



# The effect of abductor hallucis tendon release on residual adductus deformity in the surgical treatment of congenital clubfoot

## Doğuştan çarpık ayak cerrahi tedavisinde abdükör hallucis tendon gevşetmesinin cerrahi sonrası adduktus deformitesi üzerine etkisi

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**Amaç:** Doğuştan çarpık ayak deformitesinin cerrahi tedavisinde abdükör hallucis (AH) tendon gevşetmesinin cerrahi sonrası adduktus deformitesi üzerine etkisi araştırıldı.

**Çalışma planı:** Çalışmaya doğuştan çarpık ayak deformitesi olan 35 hasta alındı. On üç hastada (grup 1, 21 ayak) klasik tam subtalar gevşetme ameliyatı uygulandı. Yirmi iki hastada (grup 2, 31 ayak) ise ek olarak AH kası tamamıyla plantara sıyrıldı ve distal tendinöz kısmından kesildi. Ortalama yaş grup 1'de 19.4 ay (dağılım 13-39 ay), grup 2'de ise 13.5 ay (dağılım 11-25 ay) idi. Ortalama takip süresi grup 1'de 55.5 ay (dağılım 36-77 ay), grup 2'de 24.7 ay (dağılım 10-37 ay) idi. Ön-arka talus-birinci metatars açısı ve kalkaneoküboid ilişki ameliyat öncesi, ameliyat sonrası erken dönem ve son takip radyografilerinde değerlendirilirken, ön-arka navikülometatarsal açı ve ön-arka talonaviküler ilişki son takip radyografilerinde değerlendirildi.

**Sonuçlar:** Ameliyattan sonra erken dönemde iki grupta da ön-arka talus-birinci metatars açısında anlamlı düzelme görüldü ( $p<0.001$ ); ancak, ameliyat sonrası erken dönem ile son kontrol değerleri arasında anlamlı fark yoktu ( $p>0.05$ ). Bu açı erken dönem ve son kontrolde iki grup arasında anlamlı fark göstermedi ( $p>0.05$ ). Ön-arka navikülometatarsal açı grup 1'de 95.3 derece, grup 2'de 96.7 derece bulundu. Ön-arka navikülometatarsal açı ve ön-arka talonaviküler subluksasyon iki grupta benzer bulundu ( $p>0.05$ ). Kalkaneoküboid ilişki her iki grupta da ameliyat sonrası erken dönem ve son kontrollerde anlamlı düzelme gösterirken, bu açıdan gruplar arasında fark yoktu ( $p>0.05$ ).

**Çıkarımlar:** Doğuştan çarpık ayak deformitesinin cerrahi tedavisinde AH kasının serbestleştirilmesi, cerrahi sonrası adduktus deformitesi oranını etkilememektedir.

**Anahtar sözcükler:** Çocuk; çarpık ayak/cerrahi; ayak deformitesi, doğuştan; tendon/cerrahi.

**Objectives:** We evaluated the effect of abductor hallucis (AH) tendon release on residual adductus deformity in the surgical treatment of congenital clubfoot.

**Methods:** The study included 35 patients with congenital clubfoot. Thirteen patients (group 1, 21 feet) underwent classical complete subtalar release, while 22 patients (group 2, 31 feet) underwent the same treatment combined with AH muscle release by stripping it plantarward and transecting it distally. The mean age was 19.4 months (range 13 to 39 months) in group 1, and 13.5 months (range 11 to 25 months) in group 2. The mean follow-up period was 55.5 months (range 36 to 77 months) in group 1, and 24.7 months (range 10 to 37 months) in group 2. Radiographic assessments were made on preoperative, early postoperative, and final radiographs for the anteroposterior talo-first metatarsal angle and calcaneocuboid relationship, and for the anteroposterior naviculometatarsal angle and talonavicular relationship on final radiographs.

