The Neglected Clubfoot: A Salvage Procedure

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The study included 18 patients (28 feet), between 4 and 14 years of age. Complete homogeneous correction of the neglected clubfoot was achieved by performing a trapezoid resection osteotomy from the cuboid bone after performing an extensive posteromedial soft-tissue release. The procedure did not sacrifice any articular cartilage and allowed realignment of the forefoot. Tibialis anterior tendon transfer to the cuboid was performed in all feet to eliminate its deforming action and to help maintain the desired degree of correction. A Dwyer calcaneal lateral closing wedge osteotomy was needed in 12 feet and was performed concomitantly with the other procedures. After an average follow-up of 26 months (range 8—31 months) 14 (50%) feet had a good result with normal features, 11 (39.3%) feet had a fair result with definite improvement, and three (10.7%) feet had a poor result with limited improvement. Both good and fair results were considered satisfactory. Patients with tight ligaments were significantly more likely to have a poor outcome ($p < .0005$). However, neither the patient's age at the time of surgery nor the severity of the deformity was significantly associated with unsatisfactory results. The procedure is strongly recommended in supple feet with resilient ligaments, even in teenagers with severe deformity. In severely deformed rigid feet, the procedure serves to minimize bone resection, thus preventing excessive shortening of the foot if a triple arthrodesis should become necessary at a later date. (The Journal of Foot & Ankle Surgery 37(6):501—509, 1998)

Key words: clubfoot, congenital deformity, El-Tayeby procedure in neglected clubfoot, talipes equinovarus

Combined posteromedial release with shortening of the lateral column has been advocated by several authors for correction of a neglected or resistant clubfoot (1–6). Medial displacement of the navicular, ranging from subluxation to complete dislocation, is common (1, 2). As the cuboid and calcaneus move medially, there are often secondary adaptive changes along the lateral column of the foot (2). Evans described resecting the calcaneocuboid joint to realign the midtarsal joint and arrest growth laterally. However, because of reports of stiffness of the subtalar joint and abnormal pronation of the foot, other techniques have been proposed to shorten the lateral column, including cuboid decancellization (3), lateral excision of the distal part of the calcaneus (4), and a dorsolaterally based closing wedge resection of the distal part of the calcaneus (7) (Fig. 1).

Although it was postulated that an anterior or posterior tibial tendon transfer is seldom required since peroneal strength returned in every case (2), Feldbrin and coworkers proved by electrophysiological studies that muscle imbalance is an etiological factor in the idiopathic club foot (8). Neuropathy was detected in the peroneal nerve, the posterior tibial nerve, or both. Others showed isolated spinal cord dysfunction or a combined peripheral nerve lesion. Some authors have identified a strong tendency for recurrence of the varus deformity due to the dense scar tissue resulting from extensive soft-tissue release (4). Tibialis anterior tendon transfer to the lateral column in cases showing resistance to complete correction was therefore recommended (4, 8, 9).

Technique

In this study a one-stage procedure for correcting neglected congential clubfoot in children and teenagers is suggested. Such candidates are usually postponed for later triple arthrodesis on reaching puberty. The following salvage procedure was performed to achieve full correction and to maintain it thereafter: 1) extensive posteromedial soft-tissue release; 2) single or double resection osteotomy of the lateral column without violating any articular surface (cuboid lateral closed trapezoid resection with or without a Dwyer calcaneal closed wedge resection)(10); and 3) tibialis anterior tendon transfer to the cuboid.

Figure 2 shows the geometric principle on which the resectional osteotomy was based. By shifting the axis of

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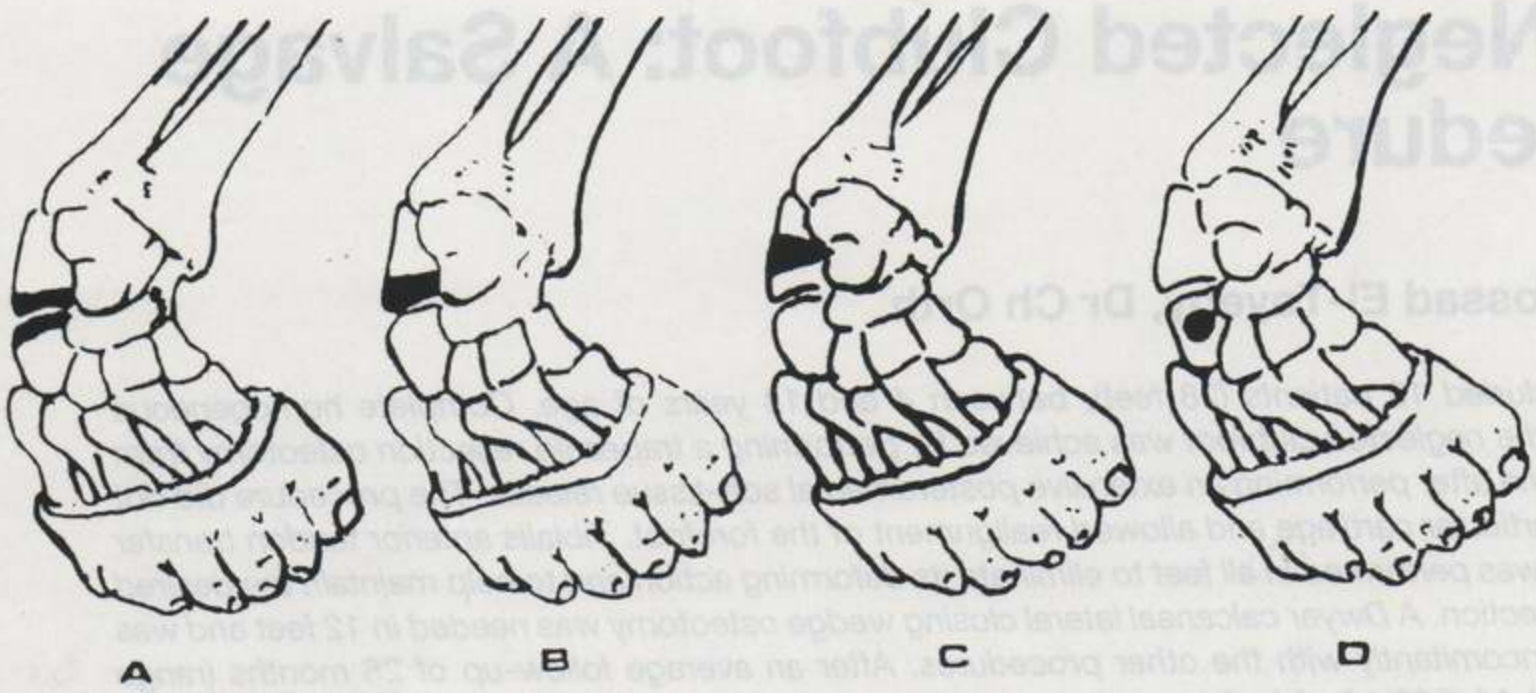


