Avascular necrosis after osteotomy of the talar neck to correct residual club-foot deformity in children

A LONG-TERM REVIEW

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In order to determine the incidence of avascular necrosis after osteotomy of the talar neck, we re-evaluated 11 patients (16 feet) with idiopathic club foot who had undergone this procedure at a mean age of eight years (5 to 13) to correct a residual adduction deformity. All had been initially treated conservatively and operatively. The mean follow-up was 39 years (36 to 41). Surgery consisted of a closing-wedge osteotomy of the talar neck combined, in 14 feet, with lengthening of the first cuneiform and a Steindler procedure.

At follow-up eight feet were free from pain, three had occasional mild pain and five were regularly painful after routine activities. Two patients were unlimited in their activity, six occasionally limited after strenuous and three regularly limited after strenuous activity. Using the Ponseti score, the feet were rated as good in four, fair in three and poor in nine. In seven feet avascular necrosis with collapse and flattening of the talar dome had occurred. In all of these feet the children were younger than ten years of age at the time of surgery. In three feet, avascular necrosis of the talar head was also observed.

We conclude that osteotomy of the talar neck in children under the age of ten years can cause avascular necrosis and should be abandoned.

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Adams¹ described the typical deformity of the talus seen in club foot as medial and plantar deviation of the neck and head. This deformity has been described at post-mortem² and also in vivo by MRI.³ Bradford⁴ in 1892 proposed an osteotomy of the talar neck to correct this deviation of the

talus. Subsequently, reports have appeared nearly every decade describing modifications of this procedure.⁵⁻¹⁰

The most serious complication of a fracture of the talar neck is avascular necrosis (AVN).¹¹ The risk is higher in children than in adults.¹²⁻¹⁴ Canale and Kelly¹⁴ reported AVN of the talus in two five-year-old children after an undisplaced fracture of the talar neck. It seems that the vascularity of the talus in children is more vulnerable than in adults. It might be expected that osteotomy of the talar neck would have a similar risk of disrupting the blood supply of the talus. In view of this, it is surprising that this operation is so widely recommended for the correction of residual club-foot deformity in children. Only one case of AVN after osteotomy of the talar neck has been previously reported.⁷

The purpose of this long-term follow-up study was to determine the incidence and functional consequences of AVN of the talus after an osteotomy of the talar neck in childhood.

Patients and Methods

Between 1960 and 1965, 14 patients (21 feet), four girls and ten boys, with residual deformity as a result of idiopathic club foot underwent osteotomy of the talar neck. The mean age at operation was eight years (5 to 13). The indication for operation was a persistent adduction deformity of the forefoot, which had been treated shortly after birth by plaster casting and orthoses, followed by posterior release with lengthening of tendo Achillis and posterior capsulotomy in 12 patients, and a derotation tibial osteotomy in two. There were no early postoperative complications, but in three feet adduction of the forefoot persisted and a further operation combining a cuboid and cuneiform osteotomy was required.

Operative technique. The osteotomy was done through a lateral approach without opening the talonavicular joint. A closing-wedge osteotomy was made, removing a wedge of bone 5 to 8 mm in size, the base of which was located on the dorsal and lateral aspect of the talar neck.

The osteotomy was closed and fixation obtained in all but two feet by suturing the periosteum. In two feet additional Kirschner-wire fixation was necessary to obtain stability. In addition, lengthening of the medial cuneiform using

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Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Radiographs showing AVN of the talar dome. Figure 1a – Residual club-foot deformity in a six-year-old girl before surgery. The stress fracture at the base of the fifth metatarsal was asymptomatic. Figure 1b – The osteotomy line is still visible two months after surgery and is a first sign of AVN. Figure 1c – Nine years after surgery there is AVN with collapse of the talar dome and flattening of the joint surface. Figure 1d – Forty years later there is collapse of the talar dome with a step in the joint surfaces. This impinges on the anterior lip of the tibia and limits dorsiflexion. The subchondral bone is sclerotic and the Ponseti score is 81 points.

the bone wedge from the talus and a Steindler procedure were carried out in all except the first patient (2 feet).

