

Total Ankle Arthroplasty

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Background

- First attempted in the early 1970s
- Abandonment of first and second generation total ankle replacements (TAR) due to unacceptably high complication and failure
- Early designs struggled to find balance between constraints and stability

Introduction

- Ankle has one third the surface area of the knee, yet carries almost twice the load of the knee.
- TAR can be used to treat post-traumatic, idiopathic (primary), and rheumatoid arthritis.
- TARs has been performed in selected patients with arthritis since the 1970s as an alternative to arthrodesis with mixed results.
- Recently, increasing patient demand due to improved outcomes and desire to maintain normal joint ROM.
- Almost all current TARs have two common features: porous coated for bone ingrowth and made of a titanium alloy with a cobalt chrome–polyethylene articulation.

Problems of Total Ankle Replacement

Table 1. SATISFACTION RATES AFTER TOTAL ANKLE REPLACEMENTS WITH OLDER DESIGNS

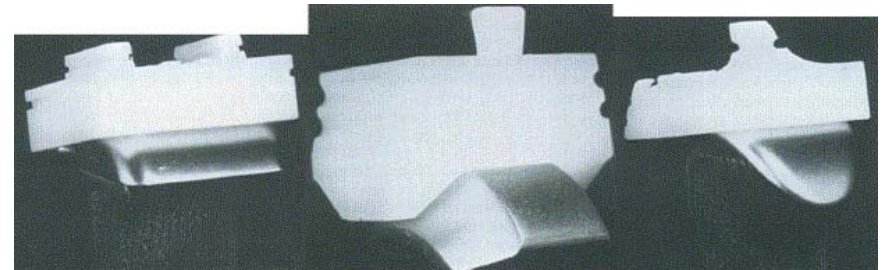
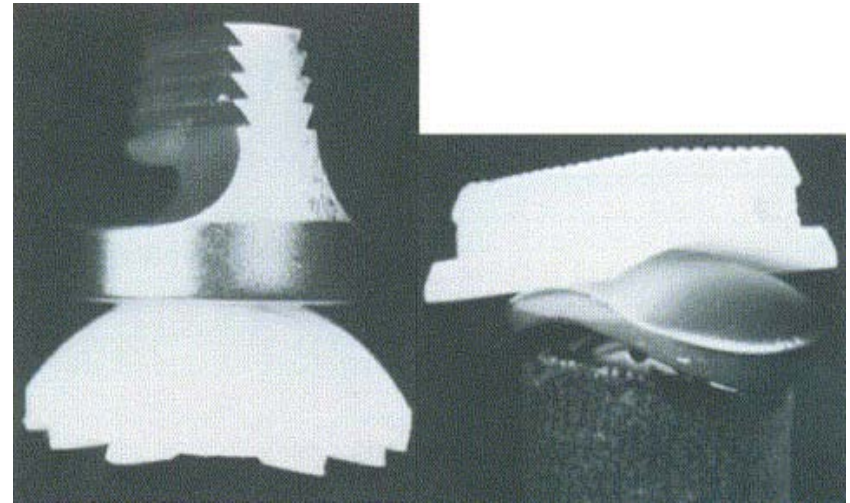
Device	Study	No. Ankles	Average Follow-up (mo)	Satisfaction Rate (%)
Smith	Dini and Bassett ¹¹	21	27	46
ICLH	Goldie and Herberts ¹³	18	36	60
TPR	Jensen and Kroner ¹⁶	23	59	69
Bath + Wessex	Carlsson et al ⁷	52	60	81
TPR	Kumar ²³	37	60	52
LCS	Buechel et al ⁶	40	72	85
Smith	Kirkup ¹⁹	18	84	61
Mayo	Kitaoka and Patzer ²⁰	160	108	19

ICLH = Imperial College, London Hospital; TPR = Thomson-Parkridge-Richards; LCS = low contact stress.