FIGURE 1 Procedures performed by different authors for correction of neglected clubfoot. *A*, Evans; *B*, Lichtblau; *C*, Toohey and Campbell; *D*, Tachdjian (decancellization).

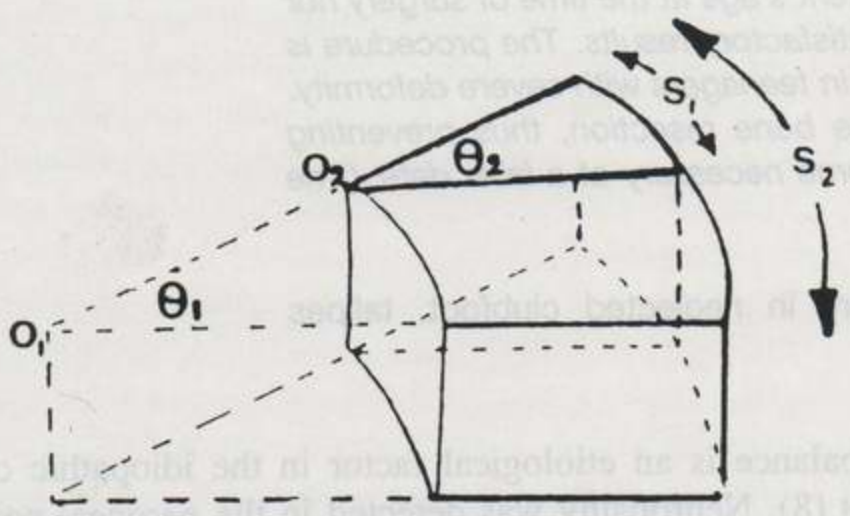


FIGURE 2 The geometric principle: $\theta_1 = \theta_2$. For the same angle of rotation, the excised base of cuboid S_2 is greater than S_1.

rotation from O_1 (medial border of cuboid) to O_2 (the medial border of navicular), an increase in the radius of rotation from r_1 to r_2 is achieved. Since the arc of displacement is governed by the equation $s = r\theta$ (θ is the angle of rotation in rads), then for the same angle of rotation θ, the excised base of cuboid S_2 is greater than S_1, allowing for better realignment of the convex lateral border of the foot. At the same time, closure of this open trapezoid will exert tension on the released yet usually tight medial soft tissues, thus bringing the long axis of the first metatarsal, navicular, and talus in line (Fig. 3). If a severe varus of the heel exists, a Dwyer closed wedge resection was performed just distal and parallel to the peroneal tendons (i.e., parallel to the subtalar joint and in a different plane from that of the cuboid). The combination of two breaks in different planes will allow for a homogeneous full alignment of the lateral column (Fig. 4).

Material and Methods

From April 1994 to June 1996, 18 children (11 boys and 7 girls) aged 4–14 years with 28 neglected congenital clubfeet were operated upon in the Health Insurance Hospital for school children in Alexandria. It is the main tertiary care hospital dealing with referrals from west delta governaries. The recently introduced health insurance service since 1992 helped to deal with such neglected cases.

The laxity of ligaments and their yielding to stretching the contracted medial column was examined clinically. This was to predict the extent of possible correction by posteromedial soft-tissue release and the expected bony resection needed to achieve full correction. The degree of deformity was classified according to Cummings and Lovell (6), and was mild in five, moderate in 14, and severe in nine feet. The foot was supple in 19 instances and rigid in nine.

Preoperative radiographic examination was done in two views, a standing anteroposterior and a lateral. In the anteroposterior view, the talocalcaneal and the naviculometatarsal angles were measured. The shape of the cuboid was noted and the trapezoid to be resected was planned beforehand. The calcaneal wedge resection was determined according to the degree of heel varus. The period of follow-up ranged from 8 to 31 months with an average of 26 months. The procedure involved an extensive posteromedial release, closed trapezoid resection of the cuboid, modified Dwyer calcaneal closed wedge osteotomy, and tibialis anterior tendon transfer. These procedures are described below.

