

COALITIO CALCANEO-NAVICULARIS AND CALCANEUS SECUNDARIUS

A clinical and radiographic study of twenty-three patients

By

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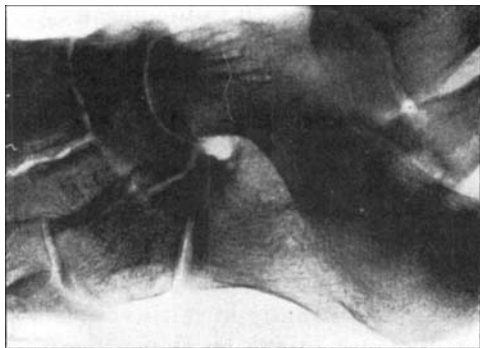
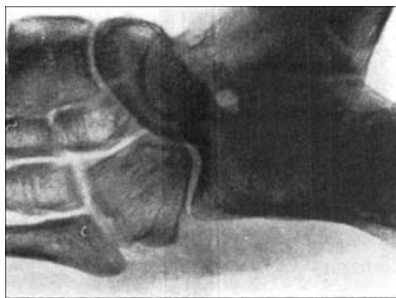
DEFINITION

In the skeleton of the normal foot the calcaneus and the naviculare are separated by a 5 to 10 mm. wide fissure (2) which is filled with ligaments and which admits of a certain mobility. An abnormally intimate connection between these bones is called *coalitio calcaneo-navicularis*. This term comprises all variations from a fibrous connection via amphiarthrosis (A) (Fig. 1) to a bony bridge which is called synostosis calcaneo-navicularis (S) (Fig. 2.). The *calcaneus secundarius* (CS) (Fig. 3) is an accessory bone occurring in the space between the calcaneus and the naviculare.

Etiology.

In human embryos, fusion or non-division of the cartilage anlagen of the calcaneus and the naviculare (8) and beginning ossification of the connecting cartilaginous bridge have been observed. Ossification proceeds from the enchondral ossific centre of the calcaneus or the naviculare and signs of narrowing and disappearance of the fissure between the centres have been observed. In some cases the cartilaginous bridge has an ossific centre of its own. The centre may fuse with the centre in the calcaneus or the naviculare or with both, forming a synostosis (3), or it may remain as a free element. In the latter case radiographic examination shows an accessory bone, the calcaneus secundarius.

Independent calcaneo secundaria with joint surfaces have been observed in adults (2) and it has been assumed that they arise from

Fig. 1.*Fig. 2.**Fig. 1.*

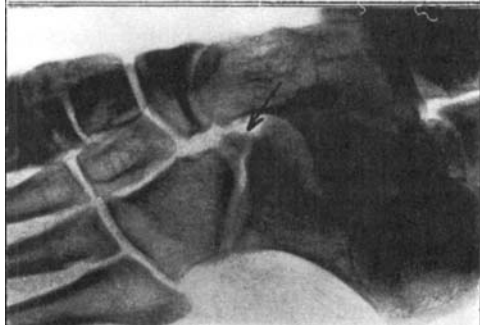
Amphiarthrosis calcaneo-
navicularis (No. 13 1).

Fig. 2.

Synostosis calcaneo-navicularis
(No. 4 1).

Fig. 3.

Calcaneus secundarius
(No. 18 1).

*Fig. 3.*

cartilaginous primordia of their own. The assumption is supported by the observation of independent primordia of other accessory bones in embryonic skeletons of the foot (8).

According to other theories, coalitio calcaneo-navicularis arises through faulty differentiation and ossification of the navicular fibrocartilage (2) and the calcaneus secundarius through ossification of the pars calcaneo-navicularis of the bifurcate ligament, through osteophyte formation (7), traumatic separation of the anterior process of the calcaneus (7), or heterotopic ossification in synovial tags (8).

Incidence.

