



Fig. E-1A



Fig. E-1B



Fig. E-1C



Fig. E-1D

Figs. E-1A through E-1F Revision arthroplasty with revision components in a sixty-four-year-old businessman and former high-level soccer player. **Figs. E-1A through E-1D** At 7.5 years after total ankle replacement, there is evidence of cysts on both the tibial and talar sides as a source of increasing pain.



Fig. E-1E

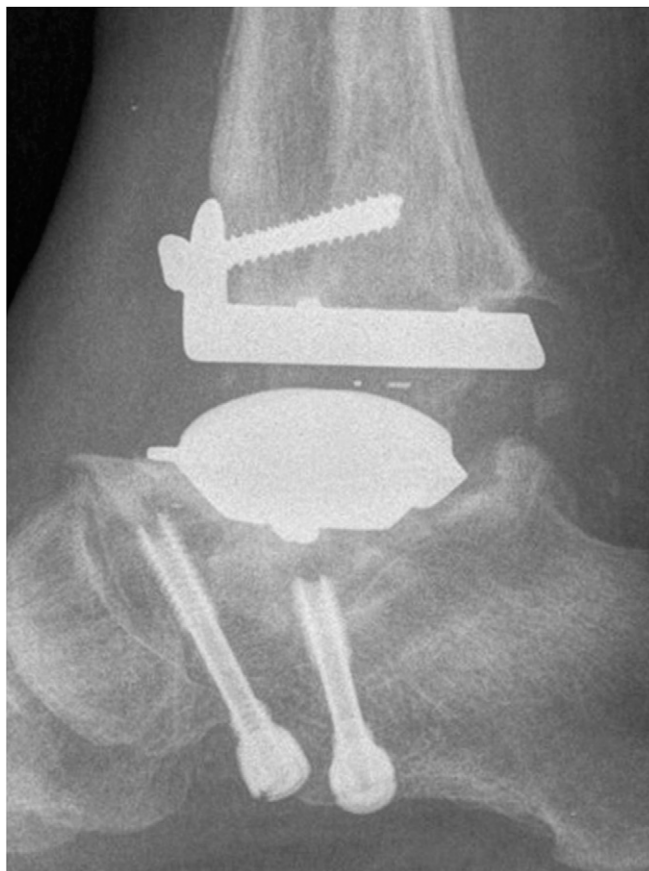


Fig. E-1F

Figs. E-1E and E-1F Eight years after revision arthroplasty and subtalar arthrodesis, the patient was pain-free and very satisfied with the result.