1. **Posteromedial release:** This included z-plasty of any tight tendon posterior to the medial malleolus (tendo-Achillis, tibialis posterior, flexor digitorum longus, and flexor hallucis longus), posterior capsulotomy of the ankle and subtalar joints, exposure of the talonavicular, naviculocuneiform, and metatarsocuneiform joints and release of the tight dorsal, medial, and plantar capsular and ligamentous structures that are tethering the foot in the deformed position.

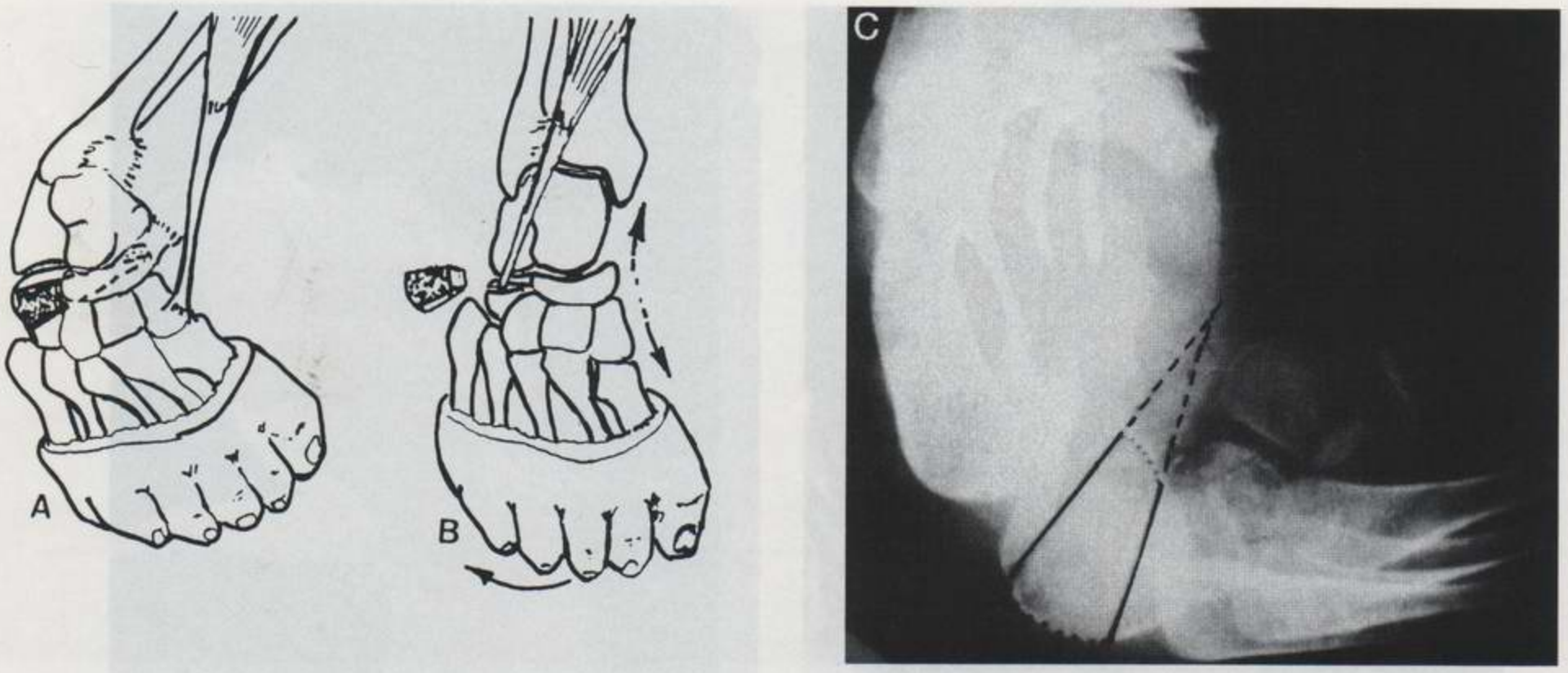


FIGURE 3 *A*, An illustration showing the trapezoid to be resected, applying the geometric principle in Figure 2. The fulcrum of rotation for the trapezoid is an imaginary point on the medial border of the navicular, allowing full correction of the deformity with the least tension on the medial soft tissues. *B*, The forefoot is shifted laterally, thus realigning the foot. The tibialis anterior tendon is transferred between the cuboid fragments to maintain correction. *C*, The radiograph of a neglected clubfoot with a planned trapezoid to be excised from the overgrown cuboid bone.

