The Role of Pantalar Arthrodesis in the Treatment of Paralytic Foot Deformities. A Long-Term Follow-up Study

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The Role of Pantalar Arthrodesis in the Treatment of Paralytic Foot Deformities

A Long-Term Follow-up Study

By Stefanos Provelengios, MD, Kyriakos A. Papavasiliou, MD, Margaritis J. Kyrkos, MD, John M. Kirkos, MD, and George A. Kapetanos, MD

Investigation performed at the 3rd Orthopaedic Department, Aristotle University of Thessaloniki Medical School, "Papageorgiou" General Hospital, Thessaloniki, Greece

Background: Pantalar arthrodesis is considered by many to be the final operative option before amputation for the treatment of paralytic foot deformities. The aim of the present study was to evaluate the long-term results of pantalar arthrodesis with regard to its impact on the adjacent joints and the walking ability of patients with paralytic foot deformities.

Methods: Twenty-four patients (seventeen men and seven women) who underwent a one-stage pantalar arthrodesis between 1953 and 1973 for the treatment of sequelae of poliomyelitis were reevaluated. All patients underwent a physical and radiographic examination, and all completed the Short Form-36 questionnaire and a pantalar arthrodesis-specific questionnaire.

Results: The average age of the patients was twenty years at the time of the operation and 57.2 years at the time of the latest evaluation. The average duration of follow-up was 37.2 years. Eleven patients had development of immediate postoperative complications, including wound-healing problems (nine) and infections (two). The long-term results, however, were good (mean Short Form-36 scores, 73 of 100 points [overall], 51.5 points [physical functioning], and >70 points [all other domains]). Sixteen patients experienced repeated episodes of ipsilateral knee pain; most (fifteen) of these patients experienced a gradual onset of this pain, starting at an average of 20.8 years (range, fifteen to thirty years) postoperatively. The position of the fused ankle did not appear to have a significant impact on the development of ipsilateral knee pain or the time interval between the pantalar arthrodesis and the onset of ipsilateral knee pain.

Conclusions: Pantalar arthrodesis effectively stabilizes the ankle, hindfoot, and midfoot in patients with severe paralytic deformities. Even though most patients can be expected to have development of osteoarthritis of the ipsilateral knee, it seems that a successfully performed pantalar arthrodesis in carefully selected cases is a reliable operative option offering a strong and stable foot that will function well for many years.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Pantalar arthrodesis (a quite challenging operative procedure) is considered by many to be the final alternative operative option prior to amputation in patients with paralytic foot deformities. The aim of this procedure is to establish an osseous continuity across the ankle, subtalar, talonavicular, and calcaneocuboid joints in order to correct deformity, to allow a brace-free gait, and to provide stability of the knee, especially in the presence of a deficient quadriceps muscle. The procedure may be performed as either a one-stage operation or a two-stage operation, thus complementing a previous triple arthrodesis or ankle fusion[1]. It initially was attempted and introduced in eight patients (between the ages of four and fourteen years) in order to correct paralytic or congenital equinovarus deformities. Lorthioir, who was the first to perform the procedure in 1911, advocated removing the talus, denuding it of its articular surfaces, and reinserting it as a

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Fig. 1-A

Fig. 1-B

Figs. 1-A through 1-G Case 9. **Figs. 1-A and 1-B** Preoperative anteroposterior (Fig. 1-A) and lateral (Fig. 1-B) plain radiographs of the ankle and foot. The patient subsequently underwent a pantalar arthrodesis in order to treat sequelae of poliomyelitis.

free graft[2]. The indications of pantalar arthrodesis were later broadened to include a flail foot, a complete dropfoot, and a calcaneal deformity[2].

Since its initial report, almost every aspect of this procedure (indications, proper selection of patients, the earliest possible age at the time of the operation, the operative procedure followed, and the degree of plantar flexion of the fused ankle needed in order to achieve optimal function) has been the subject of controversy[3]. The aim of the present retrospective case series was to evaluate the long-term results of pantalar arthrodesis with regard to its impact on the patient's adjacent joints, walking ability, and everyday life activities. By reviewing our patients, we attempted (1) to evaluate the clinical result, (2) to assess the complications associated with this procedure, and (3) to determine whether pantalar arthrodesis should be regarded as a viable reconstructive procedure for the treatment of paralytic foot deformities.