Coalitio calcaneo-navicularis was observed by *Niederecker* (7) in 27 out of 392 operatively treated feet, by *Pfitzner* (9) in 4 per cent of an anatomical series and by *Harris & Beath* (3) in 1 out of 3600 conscripts. *Hohmann* (5) estimated the incidence at 2 per cent. Until 1954 about 100 cases had been described (2).

Synostosis calcaneo-navicularis was observed in 2.9 per cent of *Pfitzer's* series. According to *Brandt* (2), only some 10 radiologically verified certain cases had been published up to 1954. Later, *Jack* (6) reported 4 cases, *Immhäuser* 1, *Brandt* 2 and *O'Rahilly* 1 case.

It has been stated that calcaneus secundarius occurs in 2 per cent of anatomical series. *Arho* (1) found 7 cases among 716 radiologically examined adult feet.

Clinical features.

Coalitio calcaneo-navicularis occurs most usually in conjunction with common, rigid or spastic flat foot, but also in the absence of any deformity of the foot and even together with pes cavus. Some cases are symptom-free. In other cases, transient or chronic symptoms such as stiffness and pain occur in connection with spraining of the ankle, usually at the age of 10 to 14. In a third group of cases these symptoms occur spontaneously. Clinically, a limited mobility in the subtalar joint is observed. Either the pain predominates, or the stiffness and deformity of the foot. The degree of deformity and of limitation in mobility is considered proportional to the degree of development of the bony bridge and, consequently, is at a maximum in synostosis calcaneo-navicularis (6).

Diagnosis.

A definitive diagnosis can only be made on the basis of a radiographic examination. Besides the usual lateral picture of the foot, this should also comprise a picture made with the medial edge of the foot against the cassette and the sole at an angle of 45 degrees to it (10).

Treatment.

Conservative treatment (immobilization, arch supports, heel wedges, possibly repeated manipulations) is recommended. Surgical procedures are postponed until after the age of 10 to 12 years. Resection of the bony bridge with interposition of soft parts (2), arthrodesis of the subtalar joint (3) and the talonavicular joint (and the calcaneo-cuboideal joint (6), when necessary combined with wedge resection and transposition of the anterior tibial tendon through a channel in the naviculare, have been performed. The small number of the cases renders objective evaluation of the end results uncertain.

Own Material.

At the Hospital of the Invalid Foundation coalitio calcaneo-navicularis and calcaneus secundarius respectively have been observed during the period 1955 to 1959 in a total of 29 feet in 17 patients and at the surgical department of the General Hospital in Björneborg during 1959 to 1961 in a total of 3 feet in 2 patients. Moreover, a transitional form between coalitio and the normal condition was observed in 6 feet in 3 patients. In one patient, a fracture of the anterior process of the calcaneus, imitating a true calcaneus secundarius, was observed. The composition of the material, the most important anamnestic data and clinical symptoms are presented in Table 1.

The anomaly was bilateral in 16 patients, being developed to different degrees on the right and left sides. In 6 cases the anomaly was unilateral. The age of the patients varied between 10 and 63 years, 13 belonging to the age group 10 to 14 years.

In patients nos. 4, 17 and 18 the diagnosis was made incidentally; all the others saw a doctor because of symptoms from their feet. Twelve feet had been entirely or almost entirely symptom-free. Only 7 of the patients with bilateral anomaly had experienced discomfort from both feet.

The commonest subjective symptom was pain, this being almost equally common in amphiarthrosis and in synostosis. Its location was most often the sinus tarsi, the next commonest site being the talocrural joint. Only 3 patients complained of stiffness, 4 of swelling and 2 of slight weakness.

In patients nos. 3, 16 and 23 objective examination according to the agreed scheme was only made after the surgical intervention. If these are excluded, the following facts emerge from the Table 1:

1. Marked or clear flatfoot, highly limited eversion and/or inversion and lack of ability to supinate the foot when standing upright were almost constant features in synostosis, while these symptoms were present in less than 1 case in 2 in amphiarthrosis.