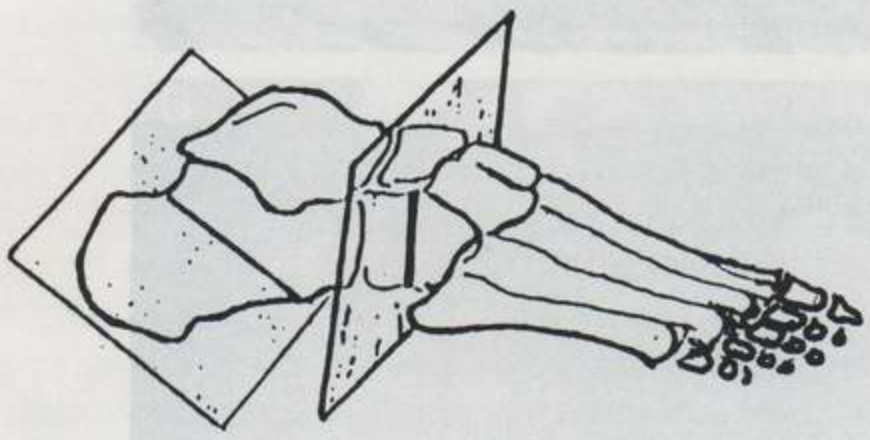


FIGURE 4 Two breaks in different planes in the lateral column will facilitate adequate correction in the severely deformed clubfoot.

2. **Closed trapezoid resection of the cuboid:** According to radiographic assessment, the exact dimensions of bone resection were planned. A triangle was drawn with the base at the lateral border of the cuboid and an imaginary apex at the medial border of the partially atrophied navicular. Through a lateral incision centered over the cuboid bone (Fig. 3) the resected trapezoid permitted the released navicular to be relocated on the talar head. If needed, the medial column was inspected for release of any tight ligaments until good coaptation of the cuboid fragments was achieved. Mild inclination of the heel was usually corrected by this procedure after release of the posteromedial structures (contracted ligaments and short tendons of secondary invertors of the heel). Moderate to severe heel varus needed a calcaneal osteotomy to correct residual varus, especially in rigid feet.
3. **Modified Dwyer calcaneal closed wedge osteotomy:** This was performed in 12 feet. The lateral incision was extended a few centimeters posteriorly, and a closing wedge based laterally was resected just distal to the peroneal tendons. The wedge was then closed and an axial Kirschner wire was introduced through the heel to maintain correction.
4. **Tibialis anterior tendon transfer:** The mobilized tendon was brought through the lateral foot incision. Held by a heavy Bunnell suture, it was drawn between the cuboid fragments. With the foot dorsiflexed and everted two crossed K-wires transfixed the tendon in between the coapted cuboid fragments while tightening the suture over a sole cigare gauze. Finally the skin was closed, and a below-knee plaster cast was applied for 2–3 months.

Results

The results were assessed according to a modification of Abrams' criteria (2), based on clinical and radiographic examination of the different components of the deformity (Table 1). Both good and fair results were considered satisfactory (89.3%). A good result (50%) was defined as a foot with normal clinical and radiographic features and unrestricted activity (Figs. 6 and 7). In this group (14 feet), the ligaments were resilient in 13 (92.9%) and tight in one (7.1%). Five (35.7%) were in the age group 4–7 years, while nine (64.3%) were older than 7 years of age (groups B and C). The deformity was mild to moderate in nine (64.3%) and severe in five (35.7%).

