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The results of the Grice subtalar extra-articular arthrodesis for pes planovalgus deformity in patients with cerebral palsy

Pes planovalguslu serebral felçli olgularda Grice subtalar eklem dışı artrodezinin sonuçları

Melih Guven[1], Abdullah Eren[1], Budak Akman[1], Koray Unay[2], Namık Kemal Ozkan[1]

[1]Göztepe Training and Research Hospital, 2nd Orthopaedic and Traumatology Clinic; [2] 1st Orthopaedic and Traumatology Clinic

Amaç: Serebral felçli olgularda pes planovalgus deformitesi nedeniyle uygulanan Grice subtalar eklem dışı artrodez girişiminin sonuçları ve ayak arkası dizilimine düzelmesi üzerindeki etkinliği değerlendirildi.

Çalışma planı: Pes planovalgus deformitesi nedeniyle serebral felçli dokuz hastanın (5 erkek, 4 kız; ort. yaş 10.3; dağılım 6-12 yıl) 14 ayağına Grice subtalar eklem dışı artrodez girişimi uygulandı. Hastaların altısı diplejik, ikisi paraplejik, biri hemiplejik idi. Dört hastada tek, beş hastada iki taraflı tutulum vardı. Tüm hastalarda aynı taraf fibula 1/3 distalinde sindesmoz seviyesinin üzerinden greft alındı. Greft tespiti için implant kullanılmadı. Hastalar ameliyat öncesi ve sonrasında, AOFAS (American Orthopaedic Foot and Ankle Society) ayak arkası skorlaması ile değerlendirildi. Ortalama izlem süresi 30 ay (dağılım 6-81 ay) idi.

Sonuçlar: Ameliyat öncesinde ortalama 53 (dağılım 41-81) olan AOFAS skoru ameliyat sonrasında 68.4'e (dağılım 51-96) yükselirken, talokalkaneal açı ön-arka planda 52.6 dereceden 30.4 dereceye, yan planda 55.8 dereceden 35.9 dereceye geriledi ($p<0.05$). Ön-arka ayak bileği grafilerinde değerlendirilen ayak bileği valgus açısında değişiklik olmadı (ort. 5°). İki taraflı ameliyat edilen üç hastanın tek tarafında (%21.4) fibuladaki verici sahada kaynamama görüldü. Bu hastaların birinde (%7.1) fibular greftte pozisyon kaybı ve kaynamama vardı. Son kontrollerde yedi hastanın ailesi (%77.8) sonuçtan memnun olduğunu belirtti ($p<0.05$).

Çıkarımlar: Serebral felçli hastalarda pes planovalgus deformitesi için uygulanan Grice subtalar eklem dışı artrodez girişimi, verici saha morbiditesine rağmen ayak arkası dizilimini düzelten etkin bir yöntemdir.

Anahtar sözcükler: Ayak bileği eklemi; artrodez/yöntem; serebral felç/komplikasyon; çocuk; ekinus deformitesi/etyoloji/cerrahi; fibula/transplantasyon; ayak deformitesi, edinsel/cerrahi.

Objectives: We evaluated the results of the Grice subtalar extra-articular arthrodesis for pes planovalgus deformity in patients with cerebral palsy and its effectiveness in providing hindfoot alignment.

Methods: Grice subtalar extra-articular arthrodesis was performed for pes planovalgus deformity in 14 feet of nine patients (5 males, 4 females; mean age 10.3 years; range 6 to 12 years) with cerebral palsy. Six patients were diplegic, two patients were paraplegic, and one patient was hemiplegic. Four patients had unilateral, five patients had bilateral involvement. A fibular graft taken from the distal third of the fibula above the syndesmosis was used in all the patients without any fixation material. The patients were assessed with the AOFAS (American Orthopaedic Foot and Ankle Society) hindfoot scoring system pre- and postoperatively. The mean follow-up was 30 months (range 6 to 81 months).

Results: Compared with the preoperative values, the mean AOFAS hindfoot score increased from 53 (range 41 to 81) to 68.4 (range 51 to 96), the mean talocalcaneal angle decreased from 52.6° (38°-60°) to 30.4°, and from 55.8° to 35.9° in frontal and sagittal planes, respectively ($p<0.05$). The mean ankle valgus angle measured on anteroposterior radiographs remained unchanged (mean 5°). Of five patients who underwent bilateral surgery, three (21.4%) developed donor-site fibular nonunion on one side. One (7.1%) of these patients also had graft nonunion and displacement. Treatment was rated as satisfactory by the parents of seven patients (77.8%; $p<0.05$).