2. Pes abductus and heel-valgus exceeding 10° were equally frequent, being found in about 1 case in 2 in both groups.

3. Moderate limitation of plantar flexion and/or dorsal extension were commoner in synostosis than in amphiarthrosis.

4. Spasticity of the peroneal muscles was observed in only 3 cases of synostosis. Tenderness on palpation was inconstant in regard to both frequency and location. A differential diagnosis between amphi-

TABLE
Symptoms and Signs in

Anomaly	Case no. and side (r = right, l = left)	Sex (M = male F = female)	Age (years)	Duration of symp- toms		Provoked by trauma	Pain					Functional disturbance	Other symptoms	Talipes				Prominence of tuber- culum naviculare	Heel-valgus in 10°	Dimi- of	
				< 1 year	> 1 year		Initial	During walk	After exertion	At sinus tarsi	Other sites			Adductus	Cavus	Abductus	Planus			Plantar flexion	Dorsal extension
S	1,r	M	17	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-
S	1,l			-	+	-	+	-	-	-	-	-	-	-	-	-	+	+	+	-	-
S	2,r	M	21	-	+	-	-	+	+	+	-	-	-	-	-	-	+	+	+	+	-
S	2,l			-	+	-	-	+	+	+	-	-	st	-	-	-	+	+	+	(+)	-
S	3,l	M	13	-	+	-	+	+	-	-	cr	-	sw	-	-	-	+	-	-	+	-
S	4,l	M	19	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	(+)	+
S	5,r	F	12	-	+	-	+	-	-	-	t	+	sw	-	-	-	-	+	+	-	-
S	6,r	M	14	+	-	-	-	-	+	+	-	-	-	-	-	-	+	+	+	(+)	-
A	5,l	F	12	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+
A	6,l	M	14	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-
A	7,r	F	11	-	+	-	-	-	-	-	cr	-	d	-	-	-	-	-	-	-	-
A	7,l			-	+	-	-	-	-	-	cr	-	d	-	-	-	-	-	-	-	-
A	8,r	M	11	+	-	-	+	-	-	-	tn	v	-	-	-	-	+	+	-	-	-
A	8,l			+	-	-	+	-	-	-	tn	v	-	-	-	-	+	+	-	-	-
A	9,r	M	12	-	+	-	-	-	+	-	mt	-	-	-	-	-	+	-	+	-	-
A	9,l			-	+	-	-	-	+	-	mt	-	-	-	-	-	+	-	+	-	-
A	10,r	F	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-
A	10,l			+	-	-	+	+	+	-	fm	+	sw	-	-	-	+	+	+	(+)	-
A	11,r	M	13	+	-	+	+	+	-	+	tm	-	sw	-	-	-	+	+	+	-	-
A	11,l			+	-	+	+	-	-	+	tm	-	sw	-	-	-	+	+	-	-	-
A	12,r	M	16	-	a	+	-	-	-	+	-	st	pi	+	+	-	-	+	+	-	-
A	12,l			-	a	-	-	-	-	-	-	st	-	+	+	-	-	-	+	-	-
A	13,r	M	37	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-
A	13,l			-	+	+	-	-	+	-	fm	st	-	-	-	-	+	+	+	-	+
A	14,r	F	63	-	+	-	-	+	-	+	-	-	M	-	-	-	+	-	-	-	-
A	14,l			-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-
A	15,r	M	12	-	+	-	+	-	-	-	cr	+	l	-	-	-	+	+	-	-	-
A	16,l	M	14	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-
A	17,l	F	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
CS	18,r	M	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(+)	-
CS	18,l			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(+)	-
CS	19,l	M	45	+	-	+	-	+	-	-	cr	-	-	-	-	-	-	-	-	-	-
tr	20,r	F	10	-	+	-	-	+	+	-	mV	-	-	-	-	-	+	+	+	-	-
tr	20,l			-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-
tr	21,r	F	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
tr	21,l			+	-	-	+	+	-	-	-	-	M	-	-	-	-	-	-	-	-
tr	22,r	F	26	+	-	-	-	-	+	+	mV	-	-	-	-	-	-	+	-	-	-
tr	22,l			-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
(CS)	23,l	M	39	-	+	+	-	+	+	-	-	-	-	-	-	-	+	-	-	-	-