Materials and Methods

The present study was approved by our institution's Scientific Research Board, and it was conducted in accordance with the World Medical Association Declaration of Helsinki of 1964 as revised in 1975, 1983, and 2000. All patients were informed about the study and gave informed consent prior to their enrollment.

During a period of twenty years (between 1953 and 1973), fifty-seven patients (twenty-seven male and thirty female) with paralytic foot deformities underwent a one-stage pantalar arthrodesis performed at the orthopaedic department of the Kilkis General Hospital, Kilkis, Greece (Figs. 1-A through 1-D) (see Appendix). The same operative procedure was used in all cases. Following a U-shaped incision around the lateral malleolus, the peroneal tendons and the calcaneofibular ligament were divided and the ankle joint was exposed by means of extreme supination and adduction of the foot. The cartilage of the joint surfaces of the tibia, the fibula, and the body of the talus was removed, and the subtalar joint was brought into view by pulling the talus upward. After denuding of the cartilage of the subtalar joint, the talonavicular ligaments were divided, the joint space between the two bones was opened, and the cartilage was removed. When the cartilage was denuded in all joints, first the talus and then the foot were placed in their new positions. The exact position of fusion was defined by the angle formed by a line down the long axis of the tibia and a line down the body of the talus, as measured on a lateral radiograph that was made intraoperatively[4]. A similarly mea-

Fig. 1-C

Fig. 1-D

Anteroposterior (Fig. 1-C) and lateral (Fig. 1-D) plain radiographs, made seven years postoperatively, demonstrating a successful fusion.

sured angle on the uninvolved side, with the ankle in the neutral position, was defined as the normal position. Departure from the normal angle on the fused side represented the degree of plantar flexion[5]. Next, the cut ends of the peroneal tendons were repaired and the wound was closed in layers (Steindler procedure[6]). A Steinmann wire was used to stabilize the ankle and subtalar joints, a long-leg cast was applied postoperatively, and no weight-bearing was allowed. After six weeks, the Steinmann pin and the long-leg cast were removed and a new short walking cast was applied for an additional period of approximately eight weeks. This period could be extended according to each patient's needs and the radiographic evidence of a successful fusion. Patient-specific, gradually increasing, weight-bearing was allowed after the removal of the second cast. The potential use of crutches, custom-made shoes, and braces was based on the overall performance of each patient and the coexistence of any other deformities (regardless of whether they were simultaneously treated or not).

All patients who were enrolled in the present study underwent a physical examination. The patients were evaluated with regard to the existence of any forefoot or ankle deformities, the existence of painful or painless callosities, the stability of the foot, the ability to bear weight, the existence of any tenderness to palpation and/or other signs of infection at the site of the operation, the range of motion and stability of the ipsilateral and contralateral knee joints, and the presence of tenderness to palpation over the contralateral and ipsilateral knees.

In order to allow us to evaluate their physical, mental, and emotional health status, all patients completed the Short Form-36 health-related quality of life questionnaire (SF-36)[7,8]. Because the SF-36 is a generic health survey instrument and because we wanted to specifically evaluate the impact of pantalar arthrodesis on the patients' lives, we invited them to answer a few more questions that were incorporated in a specially designed, "pantalar arthrodesis-specific" questionnaire (see Appendix).

Every patient underwent radiographic examination of the fused foot and adjacent joints with use of weight-bearing anteroposterior and lateral plain radiographs of the ipsilateral knee as well as non-weight-bearing anteroposterior and lateral

Fig. 1-E

Fig. 1-F

Non-weight-bearing anteroposterior (Fig. 1-E) and lateral (Fig. 1-F) plain radiographs made forty-seven years postoperatively. Even though there are some radiographic findings consistent with osteoarthritis localized to the talocuneiform joints, the history and physical examination revealed no other symptoms or signs of osteoarthritis.

plain radiographs of the ankle and forefoot (Figs. 1-E, 1-F, and 1-G). The radiographic appearance of the knee was classified according to the system of Johnson et al.[9] as Grade 1 (normal joint space), Grade 2 (narrowing by less than half of the normal joint space), Grade 3 (narrowing by more than half of the normal joint space), and Grade 4 (obliteration of the joint space).

