Acta Orthop. Belg., 2009, **75**, 654-660

ORIGINAL STUDY

Plantar contact stress and gait analysis after resection of tarsal coalition

Adrian SKWARA, Vassiliki ZOUNTA, Carsten O. TIBESKU, Susanne FUCHS-WINKELMANN, Dieter ROSENBAUM

From the University Hospital Marburg, Germany

The purpose of this study was to assess the foot loading characteristics and foot function of patients after operative correction of a tarsal coalition.

Ten patients who had undergone operative treatment of a tarsal coalition were included in this study. One foot was affected in five patients and both feet in the other five. A calcaneonavicular coalition was present in 12 feet and a talocalcaneal coalition in three feet. Mean follow-up was 11.3 years. Clinical evaluation was based on a standardized questionnaire, a visual analogue scale for pain (VAS), the American Orthopaedic Foot and Ankle Society (AOFAS) Score and radiographic evaluation of the last radiographs. An objective analysis of foot loading characteristics was carried out with instrumented gait analysis and pedobarography.

The clinical results were overall fair for pain, range of motion and walking distance. The AOFAS also showed fair results (mean : 78.1) at follow-up. Gait analysis revealed alterations in kinematic and kinetic parameters for the operated foot. Pedobarographic analysis showed altered loadings for heel and forefoot.

In this study, operative treatment of tarsal coalition achieved fair clinical and radiographic results and did not restore physiologic gait and foot loading.

Keywords : tarsal coalition ; bar resection ; gait analysis ; pedobarography.

INTRODUCTION

Tarsal coalition is a rare foot anomaly with an estimated incidence of 0.03% to 1% (*1,5,19*). It has been demonstrated that in the phylogenetic evolution of tarsal coalition, absence of segmentation of the primitive mesenchyme leads to the foot abnormality (*4,25*). Leonard suggested that tarsal coalitions may be hereditary, possibly due to a unifactorial disorder with dominant inheritance (*14*). In some cases post-traumatic or post-infectious tissue reactions have been responsible for the development of a tarsal coalition. Coalitions may be classified on the basis of completeness of ossification into synostosis, synchondrosis and syndesmosis (*16*). In approximately 90% of cases, these unions occur at

■ Adrian Skwara, MD, Orthopaedic surgeon.
■ Susanne Fuchs-Winkelmann, MD, Orthopaedic surgeon, Professor of orthopaedic surgery.
Department of Orthopaedics and Rheumatology, University Hospital Marburg, Germany.
■ Vassiliki Zounta, Resident in Internal Medicine.
Department of Internal Medicine, St. Franziskus Hospital Münster, Germany.
■ Carsten O. Tibesku, MD, Orthopaedic surgeon, Associate Professor of Orthopaedic surgery.
Sporthopaedicum Straubing, Straubing, Germany.
■ Dieter Rosenbaum, PhD, Scientist, Professor of experimental orthopaedics.
Department of Orthopaedics, Movement Analysis Lab, University Hospital Münster, Germany.
Correspondence : Adrian Skwara, MD, Department of Orthopaedics and Rheumatology, University Hospital Marburg, Baldingerstrasse, D-35041 Marburg, Germany. E-mail : skwara@med.uni-marburg.de

No benefits or funds were received in support of this study

the talocalcaneal joint (48.1%) and calcaneonavicular joint (43.6%) (*19*). The other forms of tarsal coalition are rare and often asymptomatic. Clarke reported a multiple occurrence of tarsal coalition in one foot in 20% of the patients in his study group (*2*).

Tarsal coalitions, especially talocalcaneal coalitions, have been recognized as a common cause of rigid, painful flatfoot (*16*). Furthermore, the resulting alterations of muscle activity patterns and shortening of the muscle tendons, especially of the peroneal and extensor muscles, aggravate pain and maintain foot deformity (*18*). A chronic malposition and incorrect bearing of the articular surface can also cause osteoarthritis.

The treatment of symptomatic tarsal coalitions can be divided into conservative and operative options. Operative treatment is reasonable when conservative options like orthotics, anti-inflammatory drugs or casting are not sufficient to manage the symptoms. For operative treatment of the tarsal coalition, various procedures have been proposed depending on the location and dimension of the osseous bar. Simple resection may cause hindfoot or midfoot instability and has been shown to have a higher risk of recurrence of the coalition (*10*). Fat or local muscle interposition into the resection gap may be useful to minimise the recurrence risk (*20,23,24*). In some cases, only fusion of the affected joints is reasonable. The type of procedure depends on the location of the coalition, the symptoms, the age of the patient, the foot deformity and degenerative changes in the affected joints.