We reviewed 11 patients (16 feet), four women and seven men, after a mean follow-up of 39 years (36 to 41). At follow-up, the mean age of the patients was 48 years (47 to 56). Follow-up examination included a questionnaire, clinical assessment and weight-bearing radiography of the foot. The functional outcome was assessed using the score of Laaveg and Ponseti.¹⁵ This rates pain (30 points), the level of activity (20 points), patient satisfaction (20 points), the position of the head (10 points), passive movement of the ankle (10 points) and gait (10 points). Active dorsi- and plantar flexion of the ankle were measured using an electronic goniometer. All preoperative and postoperative radiographs were available. Using anteroposterior (AP) and lateral films, the talocalcaneal and the talar-first metatarsal angles were determined. The height of the talar dome was measured as the vertical distance between the highest point of the talar neck and the roof of the trochlea. Any irregularities of the distal tibia, talus and navicular bone were noted.¹⁶

Results

Functional assessment. Eight feet were free from pain, three were occasionally painful during strenuous activity and five were regularly painful. Two patients could walk long distances with no discomfort and take part in sport without limitation. Six patients had reduced their level of activity or changed their professional occupation, but were not limited in activities of daily living. Three patients were limited in activities of daily living and could not stand or walk for a prolonged period. At follow-up all patients had an occupation with low demands on the foot. At the age of 20 years, three patients had had an occupation with high demand on the foot but had to change because of pain after exertion. Four patients limped slightly when tired. All but one could walk on their toes; only one was able to walk on his heels.

All but one patient could wear normal shoes, but only two were not limited in their selection of shoes. The others had to choose carefully, preferring a lace-up shoe. They felt more stable in shoes with heels. One patient with a stiff

Fig. 2a

Fig. 2c

Fig. 2b

Fig. 2d

Radiographs showing AVN of the fragment of the talar head. Figures 2a and 2b – One year after osteotomy of the talar neck there is AVN of the talar head with complete resorption. Figures 2c and 2d – Thirty-eight years later there is degenerative arthritis of the talonavicular joint. The Ponseti score is 53 points.

equinovarus foot which was 5 cm short and who had a leg-length discrepancy of 3 cm needed custom-made shoes. Five patients needed insoles to prevent excess pressure on the metatarsal heads or to compensate for fixed equinus. Six patients could walk barefoot only with great difficulty and pain. All patients reported rapid rates of wear and deformity of their shoes.

Clinical assessment. All affected feet were short and the calf showed marked atrophy. Six patients with unilateral club foot had a mean shortening of the leg of 1.75 cm (0.5 to 3) and of the foot of 2.6 cm (1.5 to 5). There was a mean

difference in calf circumference of 5 cm (3 to 7.5). All feet were stiff. The mean passive dorsiflexion at the tibiotalar joint was -7° ($+5^{\circ}$ to -20°) and plantar flexion, 21° (10 to 30°). In the seven feet with AVN of the talar dome the total range of movement of the ankle did not exceed 10° . The subtalar joint was stiff in all feet. The hindfoot was in a mean varus of 5° (2 to 10) in 13 feet, neutral in two and in 3° of valgus in one. In three feet there was adduction of the forefoot. All but one foot had a cavus deformity. The mean Ponseti score was 64 (42 to 87) points. There were no excellent scores; four were good, three fair and nine poor.

Fig. 3a

Fig. 3b

Radiographs showing overcorrection after osteotomy of the talar neck and AVN of the talar dome. The AP talocalcaneal angle is 5° . There is medial and plantar subluxation of the navicular and the first metatarsal is short and vertical. The foot shows a pronounced equinovarus deformity. The Ponseti score is 65 points.

The most outstanding feature among patients with AVN of the talar dome was stiffness of the ankle.