Standard statistical methods were used for descriptive statistics. Non-normally-distributed continuous variables were analyzed with use of the Mann-Whitney test. The Spearman correlation coefficient was used for all correlation tests. The normality of the data distribution was tested according to the Shapiro-Wilk test. All statistical tests were two-tailed. The level of alpha for all analyses was set at 0.05.

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Results

During a period of six months (from February 2007 until July 2007) and from the initial group of fifty-seven patients, we were able to locate and reevaluate only twenty-four patients (seventeen men and seven women). As married women in our country had, until the early 1980s, traditionally used their husbands' surnames after they were married, it was extremely difficult to locate and reevaluate the majority of the female patients who underwent pantalar arthrodesis.

The average age of the patients was twenty years (range, fourteen to twenty-eight years) at the time of the operation and 57.2 years (range, forty-five to seventy-four years) at the time of the latest evaluation. The average duration of follow-up was 37.2 years (range, twenty-seven to forty-eight years). All patients underwent pantalar arthrodesis in order to treat sequelae of poliomyelitis. The average duration of immobilization in a cast was 17.8 weeks (range, fourteen to thirty-two

Fig. 1-G

Standing anteroposterior plain radiograph of the knees, made forty-seven years postoperatively. Note that the ipsilateral right knee demonstrates no substantial narrowing of the medial joint space, although some subchondral sclerosis can be seen.

weeks). The ankle joint was fused in an average of 6.5° (range, 0° to 20°) of plantar flexion. In male patients the ankle joint was fused in an average of 3.2° (range, 0° to 5°) of plantar flexion, and in female patients it was fused in an average of 14.3° (range, 10° to 20°) of plantar flexion.

The average score on the knee radiographs, according to the system of Johnson et al.[9], was 2.1 (Grade 1 for four patients, Grade 2 for fourteen, and Grade 3 for six) (Fig. 1-G). Sixteen patients reported experiencing repeated episodes of knee pain, all in the ipsilateral knee (Table I). Primarily on the basis of each patient's case notes and on his or her recall, it was determined that the knee pain started immediately after cast removal in one patient. The remaining fifteen patients experienced a gradual onset of symptoms at an average of 20.8 years (range, fifteen to thirty years) postoperatively. With the numbers available, there was no significant difference between the patients who had ipsilateral knee pain and those who did not with regard to the position of the ankle following pantalar arthrodesis. In addition, no correlation was found between the ankle position following the pantalar arthrodesis and the time interval between the arthrodesis and the onset of ipsilateral knee pain. The pain occurred mainly after prolonged walking or stair-climbing. Two patients had anterior knee pain, whereas the remaining fourteen described the knee pain as diffuse, being unable to locate it accurately. All of these patients reported regularly using medication (mainly paracetamol and, less often, nonsteroidal anti-inflammatory drugs) in order to continue with their everyday activities. On the basis of their complaints and physical and radiographic findings, all patients with knee pain were offered either conservative or operative treatment (e.g., arthroscopic washout and/or débridement, unicompartmental or total knee arthroplasty); however, none of them opted for an operation.

It seems that pantalar arthrodesis did not negatively affect the ability of patients to walk relatively long distances as most (fifteen) of them were able to walk >1 km without experiencing any discomfort in the fused foot, and nine of the fifteen were able to walk >5 km. Two patients, however, had very limited walking ability. None reported using crutches or an orthotic device in their shoe. However, the patients consistently reported having severe difficulty when trying to climb a hill (average score, 0.79 point; range, 0 to 1 point); descending an incline, however, was much easier (average score, 2.75 points; range, 2 to 3 points) (Table I).