Explanation of abbreviations: A = amphiarthrosis, a = always, cr = at talocrural joint, CS = malleolus, l = limp, M = symptoms of Morton's neuralgia, mt = in the metatarsal region, mV = at the scar, st = stiffness, sw = swelling, t = at tarsal region, tm = at tip of tibial ing and walking.

1

Clinically Examined Cases.

inished mobility the feet				Inability to supinate foot when standing	Tenderness			Remarks
Inver- sion		Ever- sion			at sinus tarsi	at other sites	Peroneal spasm	
0-30°	35-50°	0-10°	15-30°					
+	-	+	-	+	-	-	-	earlier treated for cong. clubfoot.
+	-	+	-	+	-	-	-	earlier treated for cong. clubfoot.
+	-	-	+	+	+	-	+	stands on his toes only with flexed knees.
+	-	+	-	+	+	t	-	(Postoperative status). Bilat. insufficiency of glutei and gastrochnemii.
-	+	-	+	+	+	-	-	Luxatio cong. coxae sin.
-	+	-	-	(+)	-	-	-	
+	-	-	+	(+)	+	-	+	
-	+	-	-	(+)	-	-	-	
+	-	-	+	(+)	-	-	-	
-	-	-	+	-	-	-	-	
-	-	-	-	-	-	-	-	
-	-	-	-	-	-	fm	-	
-	-	-	-	-	-	fm	-	
-	-	-	+	-	-	-	-	earlier had calcaneus varus.
-	-	-	+	-	-	-	-	earlier had calcaneus varus.
+	-	-	+	-	-	-	-	
-	+	-	+	(+)	+	-	-	
-	+	-	+	(+)	+	-	-	
-	-	-	+	(+)	-	-	-	
-	-	-	+	(+)	-	-	-	
+	-	-	-	-	-	-	-	
+	-	+	-	(+)	-	-	-	has had no relief of the symptoms by arch supports.
-	+	-	+	-	+	-	-	treated elsewhere for "rheumatism" with injections of formic acid.
-	-	-	+	-	+	-	-	
-	-	+	-	-	+	-	-	
-	+	-	-	-	-	-	-	(postoperative status).
-	-	-	+	-	-	-	-	remitted for examination by the school physician.
-	-	-	+	-	-	-	-	treated for fracture of basis metatarsalis V.
-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	years age sprained his ankle, but not examined by a doctor.
-	-	-	-	-	-	-	-	
-	-	-	-	-	-	-	-	
-	-	-	+	-	-	-	-	
-	-	-	-	-	+	-	-	
-	-	-	-	(+)	-	mV	-	
-	-	-	-	-	-	-	-	
-	+	-	+	-	-	sc	-	(postoperative status). Fracture of anterior process of calcaneus.

calcaneus secundarius, d = repeated small distortions of the ankle, fm = in front of the tibial
= at base of V. metatarsal bone, pi = pains when walking on an inclined plane, S = synostosis,
malleolus, tn = at talonavicular joint, tr = transient case and v = varus tendency when stand-

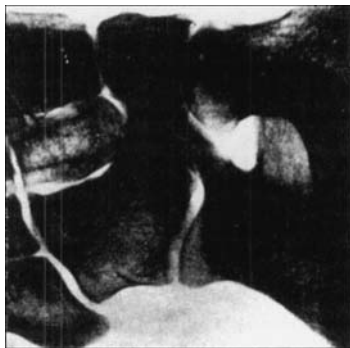


Fig. 4.

Amphiarthrosis calcaneo-navicularis et cuboideo-navicularis (No. 10 l).

