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CLINICAL RESEARCH

The Salto Total Ankle Arthroplasty

Survivorship and Analysis of Failures at 7 to 11 years

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Abstract

Background Despite the appearance of new-generation, mobile-bearing, cementless prostheses, total ankle arthroplasty remains controversial. Among the criteria guiding the choice between arthrodesis and arthroplasty, the long-term survival and postoperative function are of critical importance. The mobile-bearing Salto prosthesis has been used in Europe since 1997, but only 2 to 5 years of followup data have been reported.

Questions/purposes We analyzed the longer-term survivorship and causes of failures of the Salto prosthesis in a cohort of previously studied patients. We asked whether this prosthesis provided a functional ankle (AOFAS score) and durable radiographic fixation.

Patients and Methods We retrospectively reviewed 96 prospectively followed patients with 98 prostheses implanted between 1997 and 2000. Of those, 85 patients (87 prostheses) had a minimum followup of 6.8 years (mean, 8.9 years; range, 6.8–11.1 years).

Results The survival rate was 65% (95% CI, 50–80) with any reoperation of the ankle and 85% (95% CI, 75–95) with revision of a component as the end points. Six prostheses were removed for arthrodesis, and 18 ankles underwent reoperation without arthrodesis. We observed three main causes of reoperations: bone cysts (11 patients), fracture of the polyethylene (five patients), and unexplained pain (three patients). The mean AOFAS score was 79 ± 12 points. Radiographic subsidence was observed in three patients and bone cysts in eight patients.

Conclusions Our data suggest a high rate of reoperations but only six revisions with arthrodesis with mid-term followup. We observed few patients with loosening and/or subsidence.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

One or more authors (MB, JAC and TJ) received royalties from Tornier SA, Montbonnot, France.
Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research.
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Introduction

In patients with advanced arthrosis of the ankle, surgery most often is limited to arthrodesis and total ankle arthroplasty (TAA) with other options such as distraction arthroplasty [46, 50] and allograft transplantation [21, 22, 30] considered in select cases. Particularly in Europe, the appearance of new-generation, mobile-bearing, cementless prostheses has renewed interest in TAA [5, 11, 24, 33, 48, 51–53]. The theoretical advantages of TAA compared with arthrodesis are maintaining joint ROM and restoring more

normal kinematics in the hopes of providing the patient with greater comfort and better functional recovery [7, 31, 33, 35, 49]. The disadvantages are related to the risk of mechanical complications with failure sometimes requiring implant removal along with subsequent arthrodesis, which can be technically demanding and lead to a less satisfactory result than with primary arthrodesis [10, 19, 47].

Among the criteria guiding the choice between arthrodesis and arthroplasty, postoperative function and implant durability are particularly important. The main causes of TAA failure are implant loosening and/or migration, wear, fracture or dislocation of the mobile bearing, infection, unexplained pain, and the development of laxity [13, 15, 18, 20]. The development of osteolytic cysts has been reported in series of uncemented, mobile-bearing implants [3, 29, 48, 51–53], and Agility prostheses [26].

The Salto® prosthesis (Tornier SA, Saint Ismier, France) has a cementless, anatomic design with mobile-bearing polyethylene. It has been in use since January 1997. It is made of a cobalt-chrome alloy and coated with a layer of pure titanium (T40) and calcium hydroxyapatite. The first 98 Salto prostheses implanted between 1997 and 2000, previously investigated at a mean followup of 35 months as part of a multicenter prospective study, showed a 95% to 98% survivorship and a mean AOFAS score of 83.1 points [5].

The goals of our study were to analyze the survivorship and causes of failures of the Salto prosthesis from this first series of patients, at a longer-term followup of 7 to 11 years. We asked whether this prosthesis provides a functional ankle and durable radiologic fixation, with special attention to bone cysts.

Patients and Methods

We prospectively followed 96 patients (98 ankles) in whom Salto prostheses were implanted between January 1997 and December 2000. Our indications for TAA were end-stage ankle osteoarthritis (OA) or rheumatoid arthritis (RA). Contraindications to perform TAA included active ankle infection and poor skin and soft tissue quality believed to increase the risk of postoperative necrosis. We did not consider substantial varus and valgus deformities as contraindications, but hindfoot deformities were corrected as a first step with an associated procedure (triple arthrodesis). During the same 4-year period, 24 arthrodeses were performed by the same three surgeons, all for posttraumatic OA. The initial diagnosis was posttraumatic OA in 43 patients (20 bimalleolar ankle fractures, 14 tibial pilon fractures, four talus fractures, and five fractures of the distal third of the tibia). Eight patients presented with OA secondary to chronic instability, whereas four patients who had a prior ankle infection had OA develop. The diagnosis of primary OA was made for 14 patients in whom no other identifiable cause could be found. For the purpose of analysis, the OA group consisted of these 69 patients. Their mean age was 57 years (range, 26–81 years) at the time of surgery. Twenty-seven patients with RA had a mean age of 54 years (range, 28–77 years). The mean delay between the diagnosis of RA and surgery was 17 years (range, 3–36 years). There were 60 females and 36 males with a mean age of 56 ± 13 years (range, 26–81 years). The patients' mean weight was 66 ± 13 kg (range, 41–93 kg), height was 166 ± 8 cm (range, 152–183 cm), and body mass index was 24 kg/m^2 (range, 18–28 kg/m^2). Of the 96 patients undergoing TAA, nine died from unrelated reasons. None of these patients required reoperation. Two other patients were excluded from the final analysis; one patient underwent bilateral transtibial amputation 9 years after the TAA as a result of complications of Buerger's disease (thromboangitis obliterans) but did not have any complications directly related to the ankle prosthesis and the other patient, a female farmer, sustained a crushing injury to the ankle with a cow's hoof 1 year after the initial TAA, which led to major soft tissue loss and infection. Soft tissue healing was obtained after external fixation was performed using the Papineau technique to fuse the ankle [39]. The remaining 85 patients (87 prostheses) were followed for a minimum of 6.8 years (mean, 8.9 years; range, 6.8–11.1 years).