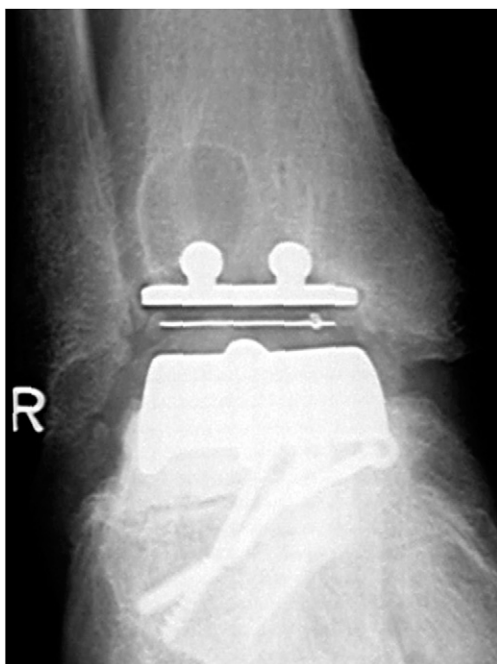


Fig. E-2A

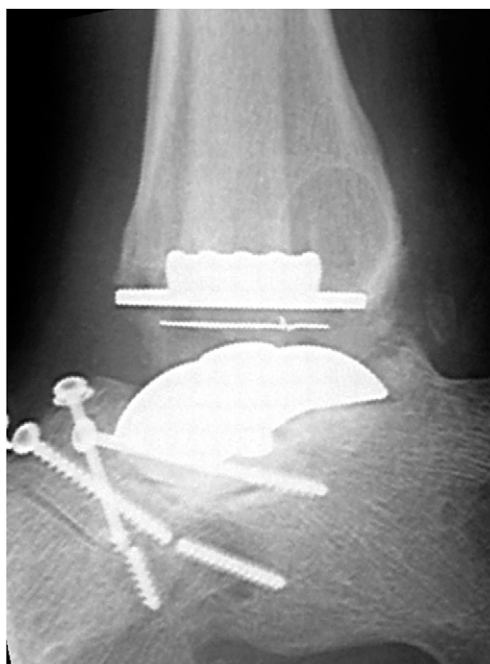


Fig. E-2B

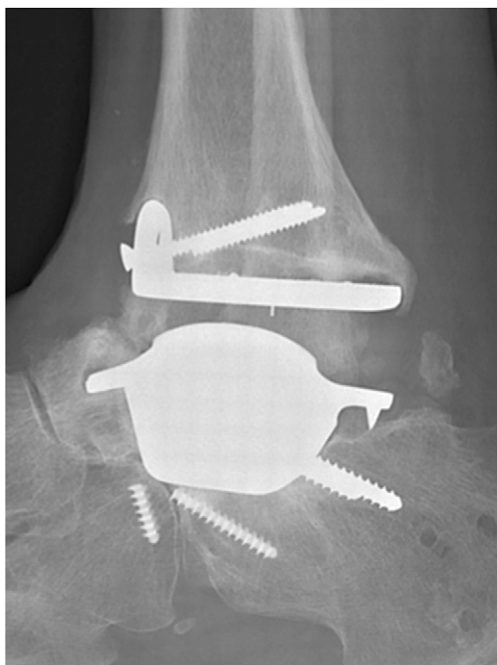


Fig. E-2C



Fig. E-2D

Figs. E-2A through E-2D Revision arthroplasty with a custom talar component in a fifty-two-year-old banker. **Figs. E-2A and E-2B** At 5.8 years after total ankle replacement for posttraumatic osteoarthritis secondary to talar fracture, radiographs show subsidence of the talar component and cyst formation involving the distal aspect of the tibia. **Figs. E-2C and E-2D** Seven years after revision arthroplasty, the components were stable. The patient reported some periarticular pain after walks of more than two hours but was very satisfied with the overall result.