Radiological assessment. Before operation, the mean adduction deformity, measured by the AP talo-first-metatarsal angle was 34° (25 to 40). After operation it was 19° (6 to 30) and at follow-up, 16° (0 to 30). At follow-up the mean AP talocalcaneal angle was 12° (0 to 30), the lateral talocalcaneal angle 14° (10 to 26) and the lateral talo-first-metatarsal angle 32° (25 to 50).

In seven feet, following AVN of the talar dome, the dome had collapsed to between 2 and 5 mm below the level of the neck, i.e., the talar dome height was negative. An anterior step was present between the joint surface and the talar neck and the joint surface was flattened and irregular (Fig. 1). In two feet, the talar dome was at the same level as the neck and the joint surface was flattened. In seven feet in which there was no sign of AVN, the height of the talar dome was between 3 and 10 mm. The joint surface was spherical and congruent in five and flattened in two. Painful degenerative arthritis of the ankle was found in two patients, both of whom had AVN. The distal tibial joint line did not show any posterior slanting or any notching of the anterior rim. The length of the talus was reduced in all feet; in the patient with unilateral involvement the talus was 9% shorter.

There was AVN of the talar head in three feet. In one, after total necrosis of the head fragment, there was ankylosis with the navicular. In the other two there was incongruity of the talonavicular joint and subsequent degenerative arthritis (Fig. 2). The functional result in these three patients was poor.

In none of the feet was the navicular anatomically aligned with the talus. In six patients, it had a sagittally wedge-shaped deformity; five showed signs of degenerative arthritis in the talonavicular joint and in one there was ankylosis. In three feet too large a wedge of bone had been removed resulting in overcorrection, with an AP talocalcaneal angle of between 0° and 5° (Fig. 3).

Discussion

Our study has shown a high incidence of AVN after osteotomy of the talar neck. Seven of 16 club feet with a residual adduction deformity which was treated by osteotomy of the talar neck developed AVN with collapse and flattening of the talar dome.

In adults, the body of the talus receives its intraosseous blood supply principally from branches of the artery of the tarsal sinus. In 40%, branches of the superior neck vessels arising from the anterior tibial artery supply a small area of the anterosuperior portion of the body and, in 28%, anastomoses between the superior neck vessels and branches from the artery of the tarsal sinus can be found.^{17,18}

Since 14 of the 16 feet had undergone a previous posterior release, this may have damaged the blood supply to the undersurface of the neck of the talus, affecting the nutrient vessels to the area through which the osteotomy was later carried out. We feel, however, that this hypothesis is unlikely. Posterior release is a minor intervention, which for anatomical reasons is unlikely to damage important vascular structures. The suggestion that AVN of the talar body is the result of the osteotomy of the neck alone is

supported by the high incidence of AVN even after undisplaced fractures of the neck in children^{13,14} and also by the case reported by Hosny and Fabry.¹⁹ They carried out an extra-articular arthrodesis of the subtalar joint in a six-year-old child with a paralytic flat foot using a screw entering dorsally through the talar neck according to the technique of Dennyson and Fulford.²⁰ Nine months later they noted AVN of the body and collapse of the talar dome, and suggested that the introduction of the screw through the talar neck may have damaged the superior neck vessels.

The high incidence of AVN after talar neck osteotomy in children under the age of ten years leads us to suggest that the blood supply to the talar body could be different from that in adults and is principally derived from the anterior tibial artery. This may be damaged by an osteotomy of the talar neck. Inokuchi et al¹² proposed that the higher metabolism of the talar body in children requires a higher blood flow than in adults and that this makes it more vulnerable.

AVN of the head fragment was seen in three feet only, but in all three the functional outcome was poor, resulting in painful degenerative osteoarthritis in two, and spontaneous ankylosis of the talonavicular joint in one.