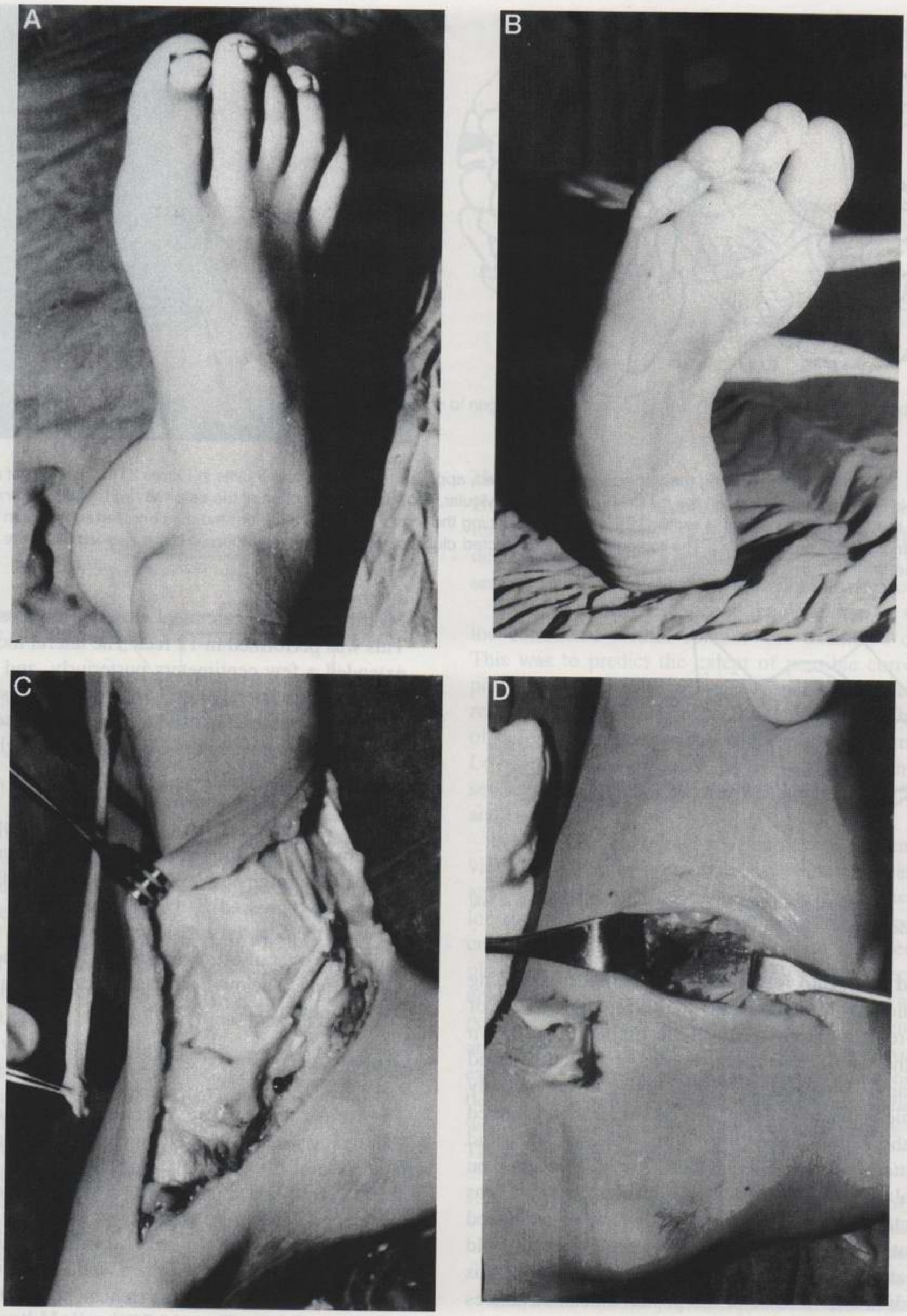
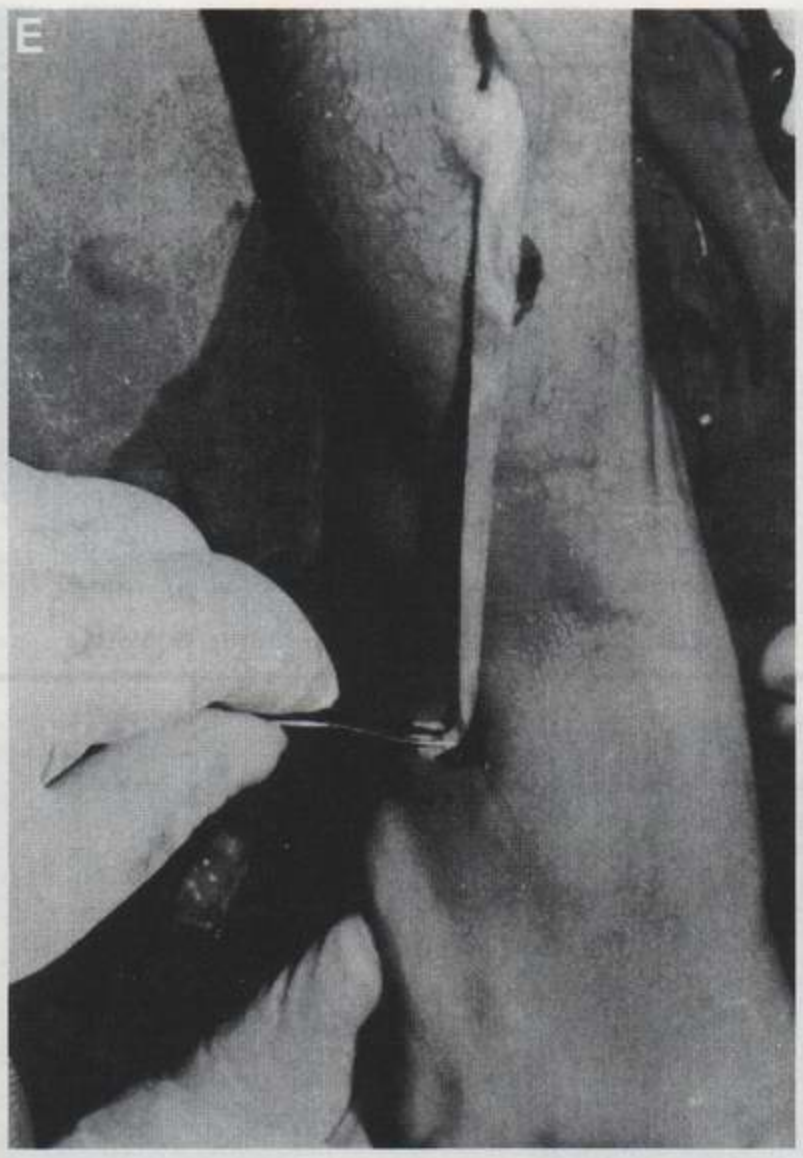


FIGURE 5 The operation in steps. *A* and *B*, The preoperative deformed foot, *C* An extensive posteromedial soft-tissue release, *D*, A trapezoid is resected from the cuboid bone.