Eight patients had surgery on the ipsilateral forefoot and 18 had undergone a previous triple arthrodesis. Eighteen patients previously had either hip or knee arthroplasty before the TAA was performed: 13 THAs (eight ipsilateral), 12 TKAs (five ipsilateral), and seven patients with both.

Three surgeons (MB, JAC, TJ) performed all operations using a standardized technique [5, 6]. The goal was to restore a physiologic tibiocalcaneal axis and an anatomic joint line level. The tibial cut was made at 90° with a 7° posterior tibial slope after aligning the extramedullary guide with the anterior tibial crest. The amount of distal tibial resection was measured to match the metal tibial base plate plus the polyethylene insert. Special attention was paid to obtain proper rotation of the components, which were centered on the line bisecting the space between the medial and lateral talar facets. In patients with lateral ligament laxity, the medial deltoid was released from the tip of the medial malleolus. Ligamentous balance then was obtained by increasing the thickness of the polyethylene. The mean thickness of the mobile polyethylene insert was 4 mm (range, 3–6 mm). Thirty prostheses had a 3-mm polyethylene insert. In 20 patients in this series, a cemented lateral malleolar component was inserted [5]. It was progressively abandoned because it did not seem to improve

the clinical results. At the end of the procedure, if dorsiflexion remained less than 5°, percutaneous lengthening of the Achilles tendon was performed (17% of cases in RA versus 45% in OA) [36].

Patients were immobilized with a cast with duration of casting depending on concomitant procedures performed and the condition of the soft tissues [5]. Weightbearing was permitted immediately, as tolerated, except in case of Achilles tendon lengthening, in which it was delayed for 3 weeks. After cast removal, nonaggressive self-rehabilitation based on weightbearing exercises, supervised by a physiotherapist, was begun. The mean delay before full weightbearing was 8 days (range, 1–31 days) and the mean duration of cast immobilization was 35 days (range, 5–45 days).

All patients were assessed with clinical and radiographic followups at 3 and 6 months, 1 year, and then every 2 years thereafter. Final scores were collected from the most recent followup for analysis. We assessed function using the AOFAS ankle-hindfoot score [25].

AP and lateral weightbearing radiographs of the ankle were taken preoperatively and at all followups. Two independent observers (FG, JRL) made measurements manually on the radiographs [1, 26, 37, 51] (Fig. 1). The accuracy of these radiographic measures has been assessed and a high level of intraobserver reliability has been reported [37]. Component migration, measured in relation to the immediate postoperative images, was defined as a change greater than 5° in the different measurements (Fig. 1). This criterion of 5° is based on previous reliability testing [37] and was recommended by Knecht et al. [26].

To analyze osteolysis and lucencies, the distal tibia and the talus were divided into different zones on the radiographs (Fig. 2). A radiolucent line was considered pathologic if it was more than 2 mm thick or if it was observed globally across a prosthetic component [29, 48, 51]. An osteolytic cyst was defined as a hypodense zone greater than 5 mm in diameter with no inner bone trabeculae but with peripheral sclerosis that was not present preoperatively [3]. Radiographs were analyzed successively by the operators and by two independent surgeons (FG and JRL). In case of disagreement, the most unfavorable assessment was adopted [3]. In seven patients, bone cysts were already visible on the preoperative radiographs and were not considered pathologic (Figs. 3–4). A CT scan was performed routinely when cysts were observed on plain radiographs.

Dynamic lateral weightbearing views with maximum dorsiflexion and plantar flexion were taken at each followup to determine the total ankle ROM using a previously described technique [5].

We analyzed the survivorship of the prosthesis using the Kaplan-Meier survivorship method [23]. A failure was defined as "any reoperation on the ankle" after implantation (revisions and reoperations) or as "removal or revision of any component, including exchange of polyethylene insert for fracture" (revisions) [17]. This last criterion is used frequently [9, 11, 23, 25, 27, 34, 39, 51]. Radiologic measurements and scores were compared using Student's t test after checking the normal distribution of the samples with the Shapiro-Wilk test and the equality of variances with the F-test. All statistical analyses were performed with Minitab software (Version 14; Minitab Inc, State College, PA, USA).

Results

The survival rate at 10 years followup with any reoperation on the ankle as the end point was 65% (95% confidence interval [CI], 50%–80%). It was 85% (95% CI, 75–95) when we used fusion or revision of any component as the criterion of failure (Fig. 5). Six implants in six patients, five in patients with OA and one in a patient with RA, were removed and converted to arthrodesis between 11 and 101 months after the initial intervention (mean delay, 54 ± 31 months) (Table 1) [10].