**Results:** Both groups showed significant improvement in the anteroposterior talo-first metatarsal angle in the early postoperative period ( $p<0.001$ ); however, early and late postoperative talo-first metatarsal angle did not differ significantly both within groups and between groups ( $p>0.05$ ). The anteroposterior naviculometatarsal angle was 95.3 degrees in group 1, and 96.7 degrees in group 2. The anteroposterior naviculometatarsal angle and talonavicular subluxation were similar in the two groups ( $p>0.05$ ). The early and late postoperative calcaneocuboid relationship showed significant improvement in both groups, without a significant difference between the groups ( $p>0.05$ ).

**Conclusion:** It seems that release of the AH muscle does not affect the incidence of postsurgical residual adduction deformity in the surgical treatment of congenital clubfoot.

**Key words:** Child; clubfoot/surgery; foot deformities, congenital; tendons/surgery.

Adduction of the forefoot is the most common residual deformity and the main indication for revision operations in surgically treated clubfeet.<sup>[1-5]</sup> In the current orthopaedic literature, authors mention that idiopathic clubfoot does not recur in a fully corrected foot; it recurs only if the releases are performed incomplete or insufficient.<sup>[3]</sup>

The incidence of post-surgical residual adduction deformity varies a great deal because of many factors, such as the degree of the initial deformity, the patient's age at the time of surgery, the surgeon's level of expertise, and the quality of the primary correction. Frequently the abductor hallucis complex is found to be the tightest medial soft tissue and is a major contributor to the deformity.<sup>[6]</sup> Many authors suggested that the direct muscular action of the abductor hallucis is the only muscle capable of causing adduction of the forefoot.<sup>[1,5-7]</sup>

Several surgical procedures have been described to treat forefoot adduction. Some of them include soft tissue releases; others include many different bone surgeries to address this problem.<sup>[1,8]</sup> However, all of these techniques that are described aim to correct a present adductus deformity rather than avoiding an adductus deformity that will emerge by time. When the literature is reviewed, it is seen that abductor hallucis tendon release is primarily performed for congenital metatarsus varus deformity. However, it is also performed for the surgical treatment of residual metatarsus adductus by many authors, after clubfoot surgery in early childhood.<sup>[4,6,9,10]</sup>

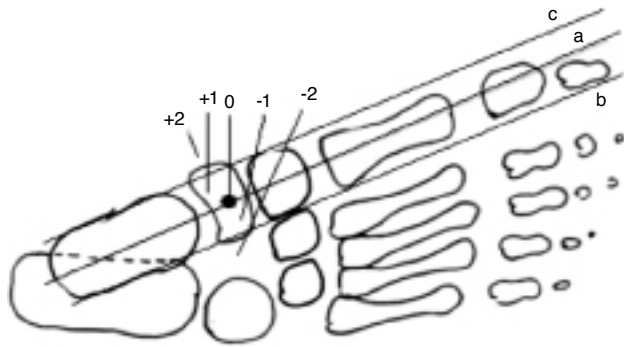
The objective of clubfoot surgery is to obtain a full and lasting correction, preferably with one operation. When the forefoot problems are not well corrected in primary surgery, an extensive surgery may be required like extensive soft tissue release at the tarso-metatarsal joints or multiple osteotomies of the metatarsals.<sup>[6]</sup> What we aim to gain with this study is to find out if releasing the abductor hallucis muscle may avoid residual or recurrent forefoot adduction deformity that become apparent in the late post-operative period or not. In follow-up, in some of the operated clubfoot cases who had residual adduction deformity, we noticed that the abductor hallucis tendon was quite tight when correcting the forefoot into neutral. Then we predicted that it would not cause disability and started to release this tendon routinely during the primary surgery in all cases.