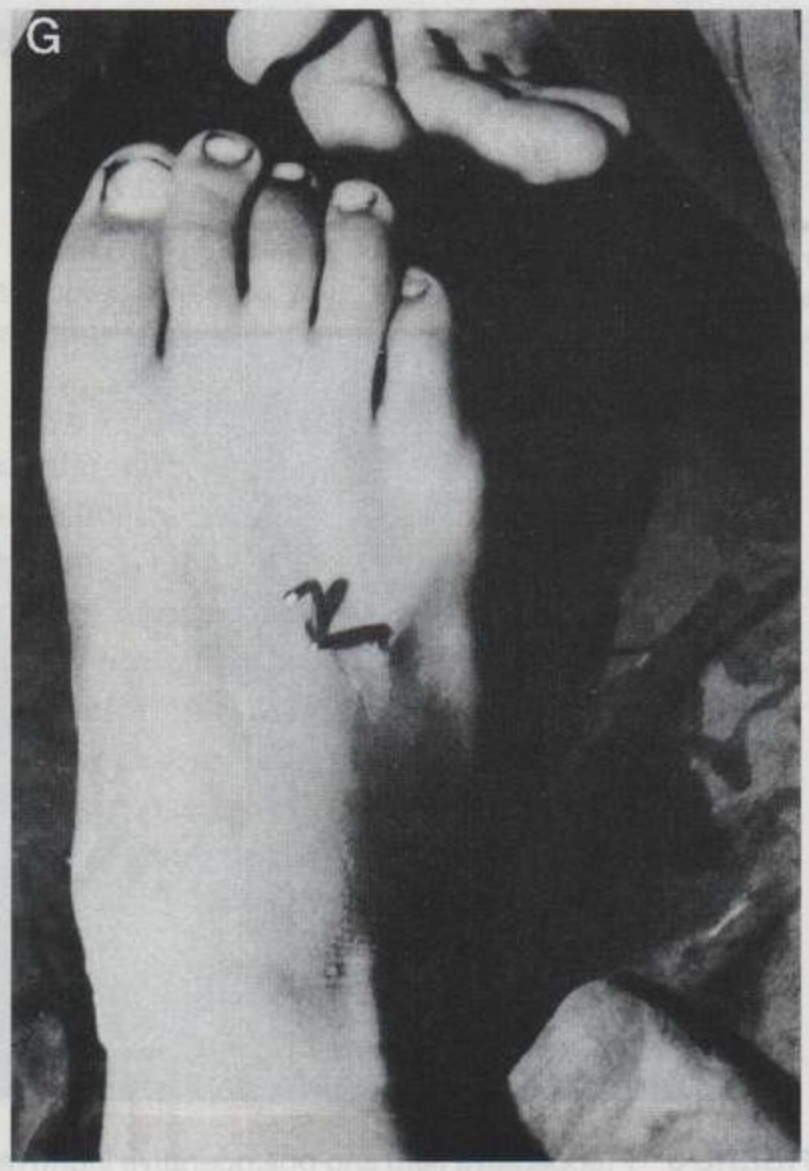


FIGURE 5 (*continued*) *E*, The tibialis anterior tendon is released from its insertion and pulled through a proximal incision, *F*, The tendon is rerouted to be inserted between the coapted cuboid fragments, *G*, Two crossing K-wires will transfix the tendon and maintain the shortened lateral column, *H*, The Bunnell suture is pulled tight over a sole cigare gauze.

TABLE 1 Criteria used for assessing the results

	Good (Normal features)	Fair (Definite improvement)	Poor (Limited improvement)
Equinus deformity	Full correction Dorsiflexion to 90° or more	Full correction Dorsiflexion to 90° or more	Restricted dorsiflexion
Heel varus	Fully corrected or mild valgus	Mild, less than 10° varus	10° varus more
Adduction of forefoot on A-P view	Navicular reduced by more than two-thirds onto the head of talus	Navicular reduced by two-thirds onto the head of talus	Minimal or no improvement
Talocalcaneal angle on A-P view	Restoration of talocalcaneal angle	Improvement of talocalcaneal angle	Minimal improvement
Eversion by tendon transfer	Active eversion	Active eversion	Weak or none
Physical activity	Unrestricted activity	Average activity	Same activity

TABLE 2 Results in 28 neglected congenital clubfeet

Age Group	Degree of Deformity		Ligaments		Results		
			Resilient	Tight	Good	Fair	Poor
A	Mild	3	1	2	1 + 1[a]	1[a]	—
4–7 years	Mod	2	—	2	—	2[a]	—
11(39.3%)	Severe	6	5	1	3	2	1[a]
B	Mild	—	—	—	—	—	—
8–11 years	Mod	7	6	1	5	1	1[a]
8(28.6%)	Severe	1	1	—	—	1	—
C	Mild	2	2	—	1	1	—
12–14 years	Mod	5	2	3	1	1 + 2[a]	1[a]
9(32.1%)	Severe	2	2	—	2	—	—
Total		28	19 (67.9%)	9 (32.1%)	14 (50%)	11 (39.3%)	3 (10.7%)

[a]Tight ligaments.

Feet graded as fair (39.3%) were still considered satisfactory. They showed definite improvement over the preoperative status with average activity. In this group (11 feet), the ligaments were resilient in six (54.5%) and tight in five (45.5%). Five were in the age group 4–7 years, while six (54.5%) were in the older age groups (7–14 years). Also the preoperative deformity was mild to moderate in eight (72.7%) and severe in three (27.3%). Functionally a plantargrade, cosmetically acceptable foot with improved walking ability was achieved even in the fair cases. The patients were able to wear shoes and to participate in normal daily activities. The size of the foot was usually relatively smaller when compared to the normal foot in unilateral cases. Poor feet (10.7%) had limited improvement in shape, the deformity was still present, and activity was still restricted. In this group (three feet), all had tight ligaments with moderate deformity in two and severe in one.