There were a total of 18 revisions without arthrodesis (Table 1). The polyethylene was exchanged secondary to fracture in five patients, between 72 and 122 months after the initial surgery (mean, 103 ± 19 months). This occurred only in patients in whom 3-mm polyethylene components were used. In one patient, concomitant revision of the tibial component was necessary owing to development of osteolysis (Fig. 6). Eight patients required reoperations for the development of symptomatic osteolytic cyst(s). The cysts were curetted and filled with cancellous autograft harvested from the ipsilateral iliac crest and the polyethylene was routinely exchanged. Histopathologic analyses of the curetted cysts revealed birefringent foreign bodies or metallic particles surrounded by a macrophage inflammatory reaction in all cases. The mean AOFAS score at last followup for these patients was 73.5 ± 12.5 (range, 52–90). Radiographs at last followup showed complete graft incorporation in four patients and residual cysts, all less than 5 mm diameter, in four patients. Five other patients underwent reoperations for various reasons: two submalleolar impingement, one loose lateral malleolar component, one synovial cyst, and one infection (Table 1).

At last followup, the mean AOFAS ankle-hindfoot score was 79 ± 12, mean dorsiflexion was 9° ± 5°, and mean plantar flexion was 18° ± 8°. The mean tibial angle was 90° ± 2°, mean talar angle was 91° ± 2°, and mean tibial slope was 10° ± 4° (Tables 2 and 3).

Radiographic evidence of subsidence was observed on the tibia for one patient with RA, and on the talus for two

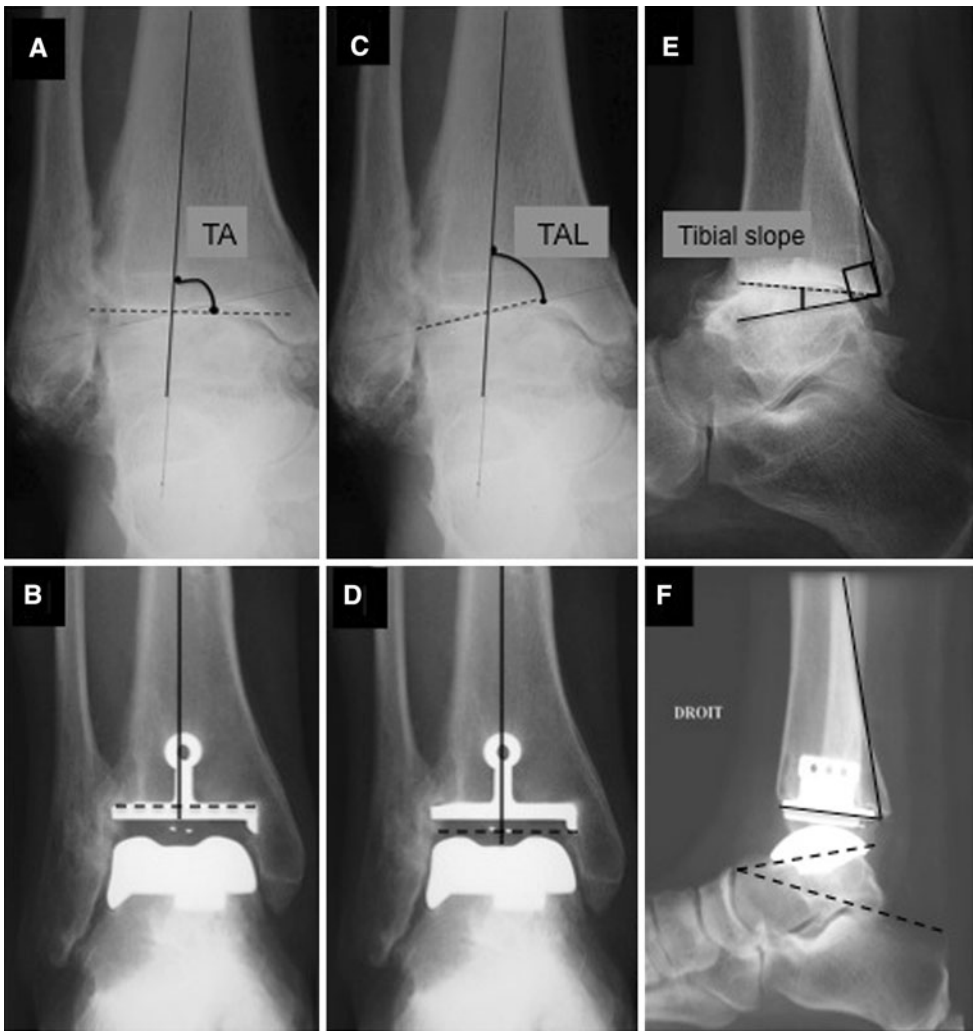

Fig. 1A–F Weightbearing AP and lateral radiographs of the ankle were performed. A representative example is shown. On the AP view, the tibial angle (TA) was measured between the axis of the tibia and the articular surface of the tibial plafond (**A**) before and (**B**) after surgery. The talar angle (TAL) was measured between the axis of the tibia and the superior articular surface of the talus (**C**) before and (**D**) after surgery. The tibial slope was measured on the lateral radiograph as the angle between a line drawn along the posterior tibial cortex and a second line connecting the most anterior and posterior points of the tibial joint surface (**E**) before and (**F**) after surgery. (**F**) The talocalcaneal angle was measured between the undersurface of the talar component and a reference line drawn from the superior border of the talonavicular joint and the most superior aspect of the posterior process of the calcaneus [1]. Any variation greater than 5° in these measurements was considered component migration.

