed.

During the first casting, after CSTR, the deformity was corrected as much as the skin tightness permitted. No window was placed in the cast. Cast change was performed on the 2nd week. The residual equine deformity was corrected at first cast change. Casting was always made above-knee. Wires were removed on the 6th week. After casting period, in addition to exercises, all patients were asked to use a thermoplastic orthosis for 6

Figure 2. Foot motions in a patient 8 years and 5 months after the complete subtalar release.

weeks to maintain reduction, which extended from the Achilles tendon to the distal part of first metatarsal, and kept the foot at neutral position, supporting the medial arch. Plain orthopedic boots to wear until school-age were also prescribed.

Functional evaluation score described by Laaveg and Ponseti and modified by Cummings was used to assess all patients (Table 2). [1] Foot bimalleolar angle and radiographic measures were also used. Clinical evaluation of all patients was performed by the same investigator (GD) (Figure 2 and 3). Scores between 85 and 100 points were considered as excellent, 70 and 84 as good, 60 and 69 points as moderate, and below 59 as poor.[1] Foot bimalleolar angle was measured and the results were graded in four categories from good to poor: [8] (i) 75-85°; (ii) 70-74° or 86-90°; (iii) 65-69°or >90°; (iv) <65°. Radiographic evaluation was performed on anteroposterior and lateral foot x-rays, obtained prior to surgery, at first postoperative day and at final assessment. Talus-first metatarsal angle and talocalcaneal angle were measured on these radiographs by the same investigator (GD).

CSTR and PMR groups were compared in statistical analysis. The relationship of foot function score with foot bimalleolar angle and radiographic measurements were analyzed. Pearson chi-square, Fisher exact test and Mann-Whitney U-test were applied. P values of <0.05 were considered as significant. Statistical analyses were done by using SPSS 10.0 for Windows.

Results

Mean follow-up duration of all patients was 117.3 months. Mean follow-up duration was 150.6 months in posteromedial release group, and 106.6 months in CSTR group. There was a significant difference between two groups in terms of follow-up durations ($p<0.05$).

Function evaluation of 47 feet was resulted in excellent score in 24, good score in 12, moderate score in 6 and poor score in 5 (Table 3). There was no significant difference between the two groups in terms of functional scores ($p>0.05$). Nevertheless, all of the five feet with poor functional outcome were in the CSTR group. Patients with poor outcome referred pain during activity and inability to participate in sports. None of them needed to use special shoes. Recurrence was noted in two feet with poor functional scores and plantigrade positioning was observed on two feet with cavus and metatarsus adductus deformities. There was only cavus deformity in one foot.

According to foot bimalleolar angle, 83.4% of PMR-treated feet, and 85.7% of CSTR-treated feet were classified as types 1 and 2 (Table 3). Of the 47 feet, 29 (61.7%) were type 1, 11 (23.4%) were type 2, 4 (8.5%) were type 3, and 3 (6.4%) were type 4. All of type 4 feet had poor functional scores whereas the type 3 feet showed different scores: two had poor, one had moderate, and one had good functional outcome. No significant correlation was found between surgery type and function score ($p>0.05$). However, there was a sig-

Figure 3. Foot motions in a patient 15 years after the posteromedial release.

Table 3. Distribution of functional assessment scores, foot bimalleolar angle in antero-posterior radiography and talus -1st metatarsal angle and lateral talocalcaneal angle results according to surgical procedures

	PMR		CSTR		Total	
	Number	%	Number	%	Number	%
Functional assessment						
Excellent (85-100)	8	66.7	16	45.7	24	51.1
Good (70-84)	1	8.3	11	31.4	12	25.5
Modest (60-69)	3	25.0	3	8.6	6	12.8
Poor (<69)	–	–	5	14.3	5	10.6
Foot bimalleolar angle						
Type 1 (75°- 85°)	5	41.7	24	68.6	29	61.7
Type 2 (70°-74°)-(86°-90°)	5	41.7	6	17.1	11	23.4
Type 3 (65°-69°)-(>90°)	2	16.7	2	5.7	4	8.5
Type 4 (<65°)	–	–	3	8.6	3	6.4
Talus-first metatarsal angle on antero-posterior radiography						
0°-(-20°)	11	91.7	30	85.7	41	87.2
<-20°	1	8.3	5	14.3	6	12.8
>0°	–	–	–	–	–	–
Lateral talocalcaneal angle						
<25°	2	16.7	6	17.1	8	17.0
25°-65°	10	83.3	29	82.9	39	83.0
>65°	–	–	–	–	–	–