## Patients and method

The study group consisted of 52 feet of 35 patients. Two patient groups were formed retrospectively. In the first group, the abductor hallucis muscle was not released (Figure 1a) and in the second group it was stripped and released distally (Figure 1b). The only difference between the groups was this. The first group consisted of 21 feet of 13 patients and the second group consisted of 31 feet of 22 patients. Mean age at the time of surgery was 19.4 (13-39) months in the first group and 13.5 (11-25) months in the second group ( $p < 0.05$ ). Mean follow-up period was 55.5 (36-77) months in the first group and 24.7 (10-37) months in the second group ( $p < 0.05$ ). All of the cases were idiopathic and had conservative treatment pre-operatively. Except for one case in the first group (this one had undergone heelcord lengthening procedure bilaterally in an another institution) all cases were operated in our hospital primarily. All of the cases were operated by two experienced surgeons (G.Z. & A.D.). Radiographies were assessed by the senior author (A.D.). In all cases, Cincinnati incision and the classical complete subtalar release technique were used, additionally in the second group the abductor hallucis tendon was transected distally and the muscle belly was completely stripped from the first metatarsal, medial cuneiform and the navicular plantarward up to its origin. So muscle belly and the distal portion of the muscle were completely free. Calcaneocuboid joint capsule release was performed in the cases of both groups who had II and/or higher grades subluxation. No complication related with this additional procedure has occurred and no tendency to hallux valgus has been observed.



**Figure 1.** The view after the transection of abductor hallucis tendon.



**Figure 2.** Evaluation of talonavicular relationship. ([+] values; adduction, [-] values; abduction, a; long axis of the talus, b; lateral tangential line of the talus, c; medial tangential line of the talus)

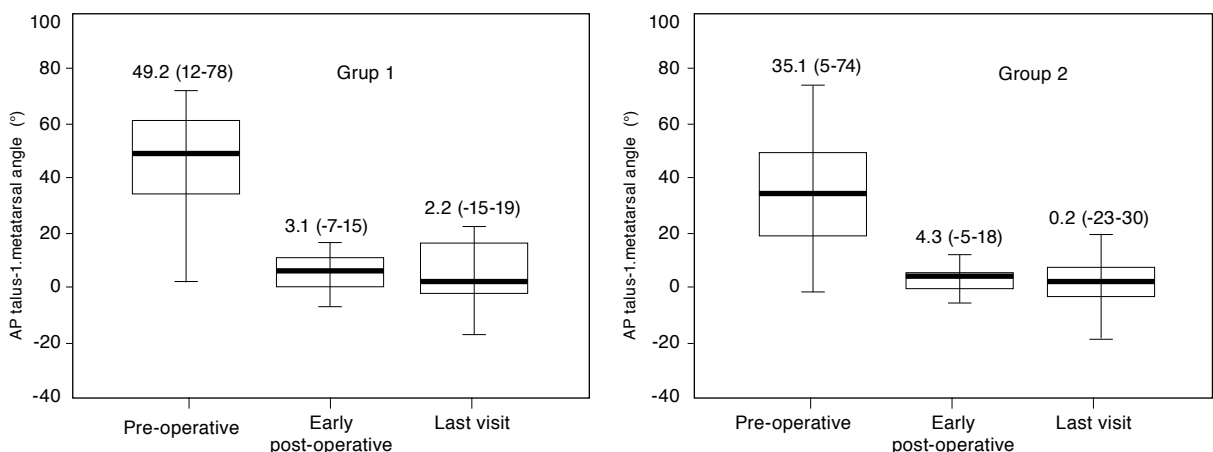
Anteroposterior talo-1.metatarsal angle and calcaneocuboid relationship were evaluated on preoperative, early post-operative, and last follow-up radiographies, AP naviculo-metatarsal angle and AP talonavicular relationship (Simons' grading system for calcaneocuboid relation was modified for this purpose) were evaluated only on the last follow-up weight-bearing anteroposterior radiographies because of the delayed ossification of the navicular in the early childhood period.<sup>[12,13]</sup> No additional procedure was applied in the post-operative period in both groups. All of the patients wore orthopaedic boots in day-time and AFO in night-time at least for one year, period depending on the clinical state of the foot. Student-t and Mann-Whitney U tests were used for statistical evaluation.  $p < 0.05$  value was considered significant.