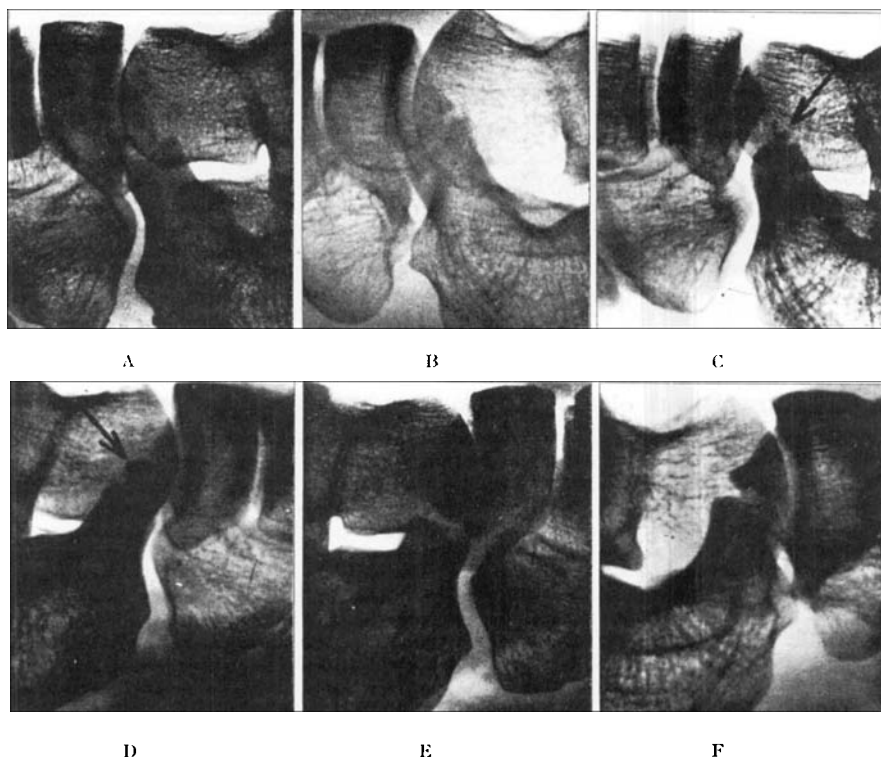
arthrosis and calcaneus secundarius and the transitional form to normal conditions could not be clinically ascertained.

Radiographic observations.

The bony bridge in synostosis was always at least 1 cm. wide, while in amphiarthrosis the width of the "joint surfaces" was less than 0.5 cm. in 6 cases. Repeated radiographic examinations showed that in one case the width of the "joint surfaces" increased proportionally with the growth of the skeleton. To be able clearly to demonstrate the absence or presence of a fissure between the calcaneus and the naviculare or between these and the os calcaneus secundarius, it was often necessary to take several radiograms, varying the position of the foot and the direction of the central ray.

The differential diagnosis between calcaneus secundarius and a fracture of the anterior process of the calcaneum may be uncertain. In case no. 18 l (Fig. 3) there had been no trauma, the foot was symptomless. The ventral joint surfaces of the bone between calcaneus and naviculare formed a "step" and the structure of the bone was "cloudy" as it was in case no. 9 r (Fig. 5 D). This case was considered as one of a true calcaneus secundarius. In case no. 23 l the symptoms were provoked by a severe hyperflexion-trauma. The joint surfaces formed an unbroken curved line and the bony structure of the bone between calcaneus and naviculare was well developed. This case was considered as one of fracture of the anterior process of the calcaneus.

In more than half the cases, equally often in synostosis and in amphiarthrosis, beginning or moderate arthrosis was observed in the talo-

*Fig. 5.*

Os calcaneus secundarius fusing with calcaneus and naviculare, respectively (No. 9 l = A-C and No. 9 r = D-F, A and D at 11½, B and E at 12 and C and F at 14).

navicular joint, the condition being severe in two of the cases of synostosis (bilaterally in patient no. 2).