PMR: Posteromedial release

CSTR: Complete subtalar release.

nificant correlation between foot bimalleolar angle and foot function score ($p<0.05$). The talus-first metatarsal angle on antero-posterior x-ray was measured between 0° and -20° in 41 feet (Table 3). No significant differences were found between surgical methods performed in terms of talus-first metatarsal angle ($p>0.05$). When the talocalcaneal angle on antero-posterior x-ray was examined, it was found that 11 of the 12 PMR-treated feet and 26 of the 35 CSTR-treated feet were within the normal range limits, as described by Simons. The angle was under -20° in four out of five feet with poor functional outcome, and was within normal range limits in only one foot. Functional outcome was excellent in one, good in two, and moderate in three feet with angles greater than 40°.

When talus-first metatarsal angle was assessed by lateral x-ray, it was observed that greater navicular luxations were present in terms of number and angular value in CSTR-treated feet. When the effect of talus-first metatarsal angle on foot function was assessed by lateral x-ray, the functional outcome was either excellent or good in 32 of the 35 feet with angles inferior to 20°. In five feet with poor outcome, the angle was above 30°. Significant correlation was found between foot function evaluation scores and whether or not the talus-first metatarsal and the talocalcaneal angles on antero-posterior x-ray as well as the talus-first metatarsal angle on lateral x-ray were within normal limits ($p<0.05$). There was no significant correlation between functional score and talocalcaneal angle on lateral x-ray whether or not it was within normal limits ($p>0.05$). No significant differences were found between surgical methods' results according to four radiographic measurements. In eight feet with cavus deformity, the navicular bone was displaced both dorsally and laterally with an accompanying metatarsus adductus deformity, and the navicular bone appeared as an inverse triangle on lateral x-ray (Figure 4). Furthermore, the forefoot was in supination from the talonavicular joint compared to the hindfoot. Out of 35 feet for which CSTR was performed, medial column lengthening, lateral column shortening and navicular bone reduction were carried out five years later in two cases due to recurrence. Improvement of functional score from poor to good was observed three years after the 2nd surgery. Debridement was performed after superfi-