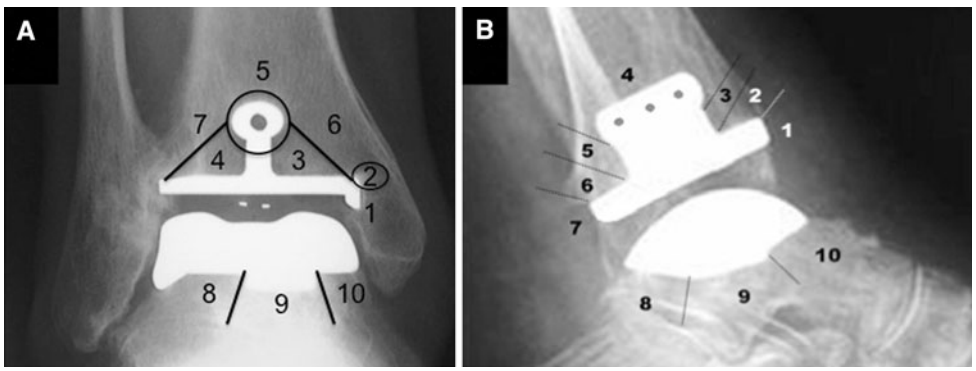

Fig. 2A–B (**A**) AP and (**B**) lateral postoperative radiographs show the different zones of cysts for the tibial and talar components. On the AP view, the tibia is divided into seven zones (1 = medial malleolus, 2 = medial flange, 3 = medial tibial base plate, 4 = lateral tibial base plate, 5 = tibial keel, 6 = medial tibial metaphysis, and 7 = lateral tibial metaphysis), whereas the talus consists of three zones (8 = from the lateral talar flange to the lateral aspect of the talar keel, 9 = directly under the talar keel, and 10 = from the medial aspect of the talar keel to the most medial aspect of the talar component). On the lateral view, the tibia is divided into seven zones (1 = anterior tibia, 2 = anterior tibial base plate, 3 = anterior keel stem, 4 = tibial keel, 5 = posterior keel stem, 6 = posterior tibial base plate, and 7 = posterior tibia), whereas the talus consists of three zones (8 = from the posterior extreme of the talar component to the posterior aspect of the talar keel, 9 = under the talar keel, and 10 = from the anterior aspect of the talar keel to anterior extreme of the talar component).

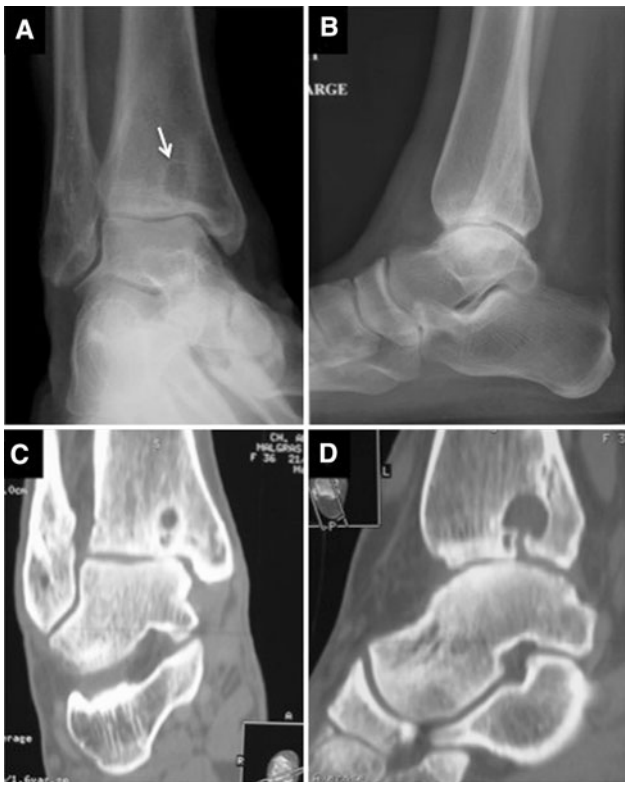

Fig. 3A–D In this patient with posttraumatic arthritis, bone cysts were observed preoperatively on (**A**) AP and (**B**) lateral radiographs and (**C**) AP and (**D**) lateral CT scans.

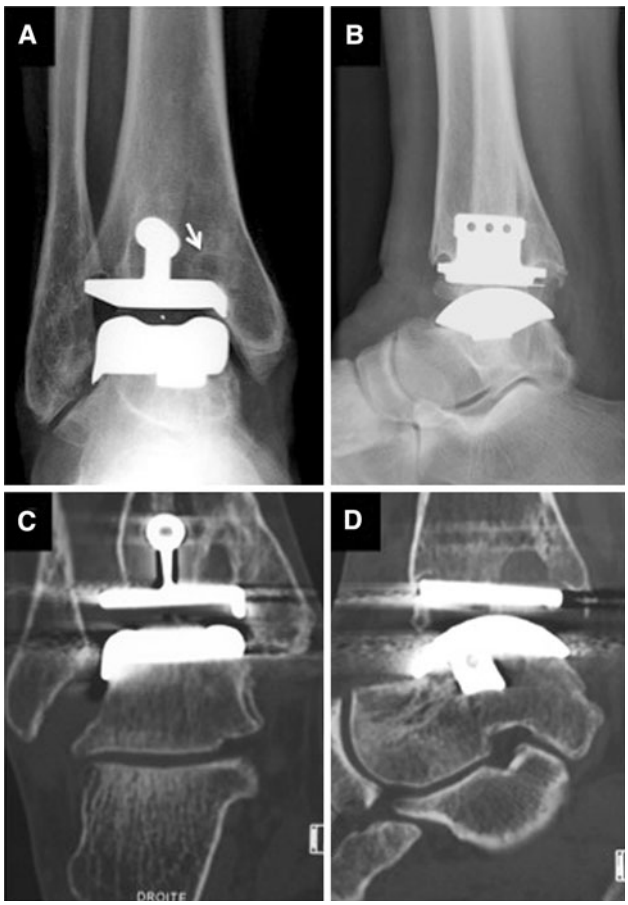

Fig. 4 Two years after implantation, the same cysts were still present in the same patient shown in Fig. 3. When bone cysts were observed preoperatively, as shown in this example, they were not included in the results.