Conclusion: Despite donor-site morbidity, the Grice subtalar extra-articular arthrodesis is an effective procedure for the correction of hindfoot alignment in patients with pes planovalgus deformity secondary to cerebral palsy.

Key words: Ankle joint; arthrodesis/methods; cerebral palsy/complications; child; equinus deformity/etiology/surgery; fibula/transplantation; foot deformities, acquired/surgery.

Correspondence / *Yazışma adresi:* Dr. Melih Güven. Göztepe Training and Research Hospital, 2nd Orthopaedic and Traumatology Clinic, Göztepe, İstanbul. Phone: +90216 - 566 40 00 / 1282 Fax: +90216 - 566 36 36 e-mail: maguven2000@gmail.com

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Pes planovalgus deformity presents with disruption of hindfoot alignment towards valgus, disapperance of longitudinal axis of the foot, and impairment of plantigrade walking. It is mostly encountered due to muscle imbalance arising from spasticities of cruris and peroneal muscles and is commonly seen in patients with cerebral palsy.[1,2] Initially, conservative treatment with casting and various orthoses may be tried. However, along with the growth period, the progression of the deformity can not be stopped by conservative interventions because of the persisting muscle spasticity. Prior to development of permanent contractures and structural osseous changes, surgical options should be discussed.[2] The aim of the treatment is known as obtaining a foot with normal alignment which exhibits no pain along with preventing the degenerative changes that may take place in the future.

Subtalar extra-articular arthrodesis was first applied by Grice[3] in 1952 on patients with poliomyelitis who completed their skeletal development. In the course of the years, indication range has been widened by comprising pathologies such as spina bifida, congenital vertical talus, talocalcaneal coalition, cerebral palsy, myelodysplasia, and idiopathic planovalgus.[2,4-6] Many disadvantages have been reported for that difficult technique in the literature. These can be summarized as graft fracture, graft displacement and nonunion, disruption in obtained correction, and fusion in varus.[4,6-9] On the other hand, there are some studies which report successful and adequate long term results with Grice technique on patients with cerebral palsy.[2,4]

In the present study, we evaluated the results of the Grice subtalar extra-articular arthrodesis that was applied with a graft obtained from fibula against pes planovalgus deformity, and its effects on hindfoot alignment.

Material and methods

Grice subtalar extra-articular arthrodesis was applied to 12 patients with cerebral palsy because of pes planovalgus deformity between June 1999 – November 2006 in our clinic. 14 feet of 9 patients in total, were evaluated (5 males, 4 females, mean age: 10.3, range: 6-12). Four patients had unilateral (3 right, 1 left), 5 patients had bilateral deformity. Six patients were diplegic, 2 were paraplegic, and one was hemiplegic. Two patients were able to walk without support while seven patients were able to walk with support. Prior to subtalar arthrodesis, multiple tendon release for one patient, achilloplasty and peroneus brevis Z-plasty for one patient, and achilloplasty and adductor tenotomy again for one patient had been applied. All the patients received physiotherapy-rehabilitation protocol during their operative period and the deformities could be corrected passively.

Patients were evaluated with AOFAS (American Orthopaedic Foot and Ankle Society) hindfoot score before the operation which included assessment of pain, function, and alignment clinically (Table 1).[10] Standing antero-posterior and lateral radiographs were applied. Anteroposterior talocalcaneal angle (Kite angle; normal range: 15°-55°) and lateral talocalcaneal angle (normal range: 25°-55°) which facilitates evaluation of subtalar varus & valgus of subtalar joint, were measured (Figure 1). Moreover, in order to evaluate the ankle valgus angle and fibular growth retardation, the relation between distal fibular epiphyseal line and ankle joint level was evaluated on antero-posterior ankle radiograph. Distal fibular epiphyseal line was at talar plateau level in four feet (stage 0), between talar plateau and distal tibial epiphysis in nine feet (stage 1), and at distal tibial epiphysis level in one foot (stage 2). Bilateral surgical intervention was not applied during the same session in none of the five patients with bilateral deformity. The mean duration between two operations in these patients was 3.2 months (range: 1-11 months).