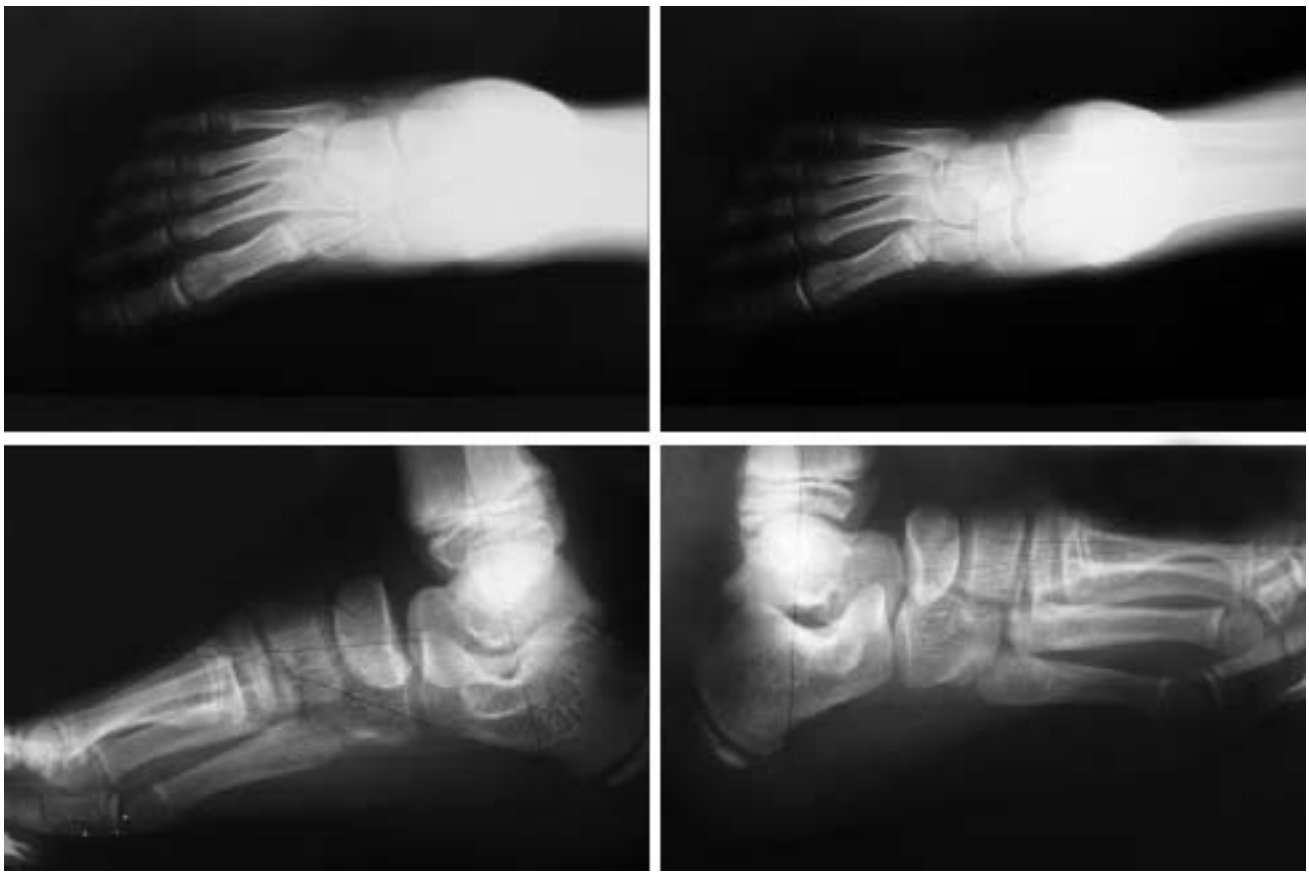

Figure 4. Radiographs of a patient taken 9 years after the bilateral complete subtalar release.

cial necrosis and infection development in one foot that underwent PMR, 30 days folowing the procedure. The most frequently observed treatment complications were metatarsus adductus, cavus and pes planus. Further surgical interventions were planned for five feet with poor and three feet with moderate outcomes.

Discussion

Congenital clubfoot is an abnormality of all tissues distal to the knee, which causes adduction, supination, varus and equinism deformities [2,4] It is one of the most common congenital abnormality. The aim of long-term management is to achieve a functional, pain-free, cosmetically acceptable, and mobile close to normal foot that does not require orthotics. There is a consensus on the selection of conservative treatment as the first approach. Recently, successful results on long-term follow-up have been reported by the Ponseti method.[11] Surgical treatment is usually performed in late cases and in failure of conservative methods. The general principle in surgical treatment is to avoid multiple procedures, to achieve full reduction at a first attempt, and to preserve it in the long run. Complications risk increases with successive surgical interventions due to the scarring resultant from the previous surgical procedure. Functionally and cosmetically poor results can be obtained due to excessive scar formation and longer immobility detection period. Therefore, CSTR technique has become more widely used than the PMR, which is a more limited approach. However, its extensive dissection has led to a complication increase. In the present study, these two techniques were compared in terms of functional outcome and complications. The differences in the number of cases and follow-up duration between the two groups are a result of the progressive general tendency to perform CSTR more frequently. Regarding the best timing for surgical treatment, it has been reported that since bone deformities are better corrected when foot development is returned to normal and early reduction is performed, this approach is recommended at two months to establish reduction in cases who fail to respond to conservative treatment. [8,12] It has been demonstrated that better results are obtained when posterior or PM release are performed in patients younger than six months compared to older ones.[13,14] However, it has also been suggested that early surgical treatment lead to severe