Eleven patients experienced immediate postoperative complications; nine had wound-healing problems, and two had development of superficial infections. At the time of the latest evaluation, however, twenty of the twenty-four patients said that they were quite happy with their lives, despite the difficulties that they were facing as a result of the pantalar arthrodesis (experienced by eighteen patients "all of the time" and by two patients "most of the time"), because the arthrodesis eliminated the severe deformity and allowed them to live life closer to normal. They all acknowledged several restrictions, problems, and disabilities that typically accompany pantalar arthrodesis, such as severe difficulties when trying to

TABLE I Data on Existence of Ipsilateral Knee Pain, Ability to Walk Without Experiencing Any Pain Arising from Fused Foot, and Ability to Function on a Hill

Case	Ipsilateral Knee Pain*	Interval Between Pantalar Arthrodesis and Onset of Knee Pain *(yr)*	Radiographic Evaluation of the Ipsilateral Knee†	Ability to Walk Without Experiencing Discomfort Arising From Fused Foot	Ability to Function on a Hill‡	
					Upward Points	Downward Points
1	Yes	15	2	>5 km	1	3
2	No	—	1	>5 km	1	3
3	Yes	20	2	1 to 2 km	1	3
4	No	—	2	>5 km	0	2
5	Yes	Immediately	3	Limited	0	2
6	Yes	15	2	<500 m	1	3
7	Yes	17	2	<1 km	1	3
8	No	—	1	>5 km	1	3
9	Yes	20	1	>5 km	1	3
10	Yes	18	3	<500 m	0	2
11	No	—	1	>5 km	1	3
12	Yes	20	2	<500 m	1	2
13	Yes	25	3	<1 km	1	2
14	Yes	30	2	<1 km	0	3
15	No	—	2	>5 km	1	3
16	Yes	20	3	>5 km	1	3
17	Yes	22	2	1 to 2 km	1	3
18	No	—	2	2 to 3 km	1	3
19	Yes	20	2	1 to 2 km	1	3
20	No	—	2	2 to 3 km	1	3
21	Yes	25	2	<1 km	0	3
22	Yes	25	3	Limited	1	2
23	No	—	2	>5 km	1	3
24	Yes	20	3	2 to 3 km	1	3

*As reported by the patients. †The radiographs of the ipsilateral knee were classified according to the system of Johnson et al.[9]. ‡See Appendix for details.

climb a hill, the inability to participate in many athletic activities, difficulties when driving a car (with both automatic and standard transmissions), difficulties when trying to ride a bicycle, the need to wear shoes of different sizes (n = 9), painful calluses (n = 2), and painless calluses (n = 7). Nevertheless, twenty-two patients stated they would undergo the same operation again.

The average overall SF-36[7,8] score was 73 points (range, 53.3 to 90.8 points). The average score for the physical functioning domain of the questionnaire was 51.5 points (range, 10 to 85 points). The average scores for all other domains were >70 points (Table II). With the numbers studied, no significant correlation could be found between the ankle position following pantalar arthrodesis and (1) the SF-36 general score ($p = 0.440$), (2) the SF-36 physical functioning score ($p = 0.577$), (3) the SF-36 role limitations (physical) score ($p = 0.941$), or (4) the SF-36 energy/fatigue score ($p = 0.949$). On the other hand, a significant difference was found (as expected) between the patients who reported ipsilateral knee pain and those who did not report knee pain in terms of (1) the SF-36 general score ($p = 0.006$), (2) the SF-36 energy/fatigue score ($p = 0.013$), and (3) the SF-36 physical functioning score ($p = 0.001$).

In order to further assess their status, we classified our patients into three groups according to age (forty-five to fifty-four years, fifty-five to sixty-four years, and sixty-five to seventy-four years). A statistical comparison between the results for our patients and the SF-36 questionnaire[7,8] norms provided by the Omnibus Survey in Britain[10] and the Canadian Multicentre Osteoporosis Study (CaMos) cohort[11] showed that as far as the physical functioning domain was concerned, our patients had significantly lower scores. In terms of general health, however, no significant differences were found (see Appendix).