patients (one with OA and one with RA). For the patient with RA, it was the result of the collapse of an autograft used at the index procedure to reconstruct severe bone loss in the talar body. None of these patients went on to revision because the functional results were satisfactory (AOFAS scores of 85, 76, and 85 points, respectively). Partial radiolucent lines were observed in numerous patients on the AP views (50 in Zone 2, eight in Zone 3, 25 in Zone 4, and one in Zone 5), but none of the patients had global radiolucencies. Bone cysts of 5 mm or larger were noted in four patients on the AP views of the tibia, involving five zones in one patient, three zones in two patients, and two zones in another patient, and in four other patients in the talus, involving three zones in one patient, two zones in one, and one zone in two. All were asymptomatic and four spontaneously regressed, as seen on radiographs, without modification in the patient's activity (Fig. 7).

Discussion

For patients with advanced arthritis of the ankle, surgery most often is limited to arthrodesis and TAA. Despite the appearance of new-generation, mobile-bearing, cementless prostheses, TAA remains controversial. Among the criteria guiding the choice between arthrodesis and arthroplasty, the long-term survival and postoperative function are of critical importance. The mobile-bearing Salto prosthesis has been used in Europe since 1997, but only 2 to 5 years of followup data have been reported [5]. The goals of our study were to analyze the survivorship and the causes of failures of the Salto prosthesis from this first series of patients, at a longer-term followup. We asked whether this prosthesis provides a functional ankle and durable radiologic fixation, with a special attention to bone cysts.

This study has several limitations. First, it is comprised of a series of patients operated on by the implant designers, including all the initial patients in the authors' experience. The importance of the learning curve has been underscored by the Swedish registry, reporting a survival rate of 70% at 5 years for the first 30 implantations and 86% for ensuing patients [18]. Second, the functional results were assessed using only the AOFAS ankle-hindfoot score, which provides a limited analysis of function [34]. Third, the analysis of cysts was not performed systematically with CT scans,

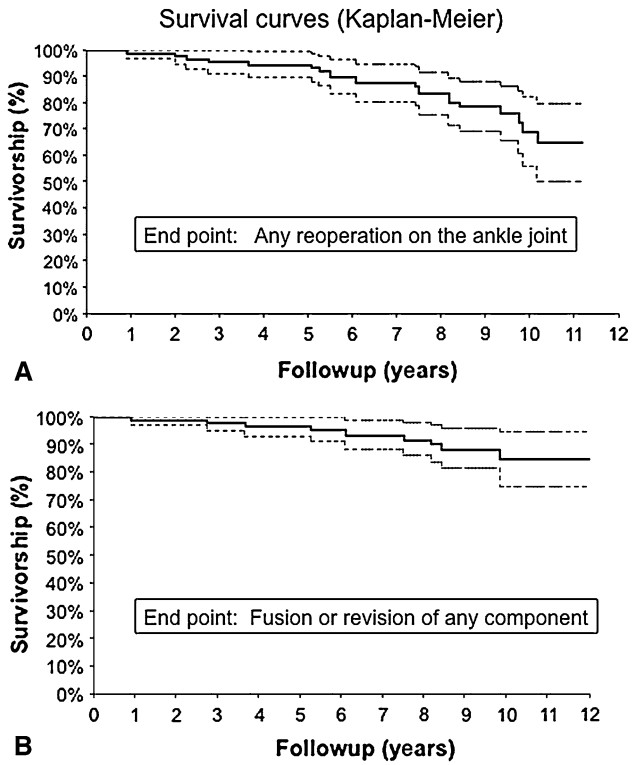

Fig. 5A–B (**A**) The survival (Kaplan-Meier) calculated with end point reoperation of the ankle for any reason shows survival rates of 65% (95% confidence interval, 50%–80%) and (**B**) 85% (95% CI, 75–95) with end point fusion or revision of any component.

which theoretically could underestimate its incidence [16]. Fourth, the device and the technique have changed during the course of the study. In 2001, we extended the hydroxyapatite coating to the medial edge of the tibial component and after the first 20 patients, we no longer used the lateral malleolar implant. We also have abandoned the 3-mm polyethylene, which is the cause of five reoperations in this series. Finally, our survivorship analysis was based only on the patients who already had reoperations and not on the intention to treat. However, even if three patients had radiologic failures, no revisions for patients in this series are planned.

Survival often is difficult to assess from reported series of ankle prostheses as a result of various criteria of failure [13] (Tables 4, 5). In a recent meta-analysis, a 77% survival rate was reported at 10 years [15]. In a similar analysis, a 9.8% failure rate at a mean followup of 5.2 years with a survival rate varying from 67% at 6 years to 95.4% at 12 years were reported [13]. Data from the national registries are particularly interesting because of their exhaustive collection of outcomes. The Swedish registry reports a 62% survival rate at 10 years with fusion or revision as the end point [18]. The New Zealand registry reports a 5-year survival rate of 86% [20] and the Finnish registry reports a 7-year survival rate of 78% [42]. Despite our survival rate being similar to those reported in the literature, many revisions were required in this series of patients, reflecting our early experience.