fibrosis and development of a rigid foot; thus, surgeries should be executed between 12 and 24 months after the infant has begun walking so that recurrences can also be prevented.[1,4,8,15] According to Simons perspective, foot size is more important than patient's age; foot size below 8 cm causes difficult and traumatic dissection; therefore, it should be waited for the foot to grow bigger than 8 cm.[16] DePuy and Drennan[17] divided 44 feet treated by PMR into 3 groups which were operated on the 4th, 9th, and 16th months. They did not find significant functional or radiographic differences between the groups. Nevertheless, less tarsal-bone deformities were observed in the early-operated first group, compared to the other two groups. In the present study, patients were first treated with conservative method. During this treatment, infants older than 3 months were reassessed in order to decide whether or not to continue a conservative approach or to perform surgical treatment and the type of procedure. Surgery was planned according to the time where the feet reached 8 cm. The mean age of patients was 10.6 months in the PMR-treated group, and 9.6 months in the CSTR-treated group. The youngest patient under surgical treatment was 5 months old. Bimalleolar angle was classified as type 1 in 45.8% of the feet that were operated before nine months and in 80% of those that were operated after nine months. There was no significant difference in function evaluation scores of those operated before or after nine months of age. The finding that functional evaluation score was not influenced by age at time of operation confirms the opinion that foot size is more important than patient's age for surgery timing.

Three different types of incisions can be used in extensive surgical dissection techniques. They are Cincinnati, Turco and Carroll incisions. Cincinnati incision, which was preferred to use in children of less than 2 years old for congenital clubfoot, provides an extensive surgical field for direct visualization of all pathologies. Despite being cosmetically acceptable, it has been suggested that it might lead to insufficient Achilles tendon release.[6,8,12,18-20] Kalenderer et al.[21] have observed superficial wound necrosis in 25% of their cases and reported that they had difficulty in performing Achilles tendon release. Karakurt et al. [22] described skin necrosis in 15% and deep necrosis including Achilles tendon in 6%. Recommendations to prevent wound necrosis include preoperative use of soft tissue expander by Rosselli et al. [23], partial wound closure by Ferlic et al.[19], and wound closure by fasciocutaneous graft by Lubicky and Altıok.[24] In order to prevent necrosis, Uglow and Clarke [25] first performed plantar and medial release, which was followed by posterolateral release a week later. No necrosis occurred in any of the 91 feet. Additionally, recurrence was present in 20.4% of the grade 3, and in 65.4% of the grade 4 feet according to Dimeglio's classification. In the present study, Cincinnati incision was adopted for all patients treated with CSTR and no necrosis occurred. No difficulties were encountered in any patients while performing Achilles tendon release. In order to prevent superficial or deep wound necrosis, we paid much attention to preserve subcutaneous fat tissue, to handle cutaneous or subcutaneous fat tissue by smooth surgical instruments, and to release the tourniquet at the end of operation for good bleeding control. It is believed that wound necrosis risk is reduced by using continuous suture during skin closure (During continuous suture procedure, the sutures are first loosened until wound-edge discoloration disappears -until circulation is provided- and then the last knot is tied.), leaving full correction of equine deformity until the time of cast change and not opening a cast window (opening a cast window may cause edema of wound edges, which can impair local blood flow.). Laaveg-Ponseti functional scoring system is based on patient's satisfaction, pain, appearance, foot-ankle range of motion, and functionality.[26] Cummings has also added talocalcaneal index and talus-first metatarsal angles to this system.[1] We adopted the scoring system described by Cummings considering it also includes radiographic abnormalities, which may later lead to further functional loss. Excellent and good short-term results have been reported in congenital clubfoot in 71% of the cases by McKay[5], in 72% of the cases by Simons[6], in 69% of the cases by Rumyantsev and Ezrohi[20], in 83% of the cases by Centel et al.[7], in 63% of the cases by Magone et al.[8], and in 84% of the cases by Turco[15], which were treated by extensive surgical dissection. Dobbs et al.[9] evaluated the long-term results of 60 feet treated with extensive surgical dissection and 14 feet treated with only posterior and plantar release. Although adequate correction was thought to be achieved in the extensive surgical dissection group at first attempt, multiple interventions were needed during follow-up in 55 feet. These second interventions were generally performed in early adolescence. Moderate and poor outcomes were noted in 67% of the patients in the mentioned study, and poor outcome was found to be significantly correlated with surgical technique and amount of dissection. In this study,