Background

1st Generation of implants

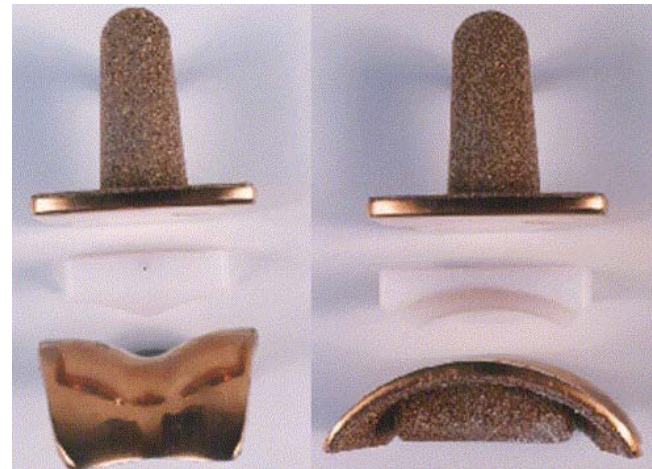
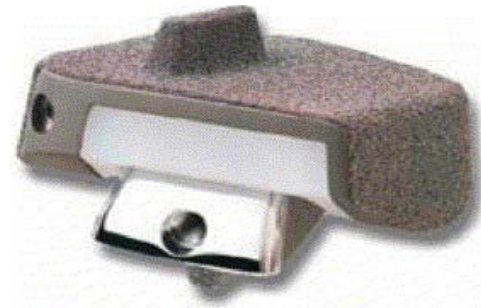
- Two part systems
- Polyethylene part was placed in the tibia and the metal part in the talus or sometimes the arrangement was reversed
- Highly constrained
- Cemented components that required significant bony resection for implantation
- Although stable, designs loosened, subsided and caused osteolysis



Background

2nd Generation of implants

- Agility ankle prosthesis (semi-constrained, two part prosthesis)
- Required less bone resection and avoided cement fixation
- Less constraint reduced the shear forces and torsion at the bone-prosthesis interface
- Increases polyethylene wear and failure and compromised stability
- Failures due to painful impingements, subluxation or complete dislocation



Anatomy and Biomechanics of the Ankle Joint

- The bony anatomy, ligaments, and joint capsule guide and restrain movement between the talus and the mortise
- Talus has a continuously changing axis of rotation as it moves from maximum dorsiflexion to maximum plantar flexion relative to the mortise.
- The talus and mortise widen slightly from posterior to anterior.
- When the talus is plantarflexed, its narrowest portion sits in the ankle mortise and allows rotatory movement between the talus and mortise.
- When the talus is maximally dorsiflexed, the tibiofibular syndesmosis spreads, and the wider portion of the talar articular surface locks into the ankle mortise, allowing little or no rotation between the talus and the mortise.

Patient Selection and Evaluation

- Ideal patient is still up for debate
- Older, thin, low demand individual with minimal deformity may be considered the optimal candidates ???
- Chronological age and body weight as independent threshold remains controversial

Patient Selection and Evaluation

- Expanded indication
 - Ipsilateral arthritis
 - Inflammatory or osteoarthritis of multiple, adjacent joints
 - Arthrodesis of hindfoot and/or contralateral arthrodesis of the ankle

Patient Selection and Evaluation

- **Absolute contraindication**
 - Active infection
 - Extensive avascular necrosis of talar dome
 - Compromised bone stocks or soft tissue
 - Peripheral neuropathy
 - Peripheral vascular disease
 - Charcot neuroarthropathy

Patient Selection and Evaluation

- **Relative contraindications**

- Remote history of infection
- Ligamentous instability
- Subluxation of talus
- Presence of severe deformities above or beneath the ankle
- Absence of the medial and/or lateral malleoli;
- Poor skin condition secondary to surgical scars or trauma.

Modern TAR Designs

- **Three components**
 - A metallic baseplate fixed to the tibia
 - A domed or condylar shaped metallic component that resurfaces the talus
 - Bearing surface made of ultra-high molecular weight polyethylene interposed between tibial and talar components

Modern TAR Designs

- Two-piece designs (fixed bearing systems) lock the polyethylene component into the baseplate
- Mobile or meniscal bearing systems do not attach the polyethylene to either component
- Both systems use similar semi-constrained design
- Increased conformity between the bearing surface and the talar component in sagittal plane while permitting more motion in the transverse and axial planes.