### Results

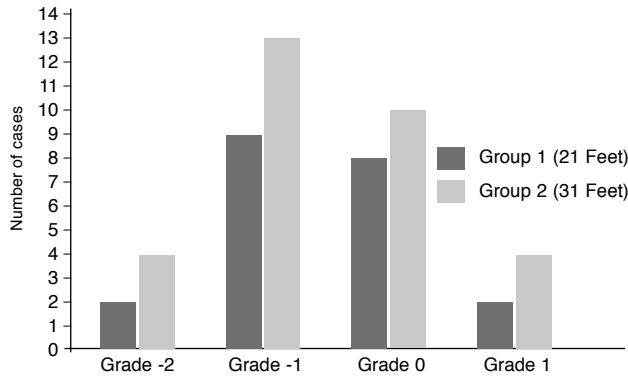
Radiographical mean values and its ranges of AP talus-1.metatarsal angle in pre-operative, early post-

operative and last follow-up periods are shown in Table-1 and Graphic 1. The deformity was significantly more severe in the first group preoperatively ( $p < 0.020$ ). In both groups, improvement in AP talo-1.metatarsal angle was statistically significant postoperatively ( $p < 0.001$ ). However, this improvement was not significant between the two groups either in the early or late postoperative periods ( $p > 0.05$ ). In the first group, there was significant difference between pre-operative and early post-operative values ( $p < 0.001$ ), but there was not a significant difference between early post-operative and late post-operative values during the last visit ( $p > 0.776$ ) and there was a significant difference between pre-operative and late post-operative values ( $p < 0.001$ ), according to the AP talus –first metatarsal angle. Also in the second group, there was significant difference between pre-operative and early post-operative values ( $p < 0.001$ ), but there was not a significant difference between early post-operative and late post-operative values during the last visit ( $p > 0.474$ ) and there was a significant difference between pre-operative and late post-operative values ( $p < 0.001$ ), according to the AP talus –first metatarsal angle. Schematic analysis of AP talonavicular relationship in both groups at the last follow-up period are shown in Graphic 2.

AP naviculo-metatarsal angle was 95.3 degrees in group 1 and 96.7 degrees in group 2. Evaluation of the AP naviculo-metatarsal angle and AP talo-navicular subluxation which were measured on the last visit radiographs were not statistically significant between the two groups ( $p > 0.05$ ). There was no statistically significant difference in pre-operative ( $p > 0.943$ ), early post-operative ( $p > 0.601$ ) periods and in the values during the last visit ( $p > 0.300$ ) between the groups according



**Figure 3.** Schematic analysis of AP talus-1.metatarsal angles; mean values and distributions in both groups. ([+] values; adduction, [-] values; abduction).



**Figure 4.** Schematic analysis of AP talonavicular relationships in both groups at the time of the last visit (distribution of the number of the cases according to grades).

to the calcaneocuboid relation. In both groups there was a significant difference between pre-operative and early post-operative values and also there was a significant difference between pre-operative values and the values obtained during the last visit ( $p < 0.05$ ). The deterioration observed during the follow-up period in calcaneocuboid relation was not significant ( $p > 0.05$ ). Schematic analysis of calcaneocuboid relationship in both groups during the last follow-up period is shown in Graphic 3. No correlation was determined between the calcaneocuboid subluxation and the severity of the adductus deformity ( $p > 0.005$ ). Any structural or insertional anomalous of abductor hallucis tendon was not noted per-operatively in any of the cases. We have not observed any complication related to this additional procedure.