by the end of a 10-year average follow-up, functional outcome was excellent and good in 76.6%, moderate in 12.8%, and poor in 10.6% of the feet treated by extensive surgical dissection. Measurement of foot bimalleolar angle is an objective, simple and effective method for foot classification prior to treatment and evaluation of its results in congenital clubfoot.[27] Simons[10] and Turco [15] have related toe-in gait without metatarsus adductus deformity to posterior displacement of lateral malleolus. Drvaric et al. [28] named it as "persistent medial spin" and stated that it occurred more frequently following Turco surgeries. McKay [12] suggested that foot bimalleolar axis should be adjusted to 90 degrees before subtalar wire fixation. Carroll [29] recommended that, after wound closure, the foot should be casted in external rotation according to malleolus direction. As described by McKay, when the foot is set free after the correct bimalleolar angle is achieved, subtalar fixation using wires should be performed. [12] Magone et al.[8] detected that all patients treated with CSTR, and 70% of the patients treated with PMR had type 1-2 feet. In the present study, foot bimalleolar angle was type 1 or 2 in 85.1% of the feet. Moreover, a significant correlation between foot bimalleolar angle and foot function score was observed. We believe that foot bimalleolar axis is an easily applicable and objective assessment method as well as an important parameter for foot function.

No significant differences were observed between the two surgical methods in terms of functional and radiographic measures in the present study. The preferred application of CSTR is associated with this technique familiarity by the team as well as our belief that anatomical structures are better exposed by this method, which also leads to less medial cutaneous necrosis. In addition to the traditional PMR incisions, the lateral subtalar capsule, calcaneofibular ligament and lateral portion of the talonavicular joint are also incised in CSTR. Since our cases had deformities of idiopathic nature, had no previous treatment by plaster casting, and underwent surgery before two years of age, the achieved advantages were less than expected in lateral release.

In conclusion, extensive surgical dissection is a treatment method which provides an opportunity to correct all components of the deformity on the same session, with successful mid- and long-term results, in those feet which fail to respond to conservative treatment. However, it should be performed by experienced surgeons owing to the difficulty of the surgical technique and possible risk of significant complications. Foot size is crucial for surgery-timing determination. Foot bimalleolar angle is a useful radiographic follow-up measure to be used in feet treated by extensive surgical dissection.