Modern TAR Designs

- The reduction in the shear and torsional forces at the bone-implant interface is an accepted advantage of the three piece design
- Insufficient data exist to offer recommendation regarding the choice of fixed or mobile-bearing design for modern TAR

Modern TAR Designs

- 4 total ankle arthroplasty systems approved by FDA
 - Agility Total Ankle System (Depuy Orthopaedics)
 - Salto Talaris Anatomic Ankle Prosthesis (Tornier)
 - Inbone Total Ankle System (Inbone Technologies)
 - Eclipse Total Ankle Implant (Kinetikos)
- Scandinavian Total Ankle Replacement System (link orthopaedics) has been recommended for approval

Agility Total Ankle System

- Approved in the US for many years
- Semi-constrained fixed bearing prosthesis
- An ultra-high molecular weight polyethylene bearing surface locks into a titanium tibial component
- Both components utilize a beaded surface to achieve fixation through bony ingrowth



Agility Total Ankle System

- Requires arthrodesis of the distal syndesmosis
- Application of an external fixator for distraction of the joint
- Large resection of the bone from the tibia for implantation

Agility Total Ankle System

- Result from one study (cohort) including 100 arthroplasties between 1984 to 1994 performed by a single surgeon
 - 90% reported decreased pain and satisfaction with the outcome of the surgery
 - 83% reported functional improvement
 - 11% required major revision (one half received another arthroplasty and the other half underwent arthodesis)
 - 76% of surviving arthroplasties demonstrated lucency around implants
 - Majority of these were either focal, stable mechanical lysis along interface between fibula and tibial component

Agility Total Ankle System

- Components of instability or loosening is defined:
 - Migration of more than 5 mm or 5 degrees
 - Progressive lysis in any zone
 - Circumferential lucency posterior to the keel of the tibial component

Agility Total Ankle System

- Reports from 400 cases yields consistently high rates of satisfaction and pain relief
- Survival of implants and a good functional outcome appear to depend on patient age
- Nonunion of the syndesmosis fusion and specific specific patterns of progressive lucency around the implants may herald subsidence and migration of the components and failure of the arthroplasty
- Level IV evidence and Grade B recommendation

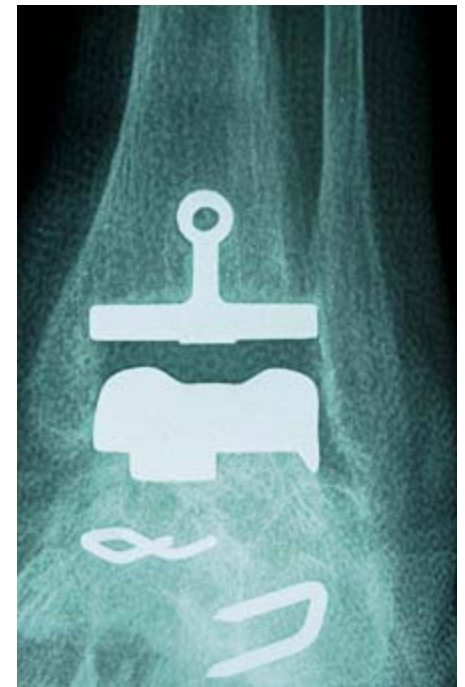
Salto Talaris Anatomic Ankle Prosthesis

- Semi-constrained, fixed bearing
- 3 universal tibial base sizes and 4 talar component sizes, wider anteriorly for better bone coverage
- Two distinct radii of curvature, medially and laterally, avoid overstressing the deltoid ligaments
- Based upon anatomy, the flexion/extension axis is the axis of a cone to allow normal external rotation of the foot during dorsiflexion
- Stability is provided by a hollow fixation plug and three bone cuts (anterior, posterior, lateral) to resurface the talus with minimal bone removal