Most reports on osteotomy of the talar neck present encouraging short-term results, Ozeki et al,⁹ however, reported poor results in a longer-term study with a mean follow-up of 11 years after opening-wedge osteotomy of the talar neck combined with an osteotomy of the calcaneum. They described a deformity of the talonavicular joint, with shortening of the talar neck similar to that seen in our study. They also observed flattening of the talar dome with loss of height in more than half of the feet, but did not attribute these changes to AVN. Hjelmstedt and Sahlstedt⁷ also reported a patient with AVN of the talus after such a procedure. Ozeki et al⁹ do not recommend osteotomy of the talar neck in children under ten years of age and limited its use to feet with a severely deformed talar neck.

We conclude that osteotomy of the talar neck should be abandoned in children under the age of ten years since it may compromise the intraosseous blood supply of the talus and lead to AVN of the talar dome.

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References

1. Adams W. *Clubfoot: its causes, pathology and treatment*. London: J. and A. Churchill, 1866.
2. Settle GW. The anatomy of congenital talipes equinovarus: sixteen dissected specimens. *J Bone Joint Surg [Am]* 1963;45-A:1341-54.
3. Kamegaya M, Shinohara Y, Kokuji Y, Moriya H. Evaluation of pathologic abnormalities of clubfoot by magnetic resonance imaging. *Clin Orthop* 2000;379:218-23.
4. Bradford EH. Operative treatment of resistant club-foot. *Trans AOS* 1892;5:183-202.
5. Batchelor JS. The treatment of the uncorrected clubfoot in childhood. *Proc Roy Soc Med* 1946;39:713-5.
6. Fredenhagen H. Der Klumpfuß: Vorkommen, Anatomie, Behandlung und Spätresultate. *Z Orthop* 1955;85:305-21.
7. Hjelmstedt A, Sahlstedt B. Talo-calcaneal osteotomy and soft tissue procedures in the treatment of clubfoot: I. Indications, principles and technique. *Acta Orthop Scand* 1980;51:335-47.
8. Roberts JM. *Talar osteotomy in conjunction with soft tissue release for salvage of persistent clubfoot deformity in the older child*. Annual meeting of the Pediatric Orthopaedic Society, San Diego, CA, 1980.
9. Ozeki S, Yasuda K, Iisaka H, Kaneda K, Monji J, Matsuno S. The results of talar neck osteotomy in resistant congenital clubfoot. In: Simons GW, ed. *The clubfoot: the present and a view of the future*. New York: Springer-Verlag, 1994:351-60.
10. Klauke K. Planovalgus and cavovarus deformity of the hind foot. *J Bone Joint Surg [Br]* 1997;79-B:892-5.
11. Hawkins LG. Fractures of the neck of the talus. *J Bone Joint Surg [Am]* 1970;52-A:991-1002.
12. Inokuchi S, Ogawa K, Usami N. Fracture of the talus in children under the age of ten. *Foot Disease* 1994;1:29-35.
13. Letts RM, Gibeault D. Fractures of the neck of the talus in children. *Foot Ankle* 1980;1:74-7.
14. Canale ST, Kelly FB Jr. Fractures of the neck of the talus: long-term evaluation of seventy-one cases. *J Bone Joint Surg [Am]* 1978;60-A:143-56.
15. Laaveg SJ, Ponseti IV. Long-term results of treatment of congenital club foot. *J Bone Joint Surg [Am]* 1980;62-A:23-31.
16. Ponseti IV, El-Khoury GY, Ippolito E, Weinstein SL. A radiographic study of skeletal deformities in treated clubfeet. *Clin Orthop* 1981;160:30-42.
17. Mulfinger GL, Trueta J. The blood supply of the talus. *J Bone Joint Surg [Br]* 1970;52-B:160-7.
18. Gelberman RH, Mortensen WW. The arterial anatomy of the talus. *Foot & Ankle* 1983;4:64-72.
19. Hosny GA, Fabry G. Avascular necrosis of the talus after Dennyson-Fulford subtalar arthrodesis. *J Pediatr Orthop B* 2000;9:50-1.
20. Dennyson WG, Fulford GE. Subtalar arthrodesis by cancellous grafts and metallic internal fixation. *J Bone Joint Surg [Br]* 1976;58-B:507-10.