Operative technique

A longitudinal incision was applied to the lateral portion of the foot through subtalar joint by taking sinus tarsi as the center. After passing through the subcutaneous layer; cutaneous branch of sural nerve, peroneal tendons, and extensor digitorum brevis were found and retracted. Anterior and posterior capsula of subtalar joint was seen and left intact. Soft tissues in sinus tarsi were cleaned with curette. Then, plantar flexion and inversion were applied to the foot. Calcaneus was reverted to its normal position under the talus and valgus deformity was corrected. By applying a thin osteotomy, osseous blocks were removed from lower articular surface of talus (roof of sinus tarsi) and upper articular surface of calcaneus (floor of sinus tarsi) in sinus tarsi and thus, graft bed was prepared and the length of the graft to be applied was determined. In all patients, graft was obtained above syndesmosis level from distal 1/3 of fibula, and while forcing subtalar joint varus, the prepared graft for sinus tarsi was placed into its bed.

Table 1. AOFAS (American Orthopaedic Foot and Ankle Society) hindfoot scale[10]

	Puan
1. Pain	
None	40
Mild, occasional	30
∑ Moderate, daily	20
Severe, almost always present	0
2. Function	
Activity limitation	
No limitations, no support	10
No limitation of daily activities, limitation of recreational activities, no support	7
Limited daily and recreational activities, cane	4
Severe limitation of daily and recreational activities, walker, crutches, brace	0
Maximum walking distance, blocks	
Greater than 6	5
4-6	4
1-3	2
Less than 1	0
Walking surfaces	
No difficulty on any surface	5
Some difficulty on uneven terrain, stairs, inclines, ladders	3
Severe difficulty on uneven terrain, stairs, inclines, ladders	0
Sagittal motion (flexion-extension)	
Normal or mild restriction (30° or more)	8
Moderate restriction (15°-29°)	4
Severe restriction (less than 15)	0
Hindfoot motion (inversion-eversion percentage)	
Normal or mild restriction (75%-100% normal)	8
Moderate restriction (25%-74% normal)	4
Marked restriction (less than 25% normal)	0
Ankle-hindfoot stability (anteroposterior,varus-valgus)	
Stable	8
Definitely unstable	0
3. Alignment	
Good, plantigrade foot, midfoot well aligned	10
Fair, plantigrade foot, some degree of midfoot malalignment observed, no symptoms	5
Poor, nonplantigrade foot, severe malalignment, symptoms	0

During this phase, attention was paid to make the long axis of the graft parallel to the long axis of the tibia while the ankle was in neutral position (Figure 2). Implant material was not used for graft fixation in any of the patients. In all patients, during the postoperative recovery period, short leg cast was used for a mean duration of 8.8 weeks (range: 6-12 weeks).

The clinical assessment at the final follow-up was carried out according to the AOFAS hindfoot score and the familial satisfaction was questioned. Radiographically, beside the evaluation of antero-posterior and lateral talocalcaneal angles, graft position against the weight-bearing axis of the tibiotalar joint and condition of the regeneration tissue in fibula which is the donor site, were assessed, as well. While evaluating the position of the graft, cases in which proximal end of the graft was anterior to the axis, were assessed to have an anterior localization; and the ones whose graft was posterior to the axis were classified as having posterior localization (this position is perpendicular to subtalar joint axis and recommended by Grice in his original manuscript), whereas cases with proximal end of the graft positioned perpendicular to the ground plane, were evaluated as having neutral localization. Moreover, ankle valgus higher than 5° on standing antero-posterior ankle radiograph, was recognized as significant.[13] Patients were followed-up for a mean period of 30 months (range: 6-81 months).

Statistical assessment was carried out by using the package program of "SPSS 14.0 for Windows Evaluation Version". Datas were compared by Friedman and chi-square tests. $P<0.05$ was recognized as statistically significant.