Nineteen patients presented with tibial and/or talar bone cysts that were 5 mm or larger. Eight of these patients underwent a second operation with bone grafting, which subsequently did not evolve, whereas three went on to implant removal and fusion. An additional eight patients had bone cysts appearing on radiologic studies but remained asymptomatic. Some authors have reported similar findings with the Agility prosthesis [26, 37]. Tibial cysts with the STAR prosthesis have been reported in 3.5% of patients at 46 months and 17.5% at 88 months [51, 52]. The overall incidence of osteolytic cysts has been reported as 21% at 31 months [28] and 43% (talus) to 62% (tibia) at 40 months [3] for the AES prosthesis. The etiology of these bone cysts is poorly understood and likely multifactorial. Small nonprogressive cysts seem to be mechanical in nature and may occur in relation to a stress-shielding phenomena or bone remodeling in the distal tibia [26]. Large cysts seem to stem from chemical phenomena related to the release of wear particles. Three sources of particles theoretically can be involved: polyethylene, titanium, and hydroxyapatite [27, 29, 48]. In the current series, volumetric wear on the explanted inserts in patients who had revision surgery for osteolysis was not observed. The Food and Drug Administration (FDA) imposes strict fixation criteria for titanium coating [14]. In Europe, only the hydroxyapatite fixation layer is subject to such regulation. The titanium anchoring layer in the Salto prosthesis has satisfied the FDA criteria only since 2006. The role of hydroxyapatite has been debated [2, 4, 32, 38, 43–45].

Osteolysis was observed in some patients in the current study particularly adjacent to the tibial keel, which is accessible to joint fluid and therefore wear debris. The observation from our experience corroborates the concept of effective joint space [41]. To isolate the keel of the joint space, we modified the surgical technique in 2003 by sealing off the anterior tibial window with bone graft after the tibia component was impacted in place. Since this change, it has not been necessary to perform secondary surgery to graft tibial cysts by any of the three surgeons in this study.

An important cause of revision was malleolar impingement and/or stiffness. A CT scan is now systematically ordered as part of the preoperative workup to ensure osteophytes and/or bone fragments are precisely located. Limitation in ankle dorsiflexion is tolerated particularly poorly, therefore requiring dorsiflexion of at least 10° be obtained at the end of surgery. When dorsiflexion is insufficient, an explanation should be sought: generally insufficient tibial resection or excessive anterior translation

Table 1. Patients undergoing reoperation(s) in the current series

Case number	Date of TAA	Gender	Age (years)	Indication	Reoperation(s)			AOFAS last followup
					Year(s) of revision	Indication	Procedure(s)	
3	2/24/97	M	42	OA, PT	1998 and 2001	Medial and lateral malleolar impingement and stiffness	Open débridement, synovectomy, and secondary arthroscopy	90
6‡	4/27/97	M	49	OA, PT	2006	Polyethylene fracture	Polyethylene exchange	71
9	5/28/97	F	70	RA	1997	Infection	Irrigation and débridement	73
13‡	10/20/97	F	64	OA, PT	2002	Unexplained pain	Fusion	–
25‡	2/20/98	F	55	RA	2008	Polyethylene fracture	Polyethylene exchange	92
26	2/25/98	M	65	OA, P	2009	Tibial cyst	Grafting	77
30	5/26/98	M	34	OA, PT	2003	Tibial and talar cysts	Grafting	76
32	6/16/98	F	50	OA, PT	2009	Tibial and talar cysts	Grafting	52
33‡	6/24/98	F	31	OA, PT	2001	Unexplained pain†	Fusion	–
37	12/15/98	F	56	OA, PT	2001	Medial malleolar impingement and stiffness	Open débridement	77
38‡	1/15/99	F	27	OA, PT	2007	Polyethylene fracture	Revision of tibia and polyethylene exchange	95
48	6/15/99	F	46	OA, PT	2008	Tibial cyst	Grafting	90
51	8/25/99	F	61	OA, PT	2007	Tibial cyst	Grafting	82
55‡	9/29/99	F	33	RA	2003 and 2004	Tibial cyst	Grafting and secondary; fusion resulting from subsidence of tibial component	–
56	10/11/99	F	75	OA, P	2007	Talar cyst	Grafting	66
57	10/19/99	F	52	OA, PT	2008	Tibial and talar cysts	Grafting	62
60‡	10/27/99	F	55	OA, PT	2008	Polyethylene fracture	Polyethylene exchange	87
63‡	12/15/99	M	61	OA, PT	2007	Loosening of malleolar component	Removal of malleolar component	72
66‡	1/18/00	M	27	OA, PT	2008	Tibial and talar cysts	Fusion	–
77‡	5/30/00	M	46	OA, PT	2006	Tibial and talar cysts	Fusion	–
79‡	6/06/00	F	54	OA, P	2001	Unexplained pain*	Fusion	–
80	6/20/00	F	78	OA, L	2005	Synovial cyst	Excision cyst	90
88	10/17/00	M	71	OA, L	2006	Tibial cyst	Grafting	83
91‡	11/15/00	M	74	OA, PT	2006	Polyethylene fracture	Polyethylene exchange	70

Patients are numbered by order of date of surgery; when survivorship was calculated with end point any reoperation on the ankle, all the patients whose data are included in this table were considered to have failed results; when survivorship was calculated with end point fusion or revision of any component, only patients whose data are indicated by ‡ were considered to have failed results; *patient lost to followup in the initial study [4]; †radiolucencies found in the medial tibia, but good fixation was observed at time of surgery; TAA = total ankle arthroplasty; AOFAS = American Orthopaedic Foot and Ankle Society; M = male; F = female; OA = osteoarthritis; PT = osteoarthritis, posttraumatic; RA = rheumatoid arthritis; L = osteoarthritis secondary to chronic laxity/instability.