A better understanding of the pathology of tarsal coalition and its influence on functional deficits appears necessary. However, few investigations were published in the literature so that general guidelines with respect to the best surgical option are still lacking. The aim of our study was the evaluation of changes in foot loading characteristics and gait patterns of patients after operative treatment of tarsal coalition. Furthermore, clinical and radiographic results were investigated.

MATERIAL AND METHODS

Clinical and functional examinations were performed in 10 patients (with 15 affected feet) with a mean age of 25.8 ± 9.5 years (range 12 to 40 years) and a mean age at operation of 14.5 ± 7.9 years (range 3-30 years) (table I). All patients or parents representing their children agreed to participate in the study and provided informed consent. Three patients were female and seven male. Three patients had a coalition of the right foot, two of the left foot and five in both feet. There was a calcaneonavicular coalition in 12 feet and a talocalcaneal coalition in three feet. In all patients a hereditary nature of the coalition was postulated, because there was no history of trauma or infection. A total of 15 operative interventions on 15 feet were performed, i.e. one intervention per foot. Simple resection of the bar was performed in nine feet ; in the other six feet, it was combined with interposition

Table I. — Demographic Data

Patient	Age [yrs]	Age at OP [yrs]	Gender	Follow-up [yrs]	Site	Coalition	Operation
1	21	4	M	17.0	bilateral	calcaneo-navicular	R
2	13	11	M	2.6	bilateral	calcaneo-navicular	MI
3	26	13	M	12.9	right	calcaneo-navicular	MI
4	28	12	M	15.4	right	calcaneo-navicular	R
5	33	26	F	6.4	right	talo-calcanear	R
6	12	11	F	1.2	bilateral	calcaneo-navicular	MI
7	18	13	M	5.3	bilateral	calcaneo-navicular(R)/ talo-calcanear(L)	R
8	32	13	M	19.8	bilateral	calcaneo-navicular	R
9	40	12	F	28.8	left	calcaneo-navicular	R
10	34	31	M	3.5	left	talo-calcanear	MI

Demographic data of the patient population presenting current age, age at operation, gender (M = male, F = female), follow-up duration, site of occurrence of the coalition, affected joint or regions and type of operative intervention (R = simple resection, MI = resection and interposition of extensor digitorum brevis muscle).

of the extensor digitorum brevis muscle. In two talocalcanear coalitions a simple resection was performed from a medial approach and in the third case, where the coalition was localised in the anterior joint facet, interposition of the extensor digitorum brevis was performed from a lateral approach. In the 12 feet with calcaneonavicular coalition, simple resection was performed in seven feet ; it was combined with interposition of a muscle flap of the extensor digitorum brevis in five other feet. A lateral surgical approach was used in all 12 cases. The indications for operation were pain on weight bearing in seven cases and persistent pain in three cases ; in three other cases, pain was combined with limited subtalar motion, non responsive to conservative treatment. The contralateral foot in all these patients did not display any tarsal coalition and was used for comparison. The mean follow-up was 11.3 ± 9.0 years (range : 1.2 to 28.8 years).

A standardised questionnaire and examination protocol was used for assessment. Instrumented gait analysis and pedobarography were performed in the Movement Analysis Laboratory. Gait analysis was performed with reflective markers applied according to the Helen-Hayes marker set (*11*). The marker movement was recorded with a six camera system at 60 Hz (Motion Analysis Corporation, Santa Rosa, USA). Ground reaction forces were recorded at 600 Hz with two force platforms embedded in the walkway (Advanced Mechanical Technology, Inc., Watertown, MA, USA). Kinetics and kinematics of the lower extremity of the affected and non affected leg were assessed. For the foot and ankle especially, the following gait parameters were analyzed : stride length, cadence, walking speed, ankle range of motion, ankle abduction and plantar flexion moments.