On statistical analysis, feet with tight ligaments showed poor results in 33.3% (three out of nine feet) while those with resilient ligaments had no poor results, which was statistically significant ($p = .0005$), confirming the effect of ligament resiliency on the end result. On the

FIGURE 6 Preoperative (left) and postoperative (right) radiographs of a 9-year old boy after 10 months of a trapezoid resection osteotomy from the cuboid. The resection permitted the midpart of the foot to be moved laterally through the talonavicular joint and shortened the lateral column, bringing the long axis of the first metatarsal, navicular, and talus in line. The defect in the cuboid is the site of insertion of tibialis anterior tendon.

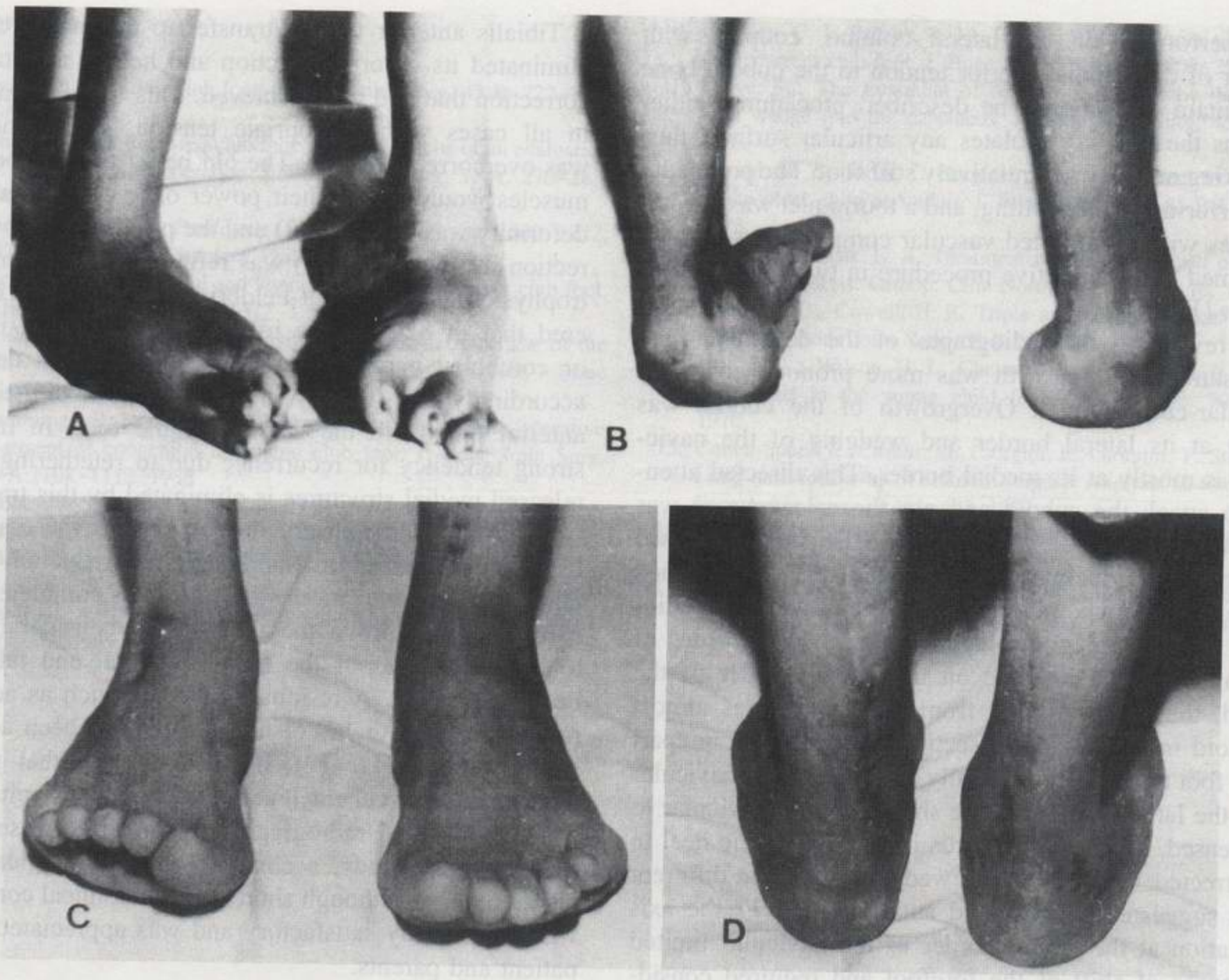


FIGURE 7 *A* and *B*, Bilateral severe neglected talipes equinovarus in a 12-year-old girl with resilient ligaments. *C* and *D*, A good result after bilateral posteromedial release, trapezoid resection osteotomy of the cuboid, Dwyers closed wedge resection of the calcaneus, and transfer of the tibialis anterior tendon to the lateral border of the foot. (Follow-up period: 12 months for the right foot, and 14 months for the left).

other hand, the effect of age and degree of deformity was not statistically significant. The 11 patients below 7 years (group A) had one poor result (9.1%), while the 17 patients above 7 years (groups B and C) had two (11.8%) ($p = .37$). Also, the 19 feet with mild to moderate deformity had two poor results (10.5%), while the nine severely deformed feet had one poor result (11.1%), ($p = .38$). Accordingly, better results should be expected in feet with resilient ligaments, even in severely deformed feet in teenagers. At follow-up, the calf girth remained the same, even in young patients with resilient ligaments who regained an almost normal gait.

Complications

A sore on the sole of the foot at the site of the cigare gauze was a complication in many cases, yet repeated dressing was enough for healing within a few days.

