TOTAL ANKLE REPLACEMENT

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Arthritis of the ankle is not only painful and disabling but also affects the quality of life and may threaten the independence of an individual. When all the conservative measures have failed to relieve the symptoms, surgery may be required. The goal is to relieve the pain, retain the function and if possible preserve the mobility. The choice is between arthrodesis and ankle arthroplasty.

Arthrodesis of the ankle is an established procedure and in the majority of patients perhaps the treatment of choice, with a successful fusion rate of 80-85%, but not without a significant morbidity rate. Various techniques to improve the fusion rate have been tried but still 15-20% of patients may need revision surgery to achieve arthrodesis. One big advantage of arthrodesis is that it should last a lifetime. There are, however, concerns that in the long run arthrodesis of the ankle may lead to degenerative changes in the subtalar and midtarsal joints due to increased stress on these joints. In patients with already fused or stiff subtalar and midtarsal joints, it may be preferable to preserve the ankle joint mobility for better function.

Enthusiasm and stimulus for ankle arthroplasty stems from a partial dissatisfaction with ankle arthrodesis and the success seen with total hip and knee arthroplasty. Ankle arthroplasty is emerging as a viable alternative to ankle arthrodesis but should only be performed in a selected number of patients after detailed counselling.

IMPORTANT FACTS ABOUT TOTAL ANKLE ARTHROPLASTY AND COMPARISON WITH TOTAL KNEE ARTHROPLASTY

Total ankle arthroplasty is technically more challenging with a slower learning curve and a higher complication rate than total hip or knee arthroplasty. However the results of modern porous-coated, cementless, congruent, 3-piece, meniscal-bearing total ankle replacements are encouraging, with 91-96% survivorship over a twelve-year period. It is estimated that within a decade ankle replacement may account for 10% of total hip or knee arthroplasty. Ankle joint replacement has been described too simplistically as an 'upside-down knee replacement' where the tibial plateau of the knee has been compared with the tibial surface of the ankle and the femoral condyles compared with the talus. Surgeons should take the following into consideration before contemplating ankle joint replacement.

Bone support

Most orthopaedic prostheses need strong bone for support. Maximum tibial bone strength is within 5mm of the articular surface. The talar bone is 40% stronger than distal tibial bone. The strongest bone is neither central nor evenly distributed across the distal tibial bone. In fact the strongest bone is eccentric posteromedially reflecting the transmission of the force of heel strike.

Force

Forces at the ankle are great because of the longer anterior lever arm of the foot. Therefore during ambulation the Achilles tendon must generate larger tensile forces to overcome the body weight on the longer lever arm. This leads to higher compression forces (up to 5.5 times body weight) across the ankle during normal ambulation.

Surface area

A larger surface area reduces the load per unit area. After the dome of the talus is resected the surface area is one half of the cut surface of the upper tibia in total knee replacement. This means that there are larger forces on a smaller support surface area in the ankle than in the knee.

The stem or keel of a tibial component in total knee arthroplasty increases the surface area to resist compression, shear and rotatory forces. Due to the small size of the talus, there is little room available for a keel whilst preserving sufficient support bone.

The force across the ankle is often neither central nor equally placed across the prosthetic support surfaces. In fact the force is off-centre (eccentric). The eccentric force across the prosthesis leads to a compressive force on one side and a lift-off force on the opposite side. Any malalignment may aggravate the eccentric distribution of the force in the bone, resulting in aseptic loosening.

Design

Early total ankle replacements were initially successful but failed on longer follow-up largely due to poor design and insufficient bone support. An ideal total ankle replacement should offer the following:

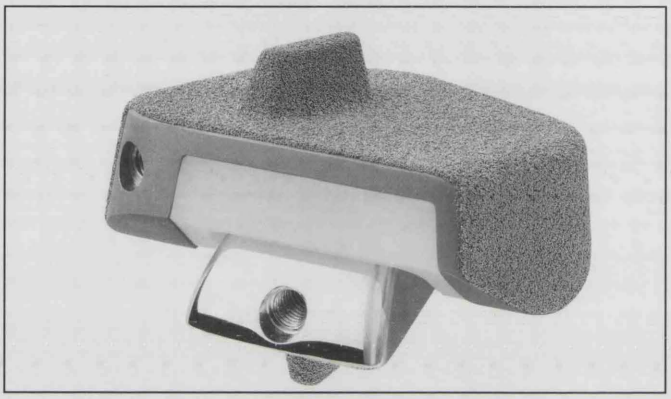
- minimum bone removal on both sides of the joint
- maximum surface area for support of the prosthesis
- maximum stability without excessive bone loss or excessively long stem
- if polyethylene is used, allow sufficient thickness and a conforming geometry
- proper balance between constraint and freedom
- bearing surface with minimum wear
- accurate instrumentation to achieve proper alignment to minimise shear, angular and eccentric forces.

CURRENTLY AVAILABLE DESIGNS

At present three designs are most widely used.