Results

None of the patients had skin necrosis and infection in the early postoperative period. Prior to operation, mean AOFAS score was 53 (range: 41-81); mean talocalcaneal angle was 52.6° (range: 38°-60°) on antero-posterior plane and 55.8° (range 40°-68°) on lateral plane; mean ankle valgus angle was 5° (range 0°-20°). At the final follow-up, the mean AOFAS score was 68.4 (range 51-96), mean talocalcaneal angle was 30.4° (range: 20°-58°) on antero-posterior plane and 35.9° (range: 20°-66°) on lateral plane ($p<0.05$). Ankle valgus evaluated on standing antero-posterior ankle radiographs, was showing a mean angle of 5° (range: 0°-20°). In one side of the three patients who had bilateral operation (21%), nonunion in fibular donor site was observed. One of those patients (7.1%), exhibited nonunion in fibular graft placed into the sinus tarsi. The AOFAS score of this patient in the last control was 51; lateral talocalcaneal angle was 76° and ankle valgus was 20° (preoperatively, distal fibu-

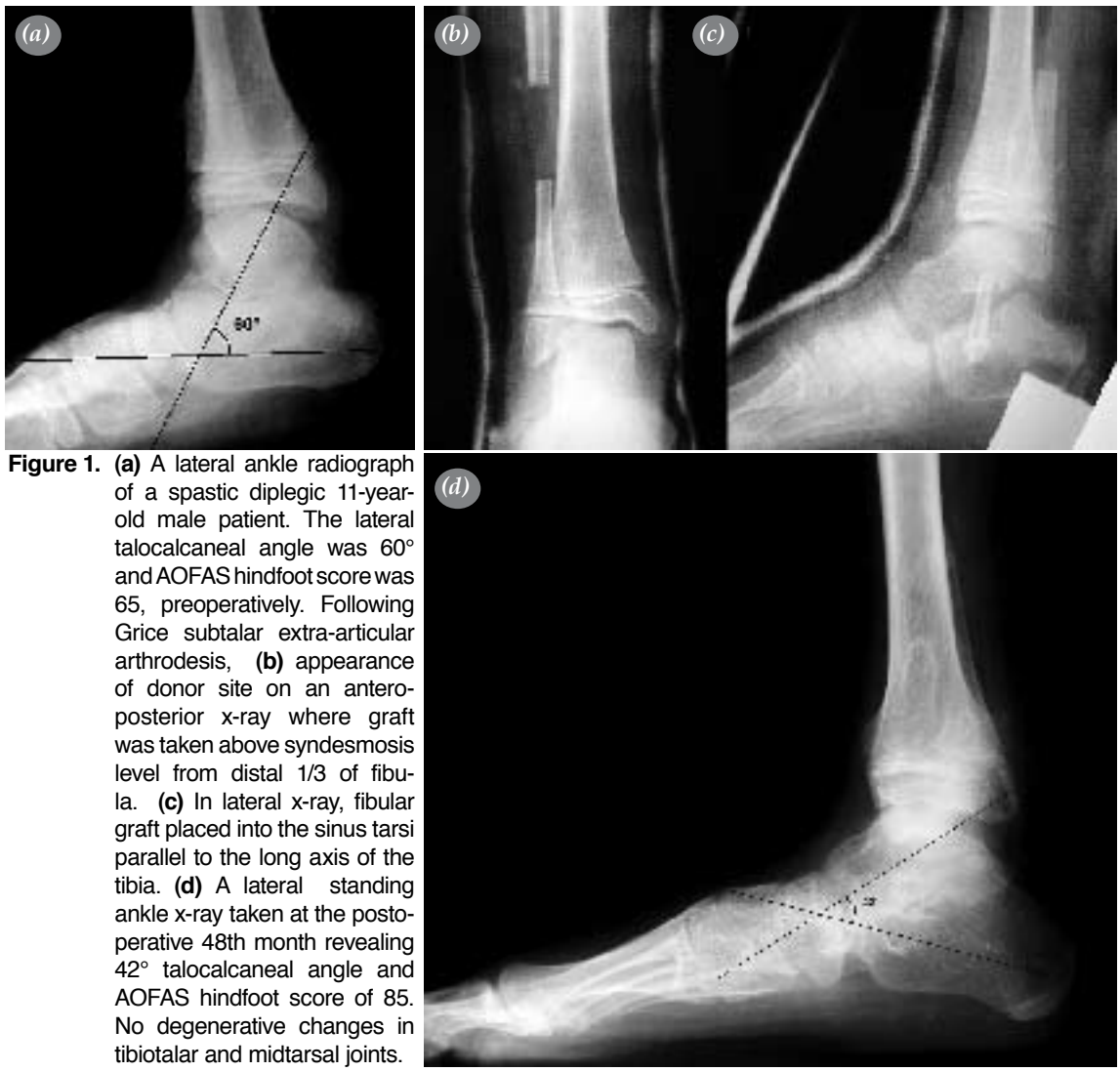

Figure 1. **(a)** A lateral ankle radiograph of a spastic diplegic 11-year-old male patient. The lateral talocalcaneal angle was 60° and AOFAS hindfoot score was 65, preoperatively. Following Grice subtalar extra-articular arthrodesis, **(b)** appearance of donor site on an antero-posterior x-ray where graft was taken above syndesmosis level from distal 1/3 of fibula. **(c)** In lateral x-ray, fibular graft placed into the sinus tarsi parallel to the long axis of the tibia. **(d)** A lateral standing ankle x-ray taken at the postoperative 48th month revealing 42° talocalcaneal angle and AOFAS hindfoot score of 85. No degenerative changes in tibiotalar and midtarsal joints.