## Discussion

Some abnormalities alone or in combination may be responsible for the forefoot adductus. Metatarsus varus, medial subluxation of the navicular, medial angulation of the neck of the talus are the major contributors to the forefoot adduction.<sup>[6,9,13]</sup> According to Main, metatarsus primus varus and medial angulation of the

talus were of little importance and attention should be directed to towards the talonavicular subluxation.<sup>[9]</sup> When metatarsus varus is present, its origin lies distal to the navicular including naviculo-cuneiform and cuneiform-metatarsal joints. It is unable to separate neither the relative contribution from these two sites to the deformity in early childhood; nor did any such distinction seem to have practical value.<sup>[13]</sup>

The abductor hallucis muscle arises from the medial process of the calcaneus and by fleshy fibres from the flexor retinaculum, the plantar aponeurosis and the intermuscular septum between the aponeurosis and the flexor digitorum brevis. The muscle is also attached to the calcaneonavicular ligament and the navicular bone. The abductor hallucis muscle is inserted into the medial side of the base of the proximal phalanx of the big toe and, partly with the medial head of flexor hallucis brevis, into the medial sesamoid bone.<sup>[10]</sup> So, it extends on the whole medial face of the foot. Posteromedial structures are contracted in clubfoot, so the abductor hallucis muscle too. In a normal foot this muscle is tonically active and helps sustain the foot arch. Its functional state in clubfoot is not clear; presumably it is shortened, hyperactive, or in a state of contracture.<sup>[14]</sup> Especially in severe cases, during the passive correction of the forefoot into the neutral position, palpation reveals a tightness in the region of the tendon of abductor hallucis. So it can be assumed one of the probable reasons for the forefoot adductus in clubfoot. When the literature is reviewed, we see that the release of abductor hallucis is primarily applied for metatarsus varus deformity. But it is also performed for the surgical treatment of residual metatarsus adductus after primary clubfoot surgery in early childhood by many authors.<sup>[4,6,9,10]</sup>

After Mitchell performed abductor hallucis release in isolated congenital metatarsus varus cases and gained successful results, he applied this technique in the cases which were initially treated due to clubfoot and had residual adductus after that.<sup>[10]</sup> Mitchell per-

**Table 1.** Analysis of AP calcaneocuboid relationships in both groups in pre-operative, early post-operative and last follow-up periods (distribution of the number of the cases according to grades).

	Group 1 (21 Feet)				Group 2 (31 Feet)			
	Grade 0	Grade I	Grade II	Grade III	Grade 0	Grade I	Grade II	Grade III
Pre-operative	2	6	8	5	5	12	9	5
Early post-operative	11	9	1	–	22	9	–	–
Last visit	19	2	–	–	25	6	–	–

formed the release procedure both from the origin and the insertion of the muscle and he reported that he obtained immediate correction per-operatively. He also mentioned in his paper that in the first case, treated only the distal muscle attachment was divided instead of complete release of the muscle origin. In this case the deformity persisted and was later successfully corrected by tarsometatarsal and intermetatarsal mobilisation.<sup>[10]</sup> In our series we did not release the origin of the muscle. We performed only distal release and belly stripping of the muscle and so it did not give any extra benefit to obtain full correction. And also it should be kept in mind that complete surgical release of the abductor hallucis muscle is a difficult procedure because of its extensive origin and the close proximity to the neurovascular bundle.

Lowe suggested that for early treatment of the residual adductus in clubfoot, detachment of the origin of the abductor hallucis muscle is recommended at the time of extended posterior release, with tenotomy of the tendon insertion as an additional measure.<sup>[13]</sup> Lowe recommended the division of the tendon of insertion of this muscle through a separate small distal incision which reduces the danger of medial tethering from secondary scarring resulted from extensive medial dissection.<sup>[13]</sup> He also mentioned in his paper that correction does not occur spontaneously with age. Lowe recommended release of abductor hallucis in the first year of life but he did not report his results. In our series, we extended the medial arm of the Cincinnati incision in order to release the distal portion of the tendon. During follow-up, we observed that in some cases medial scar tissue was so tight that it resisted the passive correction of the forefoot adductus and although it is not very important we consider this as an additional factor for the forefoot adductus.