Accessory findings were os tibiale externum 6 times (nos. 4 r, 8 r, 8 l, 12 l, 18 r and 22 r), os peronaeum once (no. 8 r), os intermetatarsale once (no. 12 r) and vesalium once (no. 18 r), and splitting into two of one of the sesamoid bones of the great toe 8 times (nos. 12 r, 12 l, 14 r, 14 l, 16 r, 16 l, 21 r and 21 l). Such accessory findings were thus observed twice in feet without other anomalies. Besides a narrow amphiarthrosis between the calcaneus and the naviculare, in case 17 l, there was also a wide one between the cuboideus and the naviculare (Fig. 4).

In radiograms of patient 9 taken at intervals of about one year from the ages of 11 to 16 years, it was possible to observe how an os calcaneus secundarius on the left side fused with the calcaneus and on the right side with the naviculare (Fig. 5). In patients 6, at the age of 13, bilateral

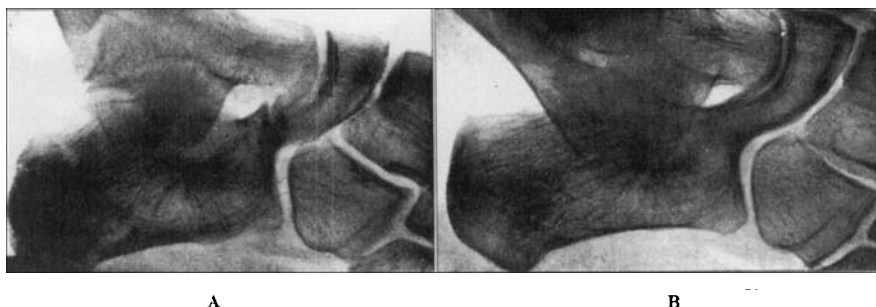


Fig. 6.

Development of amphiarthrosis to synostosis (No. 6 r, A at 13 and B at 14½).

amphiarthrosis was observed, but at re-examination one and a half years later synostosis was found on the right side (Fig. 6).

Treatment.

Thirteen patients were given, or already had, arch supports. In cases of synostosis this treatment was without any effect while in other groups considerable relief was achieved in all cases except three. The symptoms of one patient disappeared after a period of rest. Five feet in 4 patients were treated surgically:

No. 2 r and 2 l: Owing to persistent pain in the foot which was not relieved by arch supports, extra-articular subtalar arthrodesis was carried out according to *Grice*. At follow-up half a year later the patient was subjectively symptom-free, the position of the feet was improved, there was insignificant persisting eversion of the heel, and the bony transplant had healed (Fig. 7).

No. 3 l: As it was presumed that the stiffness and tenderness caused by the synostosis was the reason for the stiff gait of the patient and that through inactivity they had indirectly produced weakness of the glutei and the triceps surae, resection of the bony bridge, with interposition of a flap of soft tissue, was carried out. The joint capsule was found to be thickened, histological examination demonstrating signs of unspecific arthritis. At follow-up one year later the status of the patient, both subjectively and objectively, was unchanged. Radiographic examination revealed calcareous deposits at the site of the resected bony bridge (Fig. 8).

No. 15 l: Owing to pain at plantar flexion and inversion after strain which could not be alleviated with arch supports, the amphiarthrosis (Fig. 9) of about 1 cm. was resected and a soft tissue flap interposi-