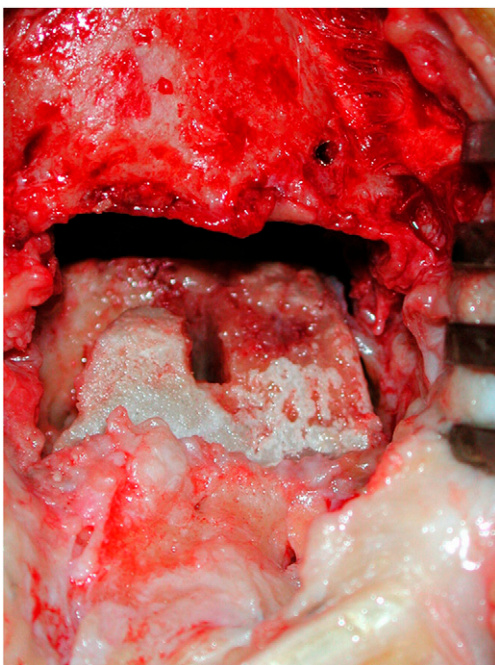


Fig. E-3A



Fig. E-3B

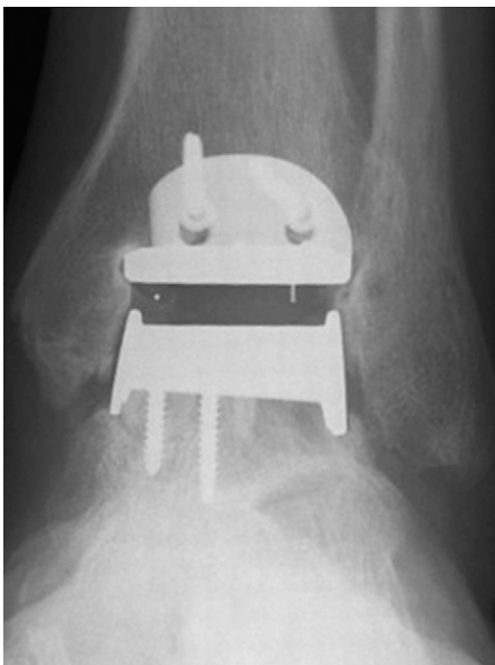


Fig. E-3C



Fig. E-3D

Figs. E-3A through E-3F Revision arthroplasty with standard components in a fifty-nine-year-old teacher. **Fig. E-3A** At 5.8 years after total ankle replacement with a STAR prosthesis, the patient had increasing pain while weight-bearing and at rest due to osteonecrosis on the talar side, as verified intraoperatively. **Fig. E-3B** There is evidence of some irregular bone beneath the talar component. **Figs. E-3C and E-3D** At seven years postoperatively, radiographs show stable components and the patient reported only minor pain after physical activities.

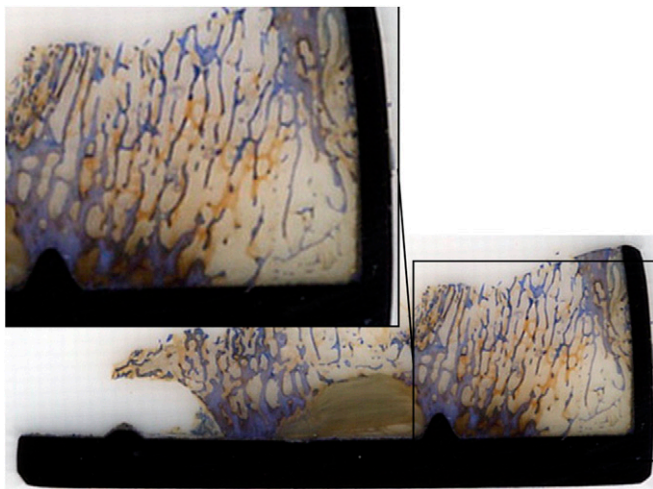


Fig. E-3E

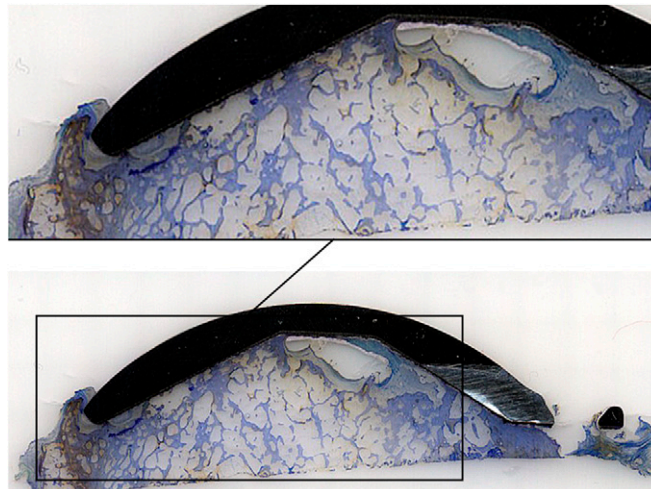


Fig. E-3F

Fig. E-3E The patient died six months later of causes unrelated to the ankle. On the tibial side, histological analysis of the harvested implant showed some stress concentration of osseous trabeculae at the pyramidal peak and the bone cement that was used to fill a cyst during the revision arthroplasty. Some stress concentration also occurred anteriorly. The bone-implant interface was stable. **Fig. E-3F** On the talar side, the bone-implant contact area was regular, with some trabecular stress concentration occurring at the posterior and anterior aspects of the talus.