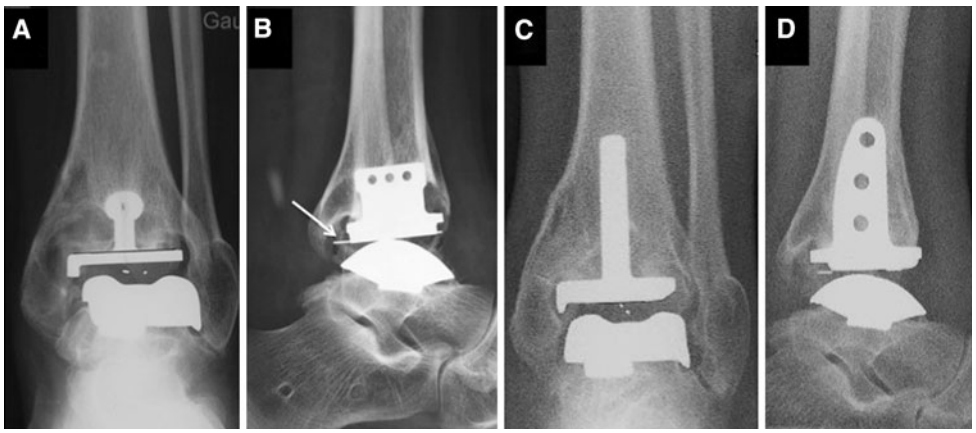

Fig. 6A–D (**A**) A fracture of the polyethylene occurred 8 years after implantation in the patient shown. The polyethylene was not revised until 6 months after the fracture occurred at which point concomitant revision of the tibial component was necessary as a result of the development of osteolysis. (**B**) On the lateral radiograph, the metal insert embedded in the polyethylene is visible behind the tibial base plate, confirming the fracture. At revision, a stemmed tibial component was implanted and the osteolysis was grafted as seen on (**C**) AP and (**D**) lateral radiographs.

Table 2. The AOFAS ankle-hindfoot scores (total possible 100 points) and range of motion*

Studied parameter	Group of patients (n = number of prostheses)						
	Overall (n = 87)		RA (n = 23)		OA (n = 64)		p Value RA versus OA
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	
Preoperative AOFAS	26.7 ± 8.9	6 to 53	21.8 ± 8.3	7 to 35	28.7 ± 8.3	6 to 53	< 0.001
Postoperative AOFAS	79.3 ± 11.9	43 to 99	76.3 ± 14.8	43 to 99	80.6 ± 10.3	44 to 97	0.070
p value (preoperative versus postoperative score)	< 0.0001		< 0.0001		< 0.0001		
Dorsiflexion (°)	8.6 ± 5.3	−5 to 20	10.4 ± 5.5	0 to 20	7.8 ± 5.1	−5 to 20	0.025
Plantar flexion (°)	18.1 ± 7.8	5 to 40	16.3 ± 8.3	5 to 30	18.8 ± 7.6	0 to 40	0.076

* The results are indicated for the overall group (rheumatoid arthritis [RA] and osteoarthritis [OA]); the statistical comparison was made between the RA and OA groups ($p < 0.05$ considered significant); ROM was measured for the 81 patients with the prosthesis still retained at final followup (excluding patients who had conversion surgery to arthrodesis); AOFAS = American Orthopaedic Foot and Ankle Society.

Table 3. Radiologic results as measured preoperatively, postoperatively (6 months after surgery), and at last followup

Radiologic measurement	Date of measurement						p Value
	Preoperative		Postoperative				
			6 months postoperative		Last followup		6 months versus last followup
	Mean ± SD	Minimum-maximum	Mean ± SD	Minimum-maximum	Mean ± SD	Minimum-maximum	
TA angle (°)	89.1 ± 2.7	80–95	90.8 ± 2.3	88–97	90.5 ± 1.8	88–95	0.20
TAL angle (°)	88.1 ± 0.6	60–98	91.4 ± 2.8	87–98	90.9 ± 2.5	87–98	0.22
Tibial slope (°)	8.5 ± 6.5	0–20	9.25 ± 3.9	0–16	9.9 ± 4.3	2–19	0.17

TA = tibial angle; TAL = talar angle.

of the talar component. If no abnormality can be seen, a percutaneous Achilles lengthening or gastrocnemius recession should be performed.