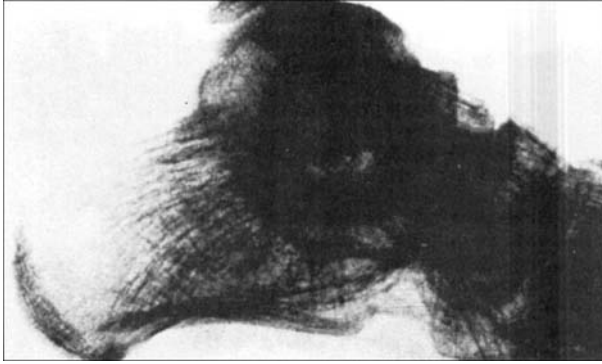
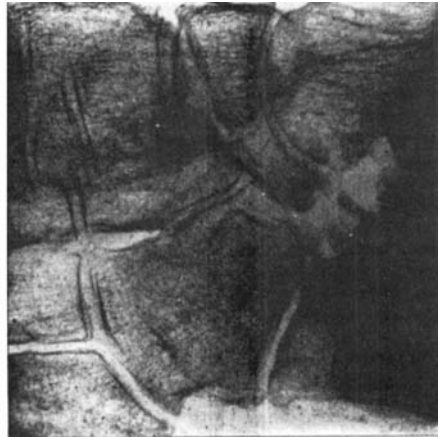


Fig. 7.

Synostosis calcaneo-navicularis treated by extra-articular arthrodesis a.m. Gice, status $\frac{1}{2}$ year postoperatively (No. 2 r).



A



B

Fig. 8.

Synostosis calcaneo-navicular treated by resection of the bony bridge, A before and B 1 year after the resection. Note the calcaneous deposits at the site of the former bridge in B (No. 3 l).



Fig. 9.

Amphiarthrosis calcaneo-navicularis treated with resection of the bridge. Radiograph of the resected specimen (No. 16 l).

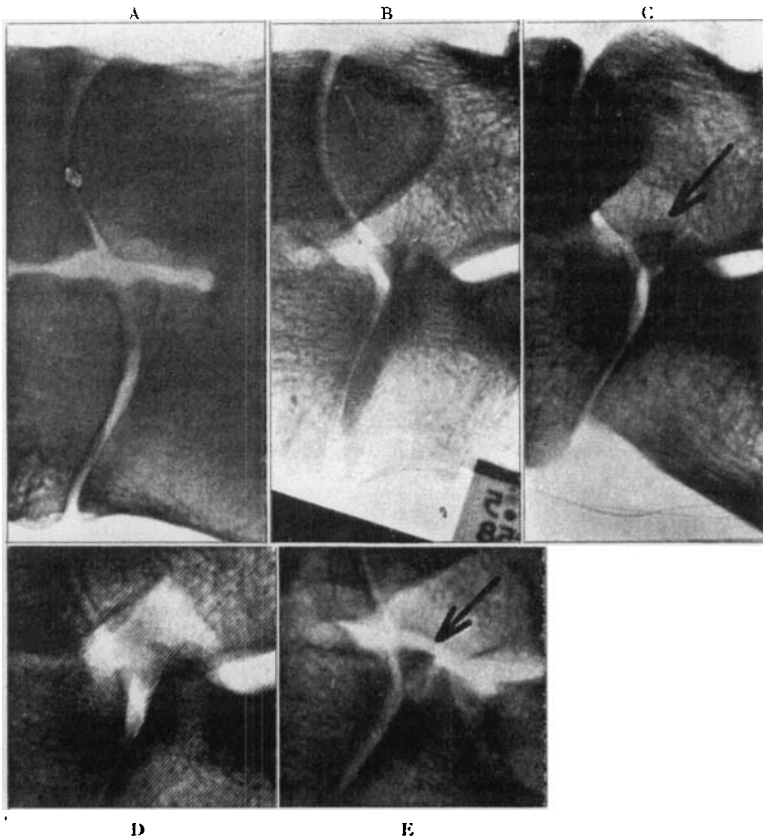


Fig. 10.

"False" os calcaneus secundarius, originating from fractured anterior process of the calcaneus, A and B after the initial trauma, C preoperatively, D at resection (interpreted as showing that the fragment has been removed) and E one year later, showing the fragment still in place (No. 23 I).

tioned. At follow-up one and a half years later the patient was subjectively symptom-free and the mobility of the foot normal with the exception of slight limitation of eversion.