Fig. E-4A



Fig. E-4B



Fig. E-4C

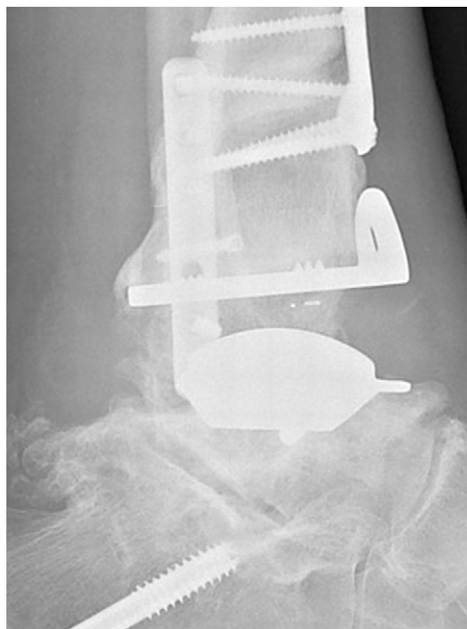


Fig. E-4D

Figs. E-4A through E-4D Revision arthroplasty with correcting osteotomies to balance the revised ankle in a sixty-one-year-old policeman and former soccer player. **Figs. E-4A and E-4B** Failure of components 4.7 years after the primary arthroplasty, with tilting and subsidence of the tibial component and anterior extrusion of the talus. **Figs. E-4C and E-4D** An opening wedge osteotomy of the distal aspect of the tibia was performed to realign the ankle in the sagittal plane and to create bone stock for the standard tibial component. In addition, a shortening osteotomy of the fibula and a medial sliding osteotomy of the calcaneus were performed to balance the ankle joint in the frontal plane. An allograft was used to strengthen the distal aspect of the fibula on its inner side. The ankle was stable and well-balanced after three years, and the patient was satisfied with the result.

TABLE E-1 Literature Review Addressing Clinical Outcomes of Patients Treated with Revision Ankle Arthroplasty*

Study	Type	N	TAR Prosthesis	Follow-up (yr)	Failures	Reasons for Failure (No. of Patients)	Time to Revision (yr)	Revision Procedure (No. of Patients)	Results of Revision
Ali et al., 2007 ⁴⁵	RS, SC	35	Buechel-Pappas	5 (0.3-12.5)	1 (3%)	Pain (1)	3	Revision TAR (1)	Converted to ankle arthrodesis 1 year later due to CRPS
Anders et al., 2010 ⁴⁶	RS, SC	93	AES	3.5 (1.1-6.1)	7 (8%)	Loosening (1), infection (2), instability (2), fx (2)	NA	Revision TAR (1), ankle arthrodesis (6)	NA
Anderson et al., 2003 ⁴⁷	RS, SC	51	STAR	(3-8)	12	Loosening (7), PE fx (2), other (3)	2.8 (0.1-5.3)	Revision TAR (5), ankle arthrodesis (5), PE exchange (2)	3 revision TARs with excellent function, 1 with good function, 1 pt. died
Bonnin et al., 2011 ⁴⁸	PS, SC	98	Salto	8.9 (6.8-11.1)	12 (12%)	Loosening (6), PE fx (5), malposition (1)	NA	Revision TAR (1), ankle arthrodesis (6), PE exchange (5)	NA
Buechel et al., 2003 ⁴⁹	RS, SC	50	Buechel-Pappas	5 (2-10)	2 (4%)	Malposition of talar component (1), talar subsidence (1)	NA	Revision TAR (2)	NA