Pedobarographic analysis was performed with a capacitive platform embedded flush in the floor (EMED ST4 ; Novel, Munich, Germany). The patients walked barefoot over this platform with a sensor array of 2736 sensors with a spatial resolution of four sensors per cm^2 and a measurement frequency of 50 Hz. The subjects were asked to walk barefoot across the platform with step length and walking speed as usual. Before measurements were made, the patients were instructed to walk repeatedly across the platform in order to familiarize with the testing conditions. Measurements were repeated until five valid trials of each foot had been recorded. Pedographic pressure patterns were subdivided into the following regions of interest : heel, midfoot, first metatarsal, second metatarsal, lateral metatarsals, hallux, second toe and lateral toes (Novel Database Pro-M 11.26). Maximum force, contact area, peak pressure and average pressure were calculated for each foot region (*9*). The contact time during the roll-over process was measured as an indication of the patient´s gait velocity.

Furthermore, the outcome was quantified using the German version of the AOFAS hindfoot score (*12*). Radiographs taken at the last follow-up examination were evaluated by a radiologist and an orthopaedic surgeon.

RESULTS

Evidence of familial predisposition was noted in two patients. With respect to pain, seven patients rated the outcome of operative treatment on a self-assessment scale as very good or good, six as fair and two as poor. With regard to range of motion, the outcome was rated as very good or good in seven patients, there was no change in motion in two patients, and one patient reported a subjectively decreased range of motion of the affected foot. Seven patients had no limitation in their walking distance, and three other patients were able to walk over 1000 meters without pain. One patient had to perform occupational retraining, but all patients were able to return to work without any disability caused by foot disorders. Postoperative complications were seen in four cases in the form of paraesthesia in the scar region. The average pain level on the VAS was 26.4 ± 24.8 mm (range 0 to 58). The German version of the AOFAS score showed excellent results in three patients, good results in two patients, fair results in three and poor results in two patients (table II).

The radiographic analysis did not show any recurrence of the tarsal coalition but radiographic signs of incipient osteoarthritis of the affected joint were noted in three feet.

In the computer assisted gait analysis, kinematic parameters showed alterations in all operated feet compared to the non operated feet for walking speed, stride length and stride cadence (table III). The kinetic parameters also showed alterations in knee range of motion in stance and swing, ankle range of motion and the first and second peak of the vertical force (table IV).

Pedobarographic analysis revealed lower peak pressures and maximum force values in the heel, midfoot and medial forefoot area of the operated foot. It was combined with longer contact times, except for the heel which had a short contact time

Table II. — Clinical Results

Patient	Side	VAS	Osteoarthritis	AOFAS	Result
1	bilateral	0	bilateral	43	Poor
2	bilateral	53	no	78	Fair
3	right	0	no	92	Excellent
4	right	58	right	64	Poor
5	right	30	no	73	Fair
6	bilateral	0	no	95	Excellent
7	bilateral	0	no	95	Excellent
8	bilateral	0	no	87	Good
9	left	20	no	82	Good
10	left	50	no	72	Fair

The table presents the postoperative clinical results containing the visual analogue scale (VAS), osteoarthritis of the affected joint at follow-up, using the German version of the American Orthopaedic Foot and Ankle Score (AOFAS) and its classification from excellent to poor.

Table III. — Gait Analysis : Temporo-Spatial Parameters

	Affected foot		Non-affected foot	
	mean	SD	mean	SD
Walking Speed (cm/sec)	120.7	8.3	124.2	7.4
Stride Length (cm)	64.4	5.2	66.3	3.1
Stance (%)	61.8	2.2	61.7	1.9
Swing (%)	38.1	2.2	38.2	1.9
Step width (cm)	11.1	2.2	11.1	1.9
Cadence (stride/min.)	111.9	10.1	107.5	6.3

Results of the gait analysis patterns showing major differences between affected and healthy feet.

compared to the non-affected foot and smaller contact areas of heel and midfoot (table V).

DISCUSSION

In the current literature, there is no general agreement regarding the efficacy of surgical treatment of tarsal coalition. Good and excellent short-term clinical results have been reported (*3,7,10,13,15,18,26*). In our investigation, which included patients with calcaneonavicular and talocalcanear coalition, we could not confirm these excellent results with a longer follow-up.