TABLE II Results on the Short Form-36 (SF-36) Questionnaire[7,8]

Case	General Score *(points)*	Domain Scores *(points)*							
		Physical Functioning	Role Limitations Due to Physical Health	Role Limitations Due to Emotional Problems	Energy/ Fatigue	Emotional Well-Being	Social Functioning	Pain	General Health
1	80	75	100	33.3	90	92	100	67.5	85
2	90.8	85	100	100	100	84	100	100	90
3	68.0	50	100	66.6	80	84	75	55	60
4	59	70	0	100	65	72	62.5	77.5	40
5	53.3	20	100	100	60	68	37.5	45	45
6	70.6	25	100	100	95	96	75	55	85
7	71.9	35	100	100	80	92	75	67.5	85
8	82.7	70	100	100	85	88	100	100	70
9	71.8	65	100	100	60	64	75	87.5	60
10	59.7	15	100	100	75	88	50	42.5	70
11	82.9	70	100	33.3	95	96	100	100	95
12	66.2	25	100	100	85	92	50	55	75
13	65.6	40	100	100	75	72	75	77.5	55
14	74.3	40	100	100	90	92	75	77.5	80
15	89	70	100	100	100	100	100	90	90
16	81.2	65	100	100	85	92	100	100	65
17	74.8	55	100	100	90	96	75	90	50
18	75.1	65	100	0	95	80	87.5	100	90
19	74	55	100	100	80	84	75	87.5	60
20	81.9	60	100	100	90	92	87.5	90	85
21	60.4	35	100	100	35	80	62.5	55	60
22	57.3	10	100	66.6	85	92	37.5	45	65
23	83.8	70	100	100	90	92	100	100	70
24	76.9	65	100	100	65	96	87.5	90	55
Average	73	51.5	95.8	87.5	81.3	86.8	77.6	77.3	70.2

Discussion

There are three basic indications for pantalar arthrodesis: severe pain, deformity, and instability[1,12]. The operation may be done as either a one or a two-stage procedure, with the triple arthrodesis and ankle arthrodesis being performed as separate operations in the latter case.

The reported rate of complications following a pantalar arthrodesis is usually relatively high, with rates of 28%[8] and even 41%[12] having been reported in some series. The number of immediate postoperative complications reported in the present study may be considered to be very high (46%). However, all eleven patients who had immediate postoperative complications had only minor complications (hematomas, skin necrosis, or skin necrosis complicated with a superficial infection) that were successfully treated with either standard conservative measures (local care of the wound combined with a short course of broad-spectrum antibiotics) or a minor surgical procedure such as débridement. Skin complications are not uncommon in patients undergoing pantalar arthrodesis (especially when managed with a one-stage procedure). Acosta et al.[12] reported that 50% of patients undergoing pantalar arthrodesis had development of either infections or skin ulcerations, with routine perioperative administration of antibiotics and the use of modern internal fixation techniques[13].

The most serious complication following pantalar arthrodesis seems to be the development of pseudarthrosis, with reported rates ranging from 0% to 28%[14]. In the literature, there is no apparent difference in fusion rates following pantalar arthrodesis, regardless of whether a one or a two-stage procedure has been performed[1,15]. The ankle seems to be the most common reported site of pseudarthrosis, followed by the talonavicular joint. Fortunately, none of our patients had development of a pseudarthrosis.

Theoretically, pantalar arthrodesis probably will have a negative impact on the adjacent joints (especially the knee). This hypothesis seems to be validated by our results, and this validation is further enhanced by the fact that residual paralysis following poliomyelitis hinders in some way the development

of osteoarthritis[16]. Ipsilateral knee pain was reported by the majority of our patients. However, none of them underwent an operative procedure (even although they were informed about that possibility) to treat this problem. No patient reported pain localized to any other joint. Jinks et al.[17] reported the overall prevalence of knee pain among the general population (average age, sixty-five years) to be as high as 47%. These findings seem to be very similar to our results and are in direct contrast with those of several other studies. Thomas et al.[18] reported that 36.3% of 6903 patients between the ages of fifty and seventy-nine years have knee pain. Seventeen of our patients were within the same age range, and eleven of them reported pain in the ipsilateral knee. Peat et al.[19], in a review article, reported the overall prevalence of knee pain among adults between the ages of forty and seventy-nine years to be 25%. All of our patients were within this age range, yet the rate of ipsilateral knee pain in this series was almost triple the rate reported by Peat et al. Carmona et al.[20], in a survey performed in Spain among adults more than twenty years of age, reported the prevalence of knee osteoarthritis to be 10.2%, more than six times lower than our findings. Therefore, we strongly believe that pantalar arthrodesis negatively affects the ipsilateral knee.