Carlsson et al., 2001 ⁵⁰	RS, SC	69	Bath and Wessex	NA	12 (17%)	Painful loosening (12)	4.3 (2.3-8.7)	Revision TAR (6), ankle arthrodesis (12)	NA
Christ and Hagena, 2005 ⁵¹	RS, SC	144	STAR	4.8	9 (6%)	Malalignment (2), loosening (1), impingement (1), instability (1), fx (1), deep infection (2)	NA	Revision TAR (7), ankle arthrodesis (2)	NA
Doets et al., 2006 ⁵²	PS, MC	93	LCS (19), Buechel-Pappas (74)	7.2 (0.4-16.3)	15 (16%)	Aseptic loosening (6), malalignment (6), deep infection (2), severe wound-healing problem (1)	NA	Revision TAR (1), ankle arthrodesis (14)	Revision TAR showed loosening and required eventual conversion to arthrodesis
Fevang et al., 2007 ⁵³	RS, MC	257	Norwegian TPR (32), STAR (216), AES (3), HINTEGRA (6)	4 (0-12)	27 (11%)	Aseptic loosening (13), instability (3), malalignment (7), deep infection (2), fx (1), pain (5), PE defect/wear (2), other (2)	2.3 (0.1-8)	Revision TAR (15), PE insert exchange (6), arthrodesis (6)	NA
Giannini et al., 2010 ⁵⁴	PS, MC	51	BOX	2.5 (2-4)	1 (2%)	Lateral impingement (1)	2	Revision TAR (1)	NA
Henricson and Ågren, 2007 ⁵⁵	RS, SC	193	STAR (109), Buechel-Pappas (62), AES (22)	4.2 (1-8)	41 (21%)	Infection (5), technical error (8), loosening (11), pain (4), instability (13)	(1.0-6.6)	Revision TAR (23), ankle arthrodesis (15), extraction of prostheses without arthrodesis (3)	2 good results, 19 fairly good, 2 poor with persisting pain and use of two crutches
Hobson et al., 2009 ⁵⁶	RS, SC	123	STAR	4 (2-8)	18 (15%)	NA	NA	Revision TAR (16), ankle arthrodesis (2)	NA
Hosman et al., 2007 ⁵⁷	RS, MC	202	Agility (117), STAR (45), Mobility (29), Ramses (11)	2.3 (0.6-6.3)	14 (7%)	Loosening (10), varus malalignment (1), pain (1), deep infection (2)	1.9 (0.1-5.4)	Revision TAR (10), ankle arthrodesis (3), BKA (1)	NA
Hurowitz et al., 2007 ⁵⁸	RS, SC	65	Agility	3.3 (2.0-5.9)	21 (32%)	Loosening (8), subsidence (5), malalignment (3), infection (3), osteolysis (1), post impingement (1)	NA	Revision TAR (17), ankle arthrodesis (2), osteochondral allograft (1), BKA (1)	NA