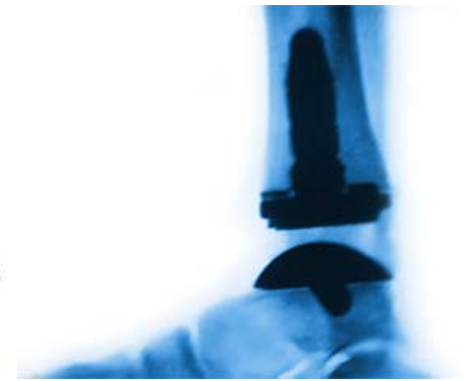
Salto Talaris Anatomic Ankle Prosthesis

- In clinical use since 1997 and at 6.4 year mean follow-up (5-8.5) has a 93% survivorship. FDA approval in November 2006
- 93 cases followed for a mean of 35 months yielded 2 failures with conversion to fusion and 2 reoperations
- AOFAS clinical rating improved and ankle ROM increased significantly
- 72 pts experienced mild or no pain
- 54 pts could walk an unlimited distance
- 92% satisfied



Inbone Total Ankle System

- FDA approved in 2005
- Utilizes an intramedullary guide for osseous cuts
- System is modular, allowing mismatch between the talar and tibial components
- System employs an ultra-high molecular weight polyethylene bearing slotted into a modular coated, stemmed tibial component



Eclipse Total Ankle Implant

- Use of medial or lateral malleolar osteotomy
- The designers contend that this feature avoids the anterior angiosome of the ankle and allows for easier bony resections keep the components congruent with the load bearing surface

New Zimmer TAR

- Will be 1st prosthesis to be implanted via lateral malleolar osteotomy to allow for less bone resection

Scandinavian Total Ankle Replacement System (STAR)

- Semi-constrained prosthesis with cobalt-chrome-molybdenum components and an ultra-high molecular weight polyethylene mobile bearing
- A porous plasma spray coating of hydroxyapatite applied to the nonbearing surface of the components facilitates bony ingrowth



Arthroplasty versus Arthrodesis

- **Arthrodesis**

- Surgical procedure of choice for relieving pain and restoring function in individuals with symptomatic arthrosis, deformity or severe instability of the tibiotalar joint
- Multiple studies have documented its efficacy in long term pain relief

Best Long-term Study

- *Coester, Saltzman, et al, JBJS 2001*
 - 23 patients with post-traumatic DJD with isolated fusion
 - Follow-up average 22 years (range: 12-44 years)
 - Average age at surgery 41 years

Ankle Arthrodesis – Long-term Follow-up

- 88% would have the surgery again
- Radiographically increased rate of arthritis ipsilateral subtalar, calcaneocuboid, talonavicular, tarsometatarsal, 1st MP, naviculocuneiform
- No increase in knee DJD

Arthroplasty versus Arthrodesis

- Disadvantages of ankle fusion
 - Onset of arthrosis of joints adjacent to the fusion
 - Alterations in gait
 - The limb with the arthrodesis also has higher incidence of pain, disability and activity limitation
 - In one study, cadence and stride length were significantly decreased

Arthroplasty versus Arthrodesis

- No studies exist that currently compare participation in sporting activities following these two procedures
- However, one study compared activity level before and after surgery of 147 with TAR
 - After mean of 2.8 years follow up the percentage of patients actively participating in sports increased from 36% to 56%
 - Pts who were active in sports after TAR demonstrated higher AOFAS scores than those that were sedentary

Conclusion

- Despite discouraging results with early TAR systems, surgeons continued to design new prostheses due to ongoing concerns with outcomes of ankle fusion
- New TAR systems employ semi-constrained components with either mobile or fixed bearing design and have demonstrated satisfactory outcomes

Personal Preference

- Single joint involvement offer/encourage ankle fusion
- Bilateral ankle DJD, preexisting hindfoot fusion/DJD encourage consideration for TAR
- Economically not very viable currently as cost of prosthesis exceeds \$10,000 to hospital which is more than Medicare reimbursement for whole procedure to hospital

Resources and References

- Title: [Current concepts review: Total ankle arthroplasty](#)
Author(s): Guyer, AJ; Richardson, EG
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- Title: [Osteoarthritis of the ankle: The role of arthroplasty](#)
Author(s): Chou, LB; Coughlin, MT; Hansen, S, et al.
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- Title: [Postoperative evaluation of the total ankle arthroplasty](#)
Author(s): Bestic, JM; Peterson, JJ; DeOrio, JK, et al.
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