The generally accepted correct position of an ankle arthrodesis, as shown by gait analysis, is neutral flexion[5,13]. However, the surgeons who performed these operations several decades ago believed, on the basis of contemporary knowledge and practice, that fusion of the ankle joint in a position of a slight plantar flexion (5° to 10°) would assist the patients with walking, especially women who usually wear shoes with heels. Furthermore, for patients with poliomyelitis and reduced quadriceps strength, it was thought that ankle plantar flexion would facilitate walking as it forces the knee into extension or hyperextension, thus allowing weight-bearing in a more efficient manner. This position of the fused ankle joint in plantar flexion may be responsible for the difficulties that our patients experienced when trying to walk up a hill.

Even though we did not identify a significant correlation between ankle position and ipsilateral knee pain, SF-36 scores, or the time interval between arthrodesis and the onset of ipsilateral knee pain, these results must be interpreted with caution because of the small number of subjects. However, we do not believe that there are sufficient data to justify the recommendation of fusion of the ankle in plantar flexion.

It is interesting that the average scores for all of the domains of the SF-36 questionnaire, except for one (physical functioning), were relatively high. In fact, our patients achieved better scores in many domains than the norms provided for "healthy" people of the same age in two different studies[10,11]. These findings, although surprising, seem to be in complete harmony with the answers that the patients gave on the pantalar arthrodesis-specific questionnaire, on which the vast majority (83%) claimed that they were happy with their lives following the operation. Only in the physical functioning domain was the average score lower (51.5 points). However, this can be expected as two of the ten questions in this domain examine the patient's ability to climb stairs and one examines the ability to perform vigorous activities, both of which are very difficult tasks for patients with sequelae of poliomyelitis.

The present study had several limitations. The most important one is the small number of patients enrolled. This limitation is offset by the relatively long follow-up period and the narrowly defined study population. Nevertheless, these factors prevented us from comparing our results with those of previously reported series of patients. Furthermore, we could not reach firm conclusions regarding several issues, and the statistical analysis should be interpreted with extreme caution. Last, the lack of a control group prevented us from comparing the overall physical and functional status of patients who underwent pantalar arthrodesis with that of other people with similar demographic characteristics and the same type of foot disorders who underwent different operative procedures.

Pantalar arthrodesis is a demanding surgical procedure that can serve a useful purpose to stabilize the ankle, hindfoot, and midfoot. It is considered by many to be a salvage procedure for the treatment of unstable and debilitating conditions as a result of severe degenerative joint disease, rheumatoid arthritis, severe posttraumatic deformities of the ankle and hindfoot joints, neuropathic joint destruction, and paralytic or flail extremity dysfunction[12]. However, when performed on carefully selected patients, with great attention paid to the technique, and in the absence of any serious postoperative complications, it seems that this operative procedure will relieve pain and dysfunction, providing a strong, stable, and painless foot that probably will function adequately for the rest of the patient's life. Problems such as ipsilateral knee pain and limited walking ability are not uncommon and should be expected, especially after the second postoperative decade.

Appendix

(eA) Tables showing demographic data on the patients, the pantalar arthrodesis-specific questionnaire, and a comparison of functional outcomes by patient age groups are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD/DVD (call our subscription department, at 781-449-9780, to order the CD or DVD). ■

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Stefanos Provelengios, MD
54 Poseidonos Avenue, 17562 Palaio Faliro, Greece

Kyriakos A. Papavasiliou, MD
3 Natalias Mela Street, 546 46 Thessaloniki, Greece.
E-mail address: kyrpap2005@yahoo.com

Margaritis J. Kyrkos, MD
John M. Kirkos, MD
138 Al. Papanastasiou Street, 54249 Thessaloniki, Greece

George A. Kapetanos, MD
8 25th Martiou Street, 552 36 Panorama,
Thessaloniki, Greece

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