Kinematic and kinetic abnormalities during gait have been demonstrated in few studies after surgery for tarsal coalition (*6,8,13,17,22*). For talocalcanear coalitions, Giacomozzi *et al* showed increased vertical stress at the hindfoot as well as abnormal kinematics of the tibiocalcaneal joint in the sagittal (dorsiflexion-plantarflexion) and coronal (inversion-eversion) planes in conservatively treated feet compared to operated feet (*6*). Non-physiological stress on the heel in stance and gait was demonstrated. Reduced hindfoot loading in the affected foot was also confimed by our own results. Furthermore, two studies showed a higher load under the lateral heel compared to healthy controls (*8,17*). In contrary, measurements of pressure on the midfoot and forefoot have produced diverging results. While Hetsroni *et al* (*8*) and our own results revealed lower pressure on the midfoot, Lyon *et al* (*17*) measured significantly greater pressures in this region. They also demonstrated significantly higher pressures of the forefoot, localised at the first metatarsal. In our patients, we noted for the heel and midfoot a shorter contact

Table IV. — Gait Analysis : Kinematics and Kinetics

	Affected foot		Non-affected foot	
	mean	SD	mean	SD
Knee Range of Motion in Stance [°]	17.26	4.02	17.44	2.50
Knee Range of Motion in Swing [°]	56.44	5.10	57.33	5.49
Ankle Range of Motion [°]	14.67	4.27	16.24	2.19
Vertical Force Maximum 1 [BW]	1.14	0.01	1.10	0.01
Vertical Force Minimum [BW]	0.77	0.01	0.75	0.01
Vertical Force Maximum 2 [BW]	1.09	0.01	1.10	0.10
Knee Abduction Moment [Nm/kg BW]	0.36	0.19	0.39	0.10
Knee Flexion Moment [Nm/kg BW]	0.39	0.21	0.43	0.01
Ankle Abduction Moment [Nm/kg BW]	0.01	0.01	0.01	0.01
Ankle Flexion Moment [Nm/kg BW]	1.32	0.19	1.35	0.01

Results of gait analysis patterns showing major differences between affected and healthy feet.

time, a smaller contact area and a lower pressure in the affected foot compared to the non-affected foot. Furthermore we measured an increased peak pressure in the lateral column of the foot, especially for the fourth and fifth metatarsal and the lateral toes. The reason for this observation could be the different hindfoot deformity and a subsequent restriction of subtalar movement which may ultimately lead to impairment of the midfoot locking mechanism needed for forefoot load transfer and propulsion. The reason for better gait patterns of operatively treated feet might be the restoration of the hindfoot and the joint alignment. This alignment is an important factor for the outcome especially in cases with talocalcaneal coalition (*6*). The increased lateral pressure in our study group may result from correction of hindfoot valgus and reactive compensatory hindfoot varus.

Wilde *et al* (*27*) reported poor outcome when a hindfoot valgus of more than 16° was present in talocalcaneal coalition. Luhmann *et al* found poor results after surgery when the hindfoot valgus was more than 21°, but a major varus deformity also had a poorer prognosis (*3,15*). Furthermore, the size of the bony bar relative to the unaffected part of the joint area is a very important factor for clinical and functional outcome. Depending on the size of the resected area of the joint, the remaining joint must sustain weight bearing stress on a smaller joint surface. A higher load per unit area may overload the remaining joint, leading to cartilage fibrillation and degeneration with subsequent osteoarthritis of the affected or adjacent joints (*15*). Almost one-fifth of our operated feet had radiographic signs of incipient osteoarthritis at follow-up. In our investigation, we could also evaluate gait abnormalities. Reduced range of motion of the ankle joint and abnormal ground reaction forces were noted, confirming the changes demonstrated by Kitaoka *et al* (*13*). Gait analysis also showed a decreased range of motion of the affected knee, which can be explained by limited ankle movement.

For operative treatment, various procedures like simple resection or interposition of fat as well as interposition of muscultendinous grafts into the resection gap have reportedly resulted in excellent or good results in 70-80% of patients (*7,13,24,26*). Peterson pointed out a major problem with respect to talocalcaneal coalition (*21*), by demonstrating that simple resection of the coalition does not lead to correction of the valgus deformity and the malalignment of the joint and may be followed by an increase of the deformity. For this problem Giannini *et al* described a procedure combining surgical resection of the talocalcanear coalition with a subtalar arthroereisis with a self-resorbing implant (*7*). Excellent and good results with a successful correction of the symptomatic flatfoot and restored hindfoot alignment and reduced pain were found in 78%. Contrary to the current literature we found excellent or good results in only 50% of our patients (*8,24*). Reasons for this result may