lar end epiphyseal level was stage 2). In this patient, while the graft was observed to be in neutral position in the early postoperative period, after the removal of the cast, it was seen to lose his position and deformity recurrence was determined. All the other eight patients showed a complete fusion of fibular graft, and none of them exhibited a graft resorption (Figure 3).

Fibular graft had a neutral localization in all the patients except ones with nonunion. The antero-posterior radiographs of the other two patients who exhibited nonunion in the donor site of the fibula, showed the ankle in neutral position. No recurrence of the deformity was seen in those patients.

In none of the patients, no degenerative changes such as narrowing of joint space and spur formation, were observed. Families of 7 patients (77.8%) expressed their satisfaction from the results in the final controls ($p<0.05$).

Discussion

Pes planovalgus deformity generally presents with bilateral character and difficulties in walking along with a progressive pain, and may be seen in approximately 25% of patients with cerebral palsy.[2,14] Deformity was reported in 42% of diplegic patients and 68% of paraplegic patients.[14] Present muscle spasticity and imbalance should be taken under control with additional interventions prior to and/or during the surgery against planovalgus.[2,15] Spasticity was taken under control with soft tissue surgeries on lower extremities before subtalar arthrodesis intervention in three of our patients. No additional intervention was applied in none of the patients during artrodesis sur-

gery. Planovalgus deformity in all patients, was correctible prior to the operation.

Subtalar extraarticular arthrodesis surgery has been first applied in 1952 by Grice on patients with poliomyelitis who exhibited retardation in skeletal development, and its indications has been widened since then. In this subtalar arthrodesis technique which is not intraarticular and realized by sinus tarsi fusion, growth of talus and calcaneus is not blocked. In the original technique, corticocancellous grafts obtained from iliac wing are employed.[3,15] Chigot and Sananes [16] have modified this technique by using fibular graft. There are studies which indicate satisfactory long-term results for Grice operation. While Bourelle et al.,[2] reported succesful results for 26 feet of 17 patients followed-up for 20 years, Lancaster and Pohl[4] reported a success rate of 83.3% in a long-term follow-up of 36 cases. However, several complications such as graft fracture, graft displacement and nonunion, disruptions in obtained correction, and fusion in varus have been reported.[4,6-9] In Grice technique, placement of graft into the space in sinus tarsi is known to be difficult and during operation, displacement and subsequent recurrence of valgus deformity may be seen. Moreover, if the graft is placed very tightly into the prepared bed in sinus tarsi, hindfoot may be forced to varus and overcorrection may be encountered.[6,7,15]

In order to prevent some problems arising from Grice technique, several modifications have been developed. Batchelor technique, in which fibular graft is harvested from above the epiphyseal line and used for arthrodesis, was first described by Brown [17] and is the most common of those modifications that gave successful results in the literature.[15] Graft harvested from fibula is placed into the graft bed extending from talus neck to calcaneus via sinus tarsi. The arthrodesis in this technique is not of extra-articular character and because only one cortical graft is used, a high level of nonunion has been reported. Furthermore, due to shear stresses, the graft crossing the sinus tarsi obliquely may fracture. Dennyson and Fulford[20] modified Batchelor technique by using screw in place of fibular graft and placing cancellous graft into the sinus tarsi, and reported a fusion incidence above 95%. The leading advantage of this technique is the strong mechanical conservation of the position obtained in the operation by a screw. However, problems associated with screw may be encountered and a second operation is required for removal of the screw.[15] Hadley et al.[21] observed screw sclerosis in 43.5% of cases in which they applied this technique. They associated a sclerosis over 1mm with nonunion. Zorer et al. [22], reported 90% radiographically and 95% clinically succesful results in their study and determined screw sclerosis in two cases, one of which gave a poor result due to sclerosis above 1mm. In this case, authors underscored that nonunion was not associated with sclerosis, but related to the poor result with recurrence of deformity. While Dennyson and Fulford [20] reported nonunion rate in their original study as 6.3%, Zorer et al. [22], did not encounter nonunion problem in any of the cases. Hsu et al. [15], applied Grice technique and Batchelor modification together. In this technique, Batchelor graft has been used for conservation of subtalar joint reduction. Thus, importance of Grice graft and potential problems related to this, were aimed to be avoided. Because sinus tarsi is opened, graft is placed under direct vision and the risk of nonunion with the second graft is tried to be avoided. Twenty-five feet of 19 patients were subjected to this technique and a solid fusion was obtained in 24 feet (96%).