Discussion

For the neglected congenital clubfoot, a posteromedial soft-tissue release combined with wedge resectional osteotomy at different levels of the lateral column has been proposed by different authors (1, 2, 4, 7), These procedures usually violated articular surfaces, resulting in disturbed growth in an already deformed, relatively small-sized foot (4). Others proposed triple arthrodesis (10–13), which was accepted as a salvage procedure for patients as young as 8 years of age (13) or at any time after the appearance of the ossific nucleus of the naviculaR (14). The long-term follow-up revealed a high incidence of degenerative joint changes in the ankle and midfoot, pseudarthrosis, and avascular necrosis (13).

In teenagers, a neglected clubfoot is relatively short and stiff. Therefore, it is advisable to avoid triple arthrodesis which further shortens the foot and eliminates motion across these joints (15). In this study, an extensive posteromedial release and a modified bony resection procedure

were performed on the lateral column, coupled with transfer of the tibialis anterior tendon to the cuboid bone to maintain correction. The described procedure neither shortens the foot nor violates any articular surface, thus preserving mobility in a relatively stiff foot. The procedure was performed in one sitting, and a tourniquet was used in all cases with no reported vascular complications. Others performed their corrective procedure in two (11) or three sittings (16).

On reviewing the radiographs of the deformed feet, the disturbance of growth was more pronounced at the navicular-cuboid level. Overgrowth of the cuboid was mostly at its lateral border and wedging of the navicular was mostly at its medial border. This directed attention to attack the cuboid and not the calcaneus as was previously suggested by Toohey and Campbell (7). Based on geometric principles, it was found that if a planned wedge was drawn on the preoperative standing radiograph with its imaginary apex at the medial border of the navicular and its base on the lateral border of the cuboid, the resected bone from the cuboid was almost trapezoid in shape. This resection permitted the midpart of the foot to be moved laterally through the talonavicular joint, the lateral column to be shortened, the navicular to be released, and the mild varus inclination of the heel to be corrected. Compared with wedge resection at different levels suggested by differend authors (1, 4, 7), the axis of rotation at the lateral border of the navicular limited the degree of shift of the forefoot and required considerable tension on the medial soft tissues which, although released, will not yield easily.

The trapezoid bony resection from the cuboid body did not sacrifice any of the articular surfaces, while the Evans procedure included wedge resection and fusion of the calcaneocuboid joint with the risk of developing a valgus deformity due to overgrowth of the medial column (4). Besides, Lichtblau (4) believed that loss of one of the three joints that ordinarily are necessary for subtalar motion will perhaps lead ultimately to arthritis of the other tarsal joints, although his procedure sacrificed the articular surface of the calcaneocuboid joint.

An extensive posteromedial release and cuboid trapezoid bony resection was usually enough to correct mild to moderate varus of the heel even in older children. This confirms the observation of Abrams (2) that the subtalar joint retained a potential of mobility which was released once the midtarsal deformity was corrected, permitting the calcaneus to rotate on the talus as the midpart of the foot shifts laterally. A second break (the modified Dwyer procedure) (10), which was performed in a different orientation (parallel to the subtalar joint), was needed in feet with tight ligaments or severe varus inclination of the heel. In fact, double break in the lateral column allowed for a homogeneous correction of the severely deformed foot.

Tibialis anterior tendon transfer to the lateral column eliminated its deforming action and helped maintain the correction that had been achieved. This transfer was done in all cases with appropriate tension, and in no case was overcorrection seen. The old belief that the peroneal muscles would regain their power once correction of the deformity was achieved (2) and the possibility of overcorrection in some cases (9) was refuted by the recent electrophysiological study of Feldbrin et al. (8). They discovered that in 83% of the idiopathic clubfeet an isolated or combined peroneal nerve abnormality was detected; accordingly they strongly suggested transfer of the tibialis anterior tendon to the dorsum of the foot. In fact, the strong tendency for recurrence due to retethering of the released medial structures is eliminated by this transfer.

In this study, the observation of Abrams was confirmed (2). It was noticed that although the reduction of the talonavicular subluxation was not always complete, it was sufficient to improve the relationship considerably and to bring the axes of the first metatarsal and talus into better alignment. A residual deformity such as adducted forefoot and up to 10° of heel varus have been accepted as satisfactory (11, 17). It was observed that patients demonstrated excellent levels of function in spite of an anatomically and radiographically imperfect result (15). In the present study, a clinically and radiologically fair result (39.3%), although short from anatomical correction, was functionally satisfactory and was appreciated by the patient and parents.

The proposed procedure has no age limit. Evans (1) recommended the age of 6 years, although he performed his procedure up to the age of 14. Toohey and Campbell's procedure worked for children under 7 years (7), and triple arthrodesis was used for those older than 7 years. A tight foot was the main contraindication in the series of Lichtblau (4). In this study, poor results should be expected in the rigid foot. The ligaments, though released, would not yield easily and more bone should be resected from the cuboid and calcaneus to achieve a reasonable correction. It should be emphasized that partial correction of the deformity is considered an achievement, since it will limit the extent of bone resection if a triple arthrodesis is performed later. A supple foot was not related to age, and was frequently seen in older children and teenagers. The author strongly recommends the proposed procedure even in teenagers with severely deformed feet, and especially in those with resilient ligaments where a normal shaped foot is assured.

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