Table V. — Pedobarography

	Affected foot		Non-affected foot	
	mean	SD	mean	SD
Maximum Force (N)				
Heel	426.0	222.2	507.0	91.3
Midfoot	125.8	114.8	131.5	15.8
Metatarsal 1	163.1	73.7	184.8	51.7
Metatarsal 2	170.6	71.8	196.8	33.9
Metatarsal 3	169.3	71.7	184.4	38.8
Metatarsal 4	126.2	65.7	98.8	26.1
Metatarsal 5	65.2	36.6	36.2	12.5
Hallux	135.0	78.6	140.6	41.4
2. Toe	20.7	10.1	24.3	8.3
3. -5. Toes	27.8	23.8	20.1	17.7
Contact Time (ms)				
Heel	303.9	147.6	360.0	55.1
Midfoot	367.8	177.6	439.2	87.7
Metatarsal 1	570.9	67.1	556.0	56.7
Metatarsal 2	581.5	64.8	568.8	53.4
Metatarsal 3	589.8	65.3	580.0	49.7
Metatarsal 4	584.6	63.1	572.8	56.0
Metatarsal 5	545.6	63.1	510.4	74.5
Hallux	495.9	135.5	484.8	79.8
2. Toe	460.1	102.1	453.6	111.2
3. -5. Toes	462.4	97.4	409.6	130.1
Contact Area (cm^2)				
Heel	30.8	14.3	34.7	3.7
Midfoot	23.7	14.1	29.2	6.4
Metatarsal 5	5.8	1.0	5.4	0.4
Peak Pressure (kPa)				
Heel	332.9	158.4	417.4	243.7
Midfoot	106.2	68.4	111.6	17.8
Metatarsal 1	351.6	194.8	332.6	114.8
Metatarsal 2	441.7	267.3	448.8	136.2
Metatarsal 3	405.2	253.3	390.4	91.5
Metatarsal 4	353.8	315.0	253.8	59.2
Metatarsal 5	319.2	305.3	128.8	52.0
Hallux	403.1	247.9	443.0	145.3
2. Toe	142.1	70.5	197.2	125.2
3. -5. Toes	128.8	111.4	104.6	91.4

Results of pedobarographic analysis demonstrating differences between the affected and non affected foot.

be persistent foot deformity in one patient and a development of osteoarthritis in the affected joint on the long term. Pain in the foot and foot deformities may cause an antalgic gait, which may also be responsible for changes in gaitand pedobarographic outcome. In our patients, interposition of muscle did not appear to influence the clinical outcome and recurrence of the coalition.

Limitations of our retrospective study were the small sample size and the two coalition types included in the investigation. Furthermore, the surgical technique has not been consistent. Therefore, we did not attempt to compare the results in various subsets of patients. However all published studies on this topic have a similar limitation because of the limited size and the heterogeneity of the cohorts studied.

In conclusion, we could not confirm the clinical and radiographic results often reported after operative resection of tarsal coalition. The operative procedures achieved overall a better and more physiological gait pattern, but were not able to restore normal gait. Currently, surgical techniques including bar resection and interposition of fat or muscle tissue in the resection gap result in the best possible results with operative treatment of tarsal coalition. Further investigations with prospective and functional study designs and homogenous study population are needed.