TABLE E-1 (continued)

Study	Type	N	TAR Prosthesis	Follow-up (yr)	Failures	Reasons for Failure (No. of Patients)	Time to Revision (yr)	Revision Procedure (No. of Patients)	Results of Revision
Karantana et al., 2010 ⁵⁹	RS, SC	52	STAR	6.7 (5.0-9.2)	8 (15%)	Stress fracture (2), stiffness (2), insert fx (2), talar subsidence (1), loosening (1)	NA	Revision TAR (6), ankle arthrodesis (2)	NA
Kitaoka and Patzer, 1996 ⁶⁰	RS, SC	160	Mayo	9 (2-17)	57 (36%)	Persistent pain and loosening (all)	4.4 (0.1-13.1)	Revision TAR (10), ankle arthrodesis (45), BKA (2)	NA
Knecht et al., 2004 ⁶¹	RS, SC	132	Agility	7.2 (2-14)	14 (11%)	Component fx (2), loosening (4), deep infection (1), talar collapse (2), varus malpositioning (1), subsidence/migration (3), other (1)	5.8 (0.5-11.3)	Revision TAR (7), ankle arthrodesis (7)	NA
Kofoed and Sørensen, 1998 ⁶²	PS, SC	52	STAR	9 (6-14)	11 (21%)	Loosening (10), deep infection (1)	4.5 (0.8-8.8)	Revision TAR (5), ankle arthrodesis (6)	NA
Kopp et al., 2006 ⁶³	RS, SC	43	Agility	3.7 (2.2-5.3)	1 (2%)	Aseptic loosening (1)	NA	Revision TAR (1)	NA
Kumar and Dhar, 2007 ⁶⁴	RS, SC	50	STAR	3 (1.5-5)	3 (6%)	Malalignment (2), pain (1)	NA	Revision TAR (3)	Good results in 2 pt., arthrodesis using ring fixator in 1 pt.
Mendolia et al., 2005 ⁶⁵	RS, SC	69	Ramses	12 (10-14)	12 (10%)	Malalignment (4), loosening (3), instability (5)	NA	Revision TAR (5), ankle arthrodesis (7)	NA
Morgan et al., 2010 ⁶⁶	RS, SC	45	AES	4.8 (4.0-6.7)	2 (4%)	Loosening (2)	NA	Revision TAR (1), ankle arthrodesis (1)	NA
Murnaghan et al., 2005 ⁶⁷	RS, SC	22	STAR	2.2 (0.7-3.8)	2 (9%)	Malalignment (2)	NA	Revision TAR (2)	Good results
Nishikawa et al., 2004 ⁶⁸	RS, SC	21	TNK	6.0 (1.3-14.1)	3 (14%)	Loosening (3)	NA	Revision TAR (1), ankle arthrodesis (2)	Revision TAR was fused after 2 yr because of loosening
Reuver et al., 2010 ⁶⁹	RS, MC	59	Salto	3.0 (1.0-5.4)	7 (12%)	Loosening (5), deep infection (2)	NA	Revision TAR (3), ankle arthrodesis (4)	NA
Rodriguez et al., 2010 ⁷⁰	RS, SC	18	AES	3.3 (1.7-5.1)	1	Loosening with cysts (1)	NA	Revision TAR (1)	NA
Rudigier et al., 2004 ⁷¹	RS, MC	117	ESKA	(0-10)	8 (7%)	Deep infection (4), talar necrosis (1), prosthesis breakage (1), prosthesis malalignment (1), loosening with cysts (1)	NA	Revision TAR (4), ankle arthrodesis (4)	NA
Schutte and Louwerens, 2008 ⁷²	PS, SC	49	STAR	2.3 (1.0-5.6)	4 (8%)	Septic (2) and aseptic (2) loosening	NA	Revision TAR (1), ankle arthrodesis (3)	NA
Spirit et al., 2004 ⁷³	RS, SC	306	Agility	2.8 (0.3-6.3)	33 (10.8%)	NA	NA	Revision TAR (24), BKA (8), ankle arthrodesis (1)	NA
Vienne and Nothdurft, 2004 ⁷⁴	RS, SC	66	Agility	2.4 (1.5-3.6)	2 (3%)	NA	NA	Revision TAR (1), ankle arthrodesis (1)	NA
Wood and Deakin, 2003 ⁷⁵	PS, SC	200	STAR	3.8 (2.0-8.4)	14 (7%)	NA	NA	Revision TAR (3), ankle arthrodesis (11)	NA