References

1. Cummings RJ, Davidson RS, Armstrong PF, Lehman WB. Congenital clubfoot. J Bone Joint Surg [Am] 2002; 84:290-308.
2. Kite JH. Nonoperative treatment of congenital clubfoot. Clin Orthop Relat Res 1972;(84):29-38.
3. Souchet P, Bensahel H, Themar-Noel C, Pennecot G, Csukonyi Z. Functional treatment of clubfoot: a new series of 350 idiopathic clubfeet with long-term follow-up. J Pediatr Orthop B 2004;13:189-96.
4. Herring JA. Disorders of the foot. In: Tachdjian's pediatric orthopaedics. 3rd ed. Philadelphia: W. B. Saunders; 2002. p. 922-59.
5. McKay DW. New concept of and approach to clubfoot treatment: Section III - evaluation and results. J Pediatr Orthop 1983;3:141-8.
6. Simons GW. Complete subtalar release in club feet. Part II-Comparison with less extensive procedures. J Bone Joint Surg [Am] 1985;67:1056-65.
7. Centel T, Bagatur AE, Ogut T, Aksu T. Comparison of the soft-tissue release methods in idiopathic clubfoot. J Pediatr Orthop 2000;20:648-51.
8. Magone JB, Torch MA, Clark RN, Kean JR. Comparative review of surgical treatment of the idiopathic clubfoot by three different procedures at Columbus Children's Hospital. J Pediatr Orthop 1989;9:49-58.
9. Dobbs MB, Nunley R, Schoenecker PL. Long-term follow-up of patients with clubfeet treated with extensive soft-tissue release. J Bone Joint Surg [Am] 2006;88:986-96.
10. Simons GW. Complete subtalar release in club feet. Part I. A preliminary report. J Bone Joint Surg [Am] 1985;67: 1044-55.
11. Siapkara A, Duncan R. Congenital talipes equinovarus: a review of current management. J Bone Joint Surg [Br] 2007; 89:995-1000.
12. McKay DW. New concept of and approach to clubfoot treatment: section II - correction of the clubfoot. J Pediatr Orthop 1983;3:10-21.
13. Franke J, Hein G. Our experiences with the early operative treatment of congenital clubfoot. J Pediatr Orthop 1988;8:26-30.
14. Main BJ, Crider RJ, Polk M, Lloyd-Roberts GC, Swann M, Kamdar BA. The results of early operation in talipes quino-varus. A preliminary report. J Bone Joint Surg [Br] 1977;59:337-41.
15. Turco VJ. Resistant congenital club foot-one-stage posteromedial release with internal fixation. A follow-up re-

port of a fifteen-year experience. J Bone Joint Surg [Am] 1979;61:805-14.
16. Simons GW. The complete subtalar release in clubfeet. Orthop Clin North Am 1987;18:667-88.
17. DePuy J, Drennan JC. Correction of idiopathic clubfoot: a comparison of results of early versus delayed posteromedial release. J Pediatr Orthop 1989;9:44-8.
18. Crawford AH, Marxen JL, Osterfeld DL. The Cincinnati incision: a comprehensive approach for surgical procedures of the foot and ankle in childhood. J Bone Joint Surg [Am] 1982;64:1355-8.
19. Ferlic RJ, Breed AL, Mann DC, Cherney JJ. Partial wound closure after surgical correction of equinovarus foot deformity. J Pediatr Orthop 1997;17:486-9.
20. Rumyantsev NJ, Ezrohi VE. Complete subtalar release in resistant clubfeet: a critical analysis of results in 146 cases. J Pediatr Orthop 1997;17:490-5.
21. Kalenderer O, Aguş H, Ak M, Ozluk S. Correlation of clinical and radiologic results of complete subtalar release in congenital clubfoot. [Article in Turkish] Acta Orthop Traumatol Turc 2003;37:368-73.
22. Karakurt L, Yilmaz E, Inci M, Serin E, Ozturk M. Early results of complete subtalar release in congenital clubfoot deformity. [Article in Turkish] Acta Orthop Traumatol Turc 2003;37:53-62.
23. Rosselli P, Reyes R, Medina A, Cespedes LJ. Use of a soft tissue expander before surgical treatment of clubfoot in children and adolescents. J Pediatr Orthop 2005;25:353-6.
24. Lubicky JP, Altiok H. Regional fasciocutaneous flap closure for clubfoot surgery. J Pediatr Orthop 2001;21:50-4.
25. Uglow MG, Clarke NM. Relapse in staged surgery for congenital talipes equinovarus. J Bone Joint Surg [Br] 2000; 82:739-43.
26. Laaveg SJ, Ponseti IV. Long-term results of treatment of congenital club foot. J Bone Joint Surg [Am] 1980;62:23-31.
27. Jain AK, Zulfiqar AM, Kumar S, Dhammi IK. Evaluation of foot bimalleolar angle in the management of congenital talipes equinovarus. J Pediatr Orthop 2001;21:55-9.
28. Drvaric DM, Kuivila TE, Roberts JM. Congenital clubfoot. Etiology, pathoanatomy, pathogenesis, and the changing spectrum of early management. Orthop Clin North Am 1989;20:641-7.
29. Carroll NC, McMurtry R, Leete SF. The pathoanatomy of congenital clubfoot. Orthop Clin North Am 1978;9:225-32.