In this first series of Salto prostheses, we found a high rate of reoperations but some subsequent potential failures likely have been eliminated through improvements in

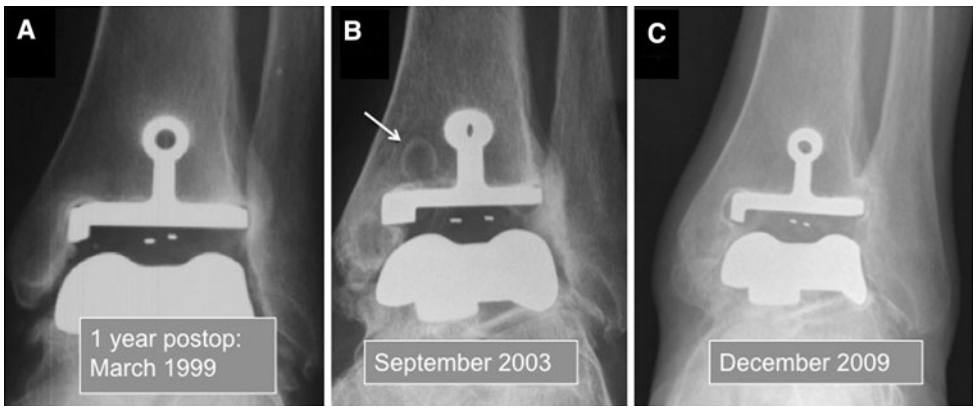

Fig. 7A–C A case example is shown for a patient undergoing spontaneous regression of a bone cyst from (**A**) 1 year postoperatively to (**B**) 5 years postoperatively with a bone cyst in Zone 3 (arrow) to (**C**) 10 years postoperatively.

Table 4. Causes of revisions of total ankle arthroplasty in different series in the literature

Cause of revision or reoperation	Published series compared with the current study				
	Haddad et al. [15] (n = 852)	Swedish Registry [18] (n = 531)	New Zealand Registry [20] (n = 202)	Finnish Registry [42] (n = 515)	Current study (n = 98)
	Number of reoperations for each etiology				
Loosening/subsidence	13	31	10	23	1
Wear	7				0
Instability/dislocation	5	16		23	0
Polyethylene subluxation	3				0
Implant fracture					
Tibial plate	2				0
Polyethylene insert	3	8		3	5
Fracture of the ankle (tibia, talus, or fibula)	2	2		1	0
Infection	1	13	2	4	1
Stiffness/bone fragments/impingement					2
Synovial cyst					1
Bone cysts/osteolysis*					11
Painful varus		3			
Unexplained pain		11	1		3
Malpositionning of implant		17	1	5	
Complication of malleolar component					1
Total number of reoperations†	46	101	14	59	25
Survivorship (95% confidence interval) End point: fusion or revision of components	77% (63%–90%) Followup: 10 years	62% (52%–72%) Followup: 10 years	86% (78%–94%) Followup: 5 years	78% (71%–85%) Followup: 7 years	84.8% (75%–95%) Followup: 11 years

* Osteolysis was not reported by Haddad et al, because this complication was unknown at the date of publication of most of the referred papers [10] and national registries analyses are limited to "fusion or failures with revision of implants"; †one patient in the current series has had two reoperations: one initial revision for grafting a cyst and a secondary revision for loosening.

surgical technique and better patient selection. The stability of the prosthetic component fixation seems satisfactory with very few patients with loosening. This study highlights the importance of CT investigations to reveal cysts before and after replacement. Understanding the etiology of bone cysts should improve future results and deserves ongoing study.

Table 5. Survivorship and clinical results in published series[‡]

Study	Prosthesis	Series	Lost at followup[†]	Mean followup (years)	Survival rate (followup)				Revisions			Function	
		TAA/ patients			(%)	Followup (years)	95% CI (%)	End point	Fusion	Exchange	Reoperation	Score	Results
Wood et al. [52]	STAR	200/187	0	7.3	80.3	10	71–89.6	Fusion or revision (including PE)	20	4	6	AOFAS	Pain: 35 (0–40) Function: 40 (20–54)
Knecht et al. [26]	Agility	132/126	12	9	63	11	35–90	Fusion or revision (PE excluded)	7	7	32	AOS [12]	2.55 ± 2.31
Buechel et al. [9]	Buechel-Pappas (shallow sulcus)	40/38	0	12	74.2	20	35–100	Revision	*	*	*	NJOH [8]	28: good/excellent Two: fair 10: poor
Buechel et al. [9]	Buechel-Pappas (deep sulcus)	75/74	0	5	92	12	55–100	Revision	*	*	*	NJOH [8]	66 good/excellent Four: fair Five: poor
San Giovanni et al. [40]	Buechel-Pappas	31/23	0	8.3	93.4	12	83–100	Fusion	2			AOFAS	81 (40–92)
Kofoed [28]	STAR (cemented)	33/33	0	9.4	70	12	60.3–78.5	Fusion or revision	4	5	0	Kofoed [28]	74.2 ± 19.3
Kofoed [28]	STAR	25/25	0	9.4	95.4	12	91–99.9	Fusion or revision	0	2	0	Kofoed [28]	91.7 ± 7.4
Karantana et al. [24]	STAR	52/45	0	5 to 9	65	9	24.3–88	Fusion or revision	2	6	9	AOFAS	78 ± 18 (range, 30–100)
Doets et al. [11]	LCS and Buechel-Pappas	93/76	0[†]	7.6	84	16.3	73–93	Fusion or revision	13	2	*	AOFAS	77 ± 3.8
Current series	Salto (mobile-bearing)	98/96	0	8.9	84.8	11	75–95	Fusion or revision (including PE)	6	5	13	AOFAS	79.3 ± 11.9

[‡] Selected on the basis of a mean followup more than 5 years * not mentioned in the article; [†]deceased patients excluded; TAA = total ankle arthroplasty; CI = confidence interval; PE = polyethylene; AOFAS = American Orthopaedic Foot and Ankle Society; AOS = ankle osteoarthritis scale; NJOH = New Jersey Orthopaedic Hospital ankle scoring scale.

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