TABLE E-1 (continued)

Study	Type	N	TAR Prosthesis	Follow-up (yr)	Failures	Reasons for Failure (No. of Patients)	Time to Revision (yr)	Revision Procedure (No. of Patients)	Results of Revision
Wood et al., 2008 ¹⁶	PS, SC	200	STAR	7.3 (5-13)	24 (12%)	Major delay to wound-healing (1), intraop. fx (1), postop. fx (2), aseptic loosening (14), edge loading (5), PE fx (1)	NA	Revision TAR (4), ankle arthrodesis (20)	1 revision TAR failed after 5 yr and was converted to ankle arthrodesis
Wood et al., 2010 ¹⁷	PS, SC	100	Mobility	3.6 (0.3-5.3)	5 (5%)	Insert luxation (1), loosening (1), talar subsidence (1), pain (1), varus deformity (1)	2.6 (0.5-3.8)	Revision TAR (1), ankle arthrodesis (2), insert exchange (2)	NA
<p>*TAR = total ankle replacement, RS = retrospective, SC = single-center, CRPS = chronic regional pain syndrome, fx = fracture, NA = not available, PE = polyethylene, PS = prospective, and MC = multicenter.</p>									

TABLE E-2 Failures and Revisions*

Original Revision						Repeat Revision				
No.	Sex	Age † (yr)	Original Prosthesis	Talar Component	Tibial Component	Cause of Failure	Time to Repeat Revision (mo)	Additional Procedures	Talar Component	Tibial Component
1	M	54	HINTEGRA	None	Standard HASC	Loosening of both components	32	None	Standard HASC-NP	Not changed
2	F	77	HINTEGRA	Standard HASC-NP	None	Loosening of talar component	21	None	Custom-made HASC-NP	Not changed
3	F	28	STAR	Custom-made	Revision HASC	Loosening of tibial component, valgus malalignment	25	Syndesmotic AD, SMOT tibia	Not changed	Not changed
4	M	43	HINTEGRA	None	Standard HASC	Loosening of talar component, progressive cyst formation	85	None	Standard HASC-NP	Not changed
5	M	71	STAR	Standard HASC-NP	Standard HASC	Chronic pain syndrome and paralysis after spine surgery	57	Tibiotalar AD		
6	F	58	HINTEGRA	Standard HASC-NP	Standard HASC	Loosening of talar component	69	None	Revision	Standard
7	F	46	HINTEGRA	Standard HASC-NP	None	Loosening of both components	68	Tibiotalar AD		
8	M	53	Mobility	Revision	Standard	Pain and stiffness, arthrofibrosis	24	Tibiotalar AD		
9	M	69	STAR	Revision	Standard	Loosening of talar component, subfibular impingement	32	None	Revision	Revision HASC
10	M	48	HINTEGRA	Revision	Standard	Recurrent lateral instability with dislocation of PE insert	7	Tibiotalocalcaneal AD		
11	F	60	STAR	Standard	Standard	Loosening of talar component, osteonecrosis of talus	15	Naviculocuneiform AD	Revision	Not changed
12	M	66	HINTEGRA	Standard	None	Varus malalignment	58	Shortening OT fibula, LSOT calcaneus, OT med. malleolus	Not changed	Standard
13	M	72	HINTEGRA	None	Standard	Loosening of tibial component	39	ORIF med. malleolus	Not changed	Standard
14	M	43	ESKA	Revision	Standard	Loosening of tibial component, valgus malalignment	12	MSOT calcaneus, SMOT tibia	Not changed	Standard
15	M	30	Irvine	Revision	Standard	Deep infection	296	Heel cord lengthening, peroneal tendon transfer†	Custom-made	Standard
16	F	64	STAR	Standard	Standard	Loosening of tibial component	13	Shortening OT fibula	Not changed	Revision HASC
17	M	83	HINTEGRA	Revision	Standard	Talar fracture after trauma	11	Tibiotalar AD		

*PE = polyethylene, HASC = hydroxyapatite single-coated, NP = no pegs, AD = arthrodesis, SMOT = supramalleolar osteotomy, OT = osteotomy, LSOT = lateral sliding osteotomy, ORIF = open reduction and internal fixation, and MSOT = medial sliding osteotomy. †At time of first revision arthroplasty. ‡14 days after prosthesis removal, gentamycin-Palacos spacer, antibiotics for 3 months.

TABLE E-3 Clinical Results and Satisfaction at Latest Follow-up in the Seventeen Patients with Repeat Revision

No.	Sex	Age (yr)*	Time to Repeat Revision (mo)	Follow-up† (mo)	VAS	AOFAS	Range of Motion (deg)	Patient Satisfaction
1	M	54	32	72	3	88	34	Satisfied
2	F	77	21	66	3	50	20	Satisfied with reservations
3	F	28	25	60	0	92	35	Very satisfied
4	M	43	85	42	3	66	30	Satisfied
5	M	71	57	48	2	69‡	NA#	Satisfied
6	F	58	69	42	1	81	30	Very satisfied
7	F	46	68	42	3	69‡	NA#	Satisfied with reservations
8	M	53	24	58	3	75‡	NA§	Satisfied with reservations
9	M	69	32	72	0	91	36	Very satisfied
10	M	48	7	54	2	60§	NA§	Satisfied
11	F	60	15	58	1	80	28	Satisfied
12	M	66	58	36	2	77	24	Satisfied
13	M	72	39	41	0	87	31	Very satisfied
14	M	43	12	36	3	62	22	Satisfied with reservations
15	M	30	296	26	2	83	24	Satisfied
16	F	64	13	32	1	78	21	Satisfied
17	M	83	11	36	1	64‡	NA#	Satisfied
Mean ± std. dev.	11M:6F	57 ± 16	51 ± 67	48 ± 14	1.8 ± 1.1	75 ± 12	28 ± 6	

*At time of first revision arthroplasty. †Time after repeat revision. ‡Out of 92 (due to performed tibiotalar arthrodesis). §Out of 86 (due to performed tibiotalar or tibiotalarlocalcaneal arthrodesis). #Not available due to performed tibiotalar or tibiotalarlocalcaneal arthrodesis.

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