REFERENCES

1. **Bohne WH.** Tarsal coalition. *Curr Opin Pediatr* 2001 ; 13 : 29-35.
2. **Clarke DM.** Multiple tarsal coalitions in the same foot. *J Pediatr Orthop* 1997 ; 17 : 777-780.
3. **Comfort TK, Johnson LO.** Resection for symptomatic talocalcaneal coalition. *J Pediatr Orthop* 1998 ; 18 : 283-288.
4. **Cooperman DR, Janke BE, Gilmore A *et al.*** A three-dimensional study of calcaneonavicular tarsal coalitions. *J Pediatr Orthop* 2001 ; 21 : 648-651.
5. **Crim JR, Kjeldsberg KM.** Radiographic diagnosis of tarsal coalition. *AJR Am J Roentgenol* 2004 ; 182 : 323-328.
6. **Giacomozzi C, Benedetti MG, Leardini A *et al.*** Gait analysis with an integrated system for functional assessment of talocalcaneal coalition. *J Am Podiatr Med Assoc* 2006 ; 96 : 107-115.
7. **Giannini S, Ceccarelli F, Vannini F, Baldi E.** Operative treatment of flatfoot with talocalcaneal coalition. *Clin Orthop* 2003 ; 411 : 178-187.
8. **Hetsroni I, Ayalon M, Mann G *et al.*** Walking and running plantar pressure analysis before and after resection of tarsal coalition. *Foot Ankle Int* 2007 ; 28 : 575-580.
9. **Hodge MC, Bach TM, Carter GM.** Orthotic management of plantar pressure and pain in rheumatoid arthritis. *Clin Biomech (Bristol, Avon)* 1999 ; 14 : 567-575.
10. **Inglis G, Buxton RA, Macnicol MF.** Symptomatic calcaneonavicular bars. The results 20 years after surgical excision. *J Bone Joint Surg* 1986 ; 68-B : 128-131.
11. **Kadaba MP, Ramakrishnan HK, Wootten ME.** Measurement of lower extremity kinematics during level walking. *J Orthop Res* 1990 ; 8 : 383-392.
12. **Kitaoka HB, Alexander IJ, Adelaar RS *et al.*** Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int* 1994 ; 15 : 349-353.
13. **Kitaoka HB, Wikenheiser MA, Shaughnessy WJ, An KN.** Gait abnormalities following resection of talocalcaneal coalition. *J Bone Joint Surg* 1997 ; 79-A : 369-374.
14. **Leonard MA.** The inheritance of tarsal coalition and its relationship to spastic flat foot. *J Bone Joint Surg* 1974 ; 56-B : 520-526.
15. **Luhmann SJ, Schoenecker PL.** Symptomatic talocalcaneal coalition resection : indications and results. *J Pediatr Orthop* 1998 ; 18 : 748-754.
16. **Lui TH.** Arthroscopic resection of the calcaneonavicular coalition or the "too long" anterior process of the calcaneus. *Arthroscopy* 2006 ; 22 : 903.e1-903.e4.
17. **Lyon R, Liu XC, Cho SJ.** Effects of tarsal coalition resection on dynamic plantar pressures and electromyography of lower extremity muscles. *J Foot Ankle Surg* 2005 ; 44 : 252-258.
18. **Mosier KM, Asher M.** Tarsal coalitions and peroneal spastic flat foot. A review. *J Bone Joint Surg* 1984 ; 66-A : 976-984.
19. **Newman JS, Newberg AH.** Congenital tarsal coalition : multimodality evaluation with emphasis on CT and MR imaging. *Radiographics* 2000 ; 20 : 321-332 ; quiz 526-327, 532.
20. **Olney BW, Asher MA.** Excision of symptomatic coalition of the middle facet of the talocalcaneal joint. *J Bone Joint Surg* 1987 ; 69-A : 539-544.
21. **Peterson HA.** Dowel bone graft technique for triple arthrodesis in talocalcaneal coalition – report of a case with 12-year follow-up. *Foot Ankle* 1989 ; 9 : 201-203.
22. **Pontious J, Hillstrom HJ, Monahan T, Connelly S.** Talonavicular coalition. Objective gait analysis. *J Am Podiatr Med Assoc* 1993 ; 83 : 379-385.
23. **Raikin S, Cooperman DR, Thompson GH.** Interposition of the split flexor hallucis longus tendon after resection of a coalition of the middle facet of the talocalcaneal joint. *J Bone Joint Surg* 1999 ; 81-A : 11-19.
24. **Scott AT, Tuten HR.** Calcaneonavicular coalition resection with extensor digitorum brevis interposition in adults. *Foot Ankle Int* 2007 ; 28 : 890-895.
25. **Vincent KA.** Tarsal coalition and painful flatfoot. *J Am Acad Orthop Surg* 1998 ; 6 : 274-281.
26. **Westberry DE, Davids JR, Oros W.** Surgical management of symptomatic talocalcaneal coalitions by resection of the sustentaculum tali. *J Pediatr Orthop* 2003 ; 23 : 493-497.
27. **Wilde PH, Torode IP, Dickens DR, Cole WG.** Resection for symptomatic talocalcaneal coalition. *J Bone Joint Surg* 1994 ; 76-B : 797-801.