Section of the abductor hallucis tendon was also recommended by Lichtblau in 1975 for early correction of the metatarsus adductus deformity especially for the treatment of primarily treated residual equinovarus foot cases.<sup>[6]</sup> In his paper, he mentioned that in the properly selected cases (who have a tight abductor hallucis tendon under an abduction stress), an early section of the tendon of the abductor hallucis could help decreasing the deformity and diminishing the resistance of the foot against correction. Lichtblau performed this procedure in a second session out of the primary surgery, in the cases who were between 7 and 11 years old

and had forefoot adduction. Although average patient age was far younger (13.5 months) in our series, this procedure didn't help correcting the residual forefoot adduction. We also do not think that it is possible to overcome this problem only with an isolated tendon release after the secondary adaptive changes develop (in about 4-5 years old) in bony structures. Lowe also mentioned that abductor hallucis release may be performed in the first year of life, but in the cases older than 3 years old a bony procedure was necessary<sup>[13]</sup>.

Lichtblau also mentioned that this procedure might be helpful for correction of the hindfoot varus in clubfoot.<sup>[6]</sup> However, he did not address any objective evaluation criteria about this. In our series, although we achieved a significantly ( $p=0.014$ ) better correction of the hindfoot varus in early post-operative period in the group in which we did not release abductor hallucis, in the evaluation made according to the AP and lateral talocalcaneal angles (talocalcaneal index), there was not a significant ( $p=0.730$ ) difference between the groups during the last visit. But during the follow-up period, although the recurrence to varus position of the heel was found significant ( $p=0.049$ ) in the group in which abductor hallucis was not released, it was not significant ( $p=0.253$ ) in the group in which abductor hallucis was released. Thus, we may conclude that releasing abductor hallucis does not effect on the correction of the heel varus but it may help decreasing recurrence that may develop by time. However we think that larger series with longer follow-up periods are necessary to evaluate this.

Asirvatham performed a fractional lengthening of the distal musculotendinous portion of the abductor hallucis and if it was still tight after this procedure, he released the origin of the muscle proximally. And also he divided the capsules of the naviculocuneiform and cuneiform first metatarsal joints on the dorsal, medial, and plantar aspects. Therefore, he reported in his paper that the talo-first metatarsal angle improved in all of the cases, although all of them were not brought to normal values. In most patients, the residual deformity was acceptable and flexible. Additionally he mentioned that a spectrum of fibrous tissue abnormality was found involving the abductor hallucis and the tibialis anterior.<sup>[15]</sup> In our series, during the operations we did not observe any soft tissue abnormality and/or muscular insertion anomalous macroscopically.

In his series that he performed posteroplantar release, Reichel routinely released abductor hallucis and plantar fascia from their insertions on calcaneus. He reported residual adductus in only %12.7 of the cases after an average follow-up period of 7.4 years. He claimed that the main reason for this was residual talonavicular medial subluxation. And metatarsus varus influenced little on it <sup>[16]</sup>.

In his series in which he performed a closing wedge osteotomy of the cuboid combined with an opening wedge osteotomy of the medial cuneiform for the surgical treatment of residual adductus after primary clubfoot surgery, Lourenco divided the tendon with the muscle fibers through a third incision if the abductor hallucis is contracted.<sup>[1]</sup> Additionally, if the plantar fascia is tight, the same is done through a fourth incision. He mentioned that talo-1.metatarsal angle was below normal in only %10.3 of the patients and they had only mild residual deformities. The correction managed with this technique is also a correction in bony structure. The same as we think, he performed the release procedure of the abductor hallucis only in the cases in which he observed contraction after bony surgery.

In conclusion, forefoot adduction deformity may occur due to various causes. To prevent the future risk of development of post-surgical residual adductus, distal release of the abductor hallucis muscle and stripping the muscle belly plantarward in primary surgery are not sufficient. We think that hypothesis claiming that abductor hallucis release decreases the recurrence incidence of heel varus must be supported with larger series with longer follow-up periods.

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