No. 23 I: Under the diagnosis fracture of the anterior process of the calcaneus the patient had been treated elsewhere with immobilization and arch supports, without subjective alleviation of the symptoms. Injection of Hydrocortisone between the calcaneus and naviculare gave no relief. At operation, a piece of bone was removed which at radiographic control (also postoperatively) was identified as the primarily observed fragment, and a flap of soft tissue was interpositioned. At follow-up one year later the patient stated that symptoms still occurred

after heavy work, but that otherwise arch supports gave sufficient relief. Radiographic examination showed that the primarily observed fragment still persisted (Fig. 10).

CONCLUSIONS

The present study corroborates previous observations on subjective symptoms and objective findings in this anomaly of the skeleton of the foot. An almost constant phenomenon in synostosis was inability to supinate the foot when standing upright. In amphiarthrosis the foot may preserve a high degree of mobility even when the "joint surfaces" are wide and the "joint space" narrow.

The observations in cases 6 and 9 argue in favour of the assumption of an undivided cartilaginous primordium of the calcaneus and the naviculare in coalitio calcaneo-navicularis. In none of the observed cases does the shape of the connection or its topographical site lend support to the suggestion that it originates through ossification of the navicular fibrocartilage. In case 23 a condition resembling os calcaneus secundarius may have occurred through fracture of the anterior process of the calcaneus, followed by pseudoarthrosis.

Treatment of synostosis with arch supports seems futile while in mild cases of coalitio it may be adequate. Early radical resection in amphiarthrosis may result in freedom from symptoms (no. 16). No certain conclusions can be drawn on the basis of cases 3 and 23; in the former the picture was complicated by an unspecific arthritis and in the latter the operation contemplated was not carried out. Case 2 shows that as long as marked arthrosis of the talonavicular and calcaneo-cuboideal joints do not demand triple arthrodesis, extra-articular subtalar arthrodesis as described by *Grice* may give good results in synostosis.

SUMMARY

A series of altogether 31 cases of coalitio calcaneo-navicularis or calcaneus secundarius and one case of "false" calcaneus secundarius is reported, in 5 of which surgical treatment was given. Treatment with arch supports may be adequate in mild cases of coalitio, but seems futile in synostosis. Early resection in amphiarthrosis may give good results, as extra-articular subtalar arthrodesis may do in cases of synostosis without marked deforming arthrosis. Triple arthrodesis is probably the most adequate treatment in cases with pronounced arthrosis.

RESUME

Rapport sur une série qui compte en tout 31 cas de coalitio calcaneo-navicularis ou calcaneus secundarius et un cas de faux calcaneus secundarius. Un traitement chirurgical a été appliqué dans 5 de ces cas. Le traitement au moyen de supports courbés peut être approprié dans les cas bénins de coalitio, mais peut paraître futile lorsqu'il s'agit de synostose. Une résection précoce de l'amphiarthrose peut donner de bons résultats, également l'arthrodèse subtalar extra-articulaire dans les cas de synostose sans arthrose déformante marquée. Une triple arthrodèse est probablement le traitement le plus approprié dans les cas chez lesquels il y a arthrose prononcée.

ZUSAMMENFASSUNG

Über eine Reihenfolge von 31 Fällen von Coalitio calcaneo-navicularis oder calcaneus secundarius und einen Fall von falschem calcaneus secundarius wird berichtet. Bei fünf von diesen Fällen wurde eine chirurgische Behandlung vorgenommen. Die Behandlung mit Plattfusseinlagen kann in milden Fällen von Coalitio ausreichend sein, scheint jedoch bei Synostosen vergeblich zu sein. Frühzeitige Resektion kann bei Amphiarthrosen gute Ergebnisse zeitigen. Ebenso kann man mit der extra-artikulären subtalaren Arthrodese in Fällen von Synostosis ohne ausgesprochene Arthrosis deformans gute Resultate erzielen. Triple Arthrodese ist wahrscheinlich die beste Behandlungsmethode in Fällen mit ausgesprochener Arthrose.

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