In many studies, unsuccesful results of Grice technique have been reported to be associated with resorption of graft and nonunion, and the incidence of this result was reported to be 6-33% in patients with cerebral palsy.[2,8,13] Lancaster and Pohl [4] reported no graft resorption. Graft resorption and nonunion do not necessarily lead to recurrence of deformity because fibrosis developing in the subtalar joint causes preservation of the alignment.[2] Bourelle et al. [2], did not determine any recurrence of deformity in their seven cases exhibiting resorption in fibular graft. Scott et al.[13], monitored 62 feet of 45 patients until their skeletal development is finished and reported poor results in 61%; most of those showed recurrence of deformity due to anterior localization of the graft. In the present study, postoperative early period control radiographs of a case determined to show nonunion in fibular graft (7.1%), exhibited a displacement of fibular graft towards anterior aspect and the recurrence of deformity was associated with this displacement. In the rest of the cases, fibular graft preserved its neutral position and no recurrence of the deformity was seen.

As a result of a delay in regeneration of the donor site and nonunion, lateral malleolus was observed to be ascended and an associated development of a valgus deformity in the ankle was reported to be possible. [15,23] In several studies, no fibular pseudoarthrosis and ankle valgus was observed.[4,16] In order to solve this problem, Hsu et al.[15] recommended harvesting of the graft from mid 1/3 of fibula by paying attention for not to destroy periosteum and reported fibular regeneration in all of their patients. In the present study, grafts were obtained from distal 1/3 of fibula above the syndesmosis level with attention was paid for not to destroy periosteum. Despite that, donor site nonunion was observed unilaterally in fibulas (21.4%) of three patients subjected to bilateral operation. In two of those patients, final antero-posterior radiographs showed ankle in neutral position and no recurrence of deformity was determined. In the other patient whose ankle valgus had been measured as 20°, recurrence of the deformity was present. We believe this to be due to displacement of the fibular graft rather than nonunion in donor site.

Most of the patients with cerebral palsy present with a planovalgus deformity associated with an ankle (tibiotalar joint) valgus. Retardation in fibular development is hold responsible for the ankle valgus and this condition may continue after the arthrodesis, [5,8,13] as well. If ankle valgus is not detected prior to surgery, hindfoot varus may develop along with forefoot supination and adduction [5,13]. Presence or absence of valgus in ankle should be evaluated before the operation.[2] In the present study, mean ankle valgus evaluated on standing antero-posterior ankle radiographs, was 5° (range 0°-20°). When the relation between ankle and distal fibular epiphyseal line described by Malhotra et al [12] evaluated, epiphyseal line was at talar plateau level in four feet (stage 0, no ankle valgus), between talar plateau and distal tibial epiphyseal line in nine feet (stage 1, 5° ankle valgus), and at distal tibial epiphyseal level in one foot (stage 2, ankle valgus ≥10°). Mean value of ankle valgus did not change postoperatively. After Grice operation, degenerative changes have been reported in the related joints in 6-84% of cases.[5,8] Bourelle et al. [2], did not find arthrosis in any of their patients followed-up for 20 years. In the present study, while none of the patients exhibited degenerative changes in tibiotalar or midtarsal joints, since our mean follow-up period was not sufficient (30 months; range: 6-81 months), we are not able to come to a definitive conclusion on that matter.

The aim of the treatment of pes planovalgus deformity in patients with cerebral palsy is to achieve a painless and plantigrade foot which has an as normal as possible hindfoot alignment. Grice operation is an effective method which requires no internal fixation and corrects hindfoot alignment despite donor site morbidity. Attention should be paid to the placement position of the graft in the surgical method and conserving this position.

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