Agility total ankle

- the unique feature of this ankle is the arthrodesis of the distal tibio-fibular syndesmosis at the time of surgery. This provides a larger bone surface area to support the prosthesis but risks the loss of fixation due to possible nonunion
- the polyethylene insert into the metal-backed tibial component is concave in the sagittal plane. This adds to the anteroposterior stability

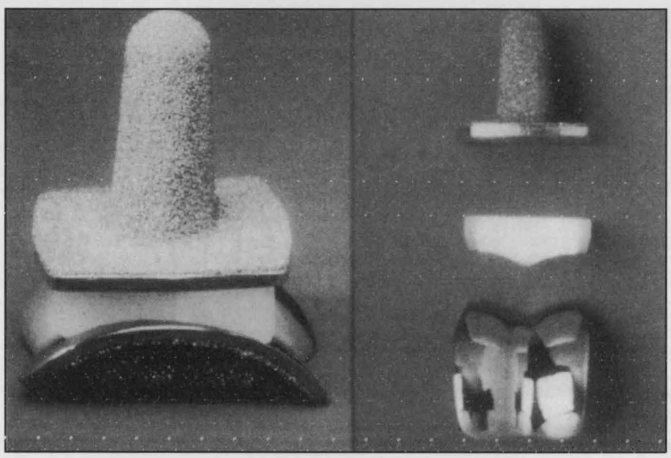


Agility total ankle
Image courtesy of DePuy International

- a deliberate mismatch exists between the larger upper tibial component and the smaller talar component to allow freedom from excessive constraint. This mismatch could, potentially, allow increased contact stresses in the polyethylene. Any malalignment or ligament imbalance may lead to 'edge loading' of the talar component
- the polyethylene component is relatively thin
- this prosthesis requires aggressive tibial and talar cuts resulting in substantial bone removal.

Buechel-Pappas (BP) total ankle

- the Buechel-Pappas total ankle is a three-component design, which utilises a mobile polyethylene bearing
- the mobile bearing reduces excessive stress transfer to the bone prosthesis interface

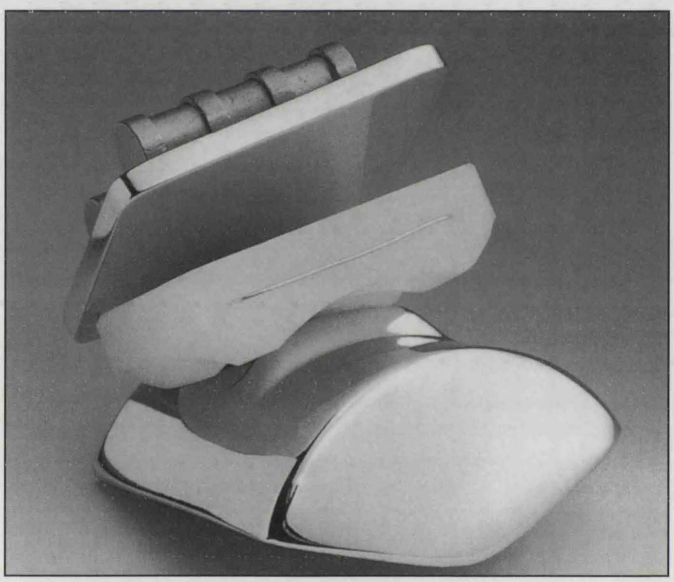


Buechel-Pappas total ankle[1]

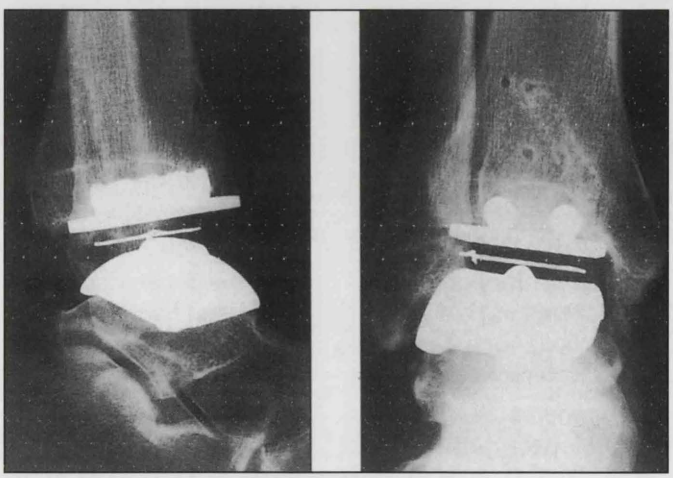
- there is full conformity between the polyethylene component and the tibial and talar components
- the tibial component has a short stem. This may, potentially, protect tibial trabecular bone but avoid excessive stress shielding from an overly long stem
- the talar component is an on-lay component with two fins for fixation. It does not resurface the medial or lateral talar facets and so preserves the talar cortical bone
- the flat upper surface of the mobile bearing may reduce anteroposterior stability.

Scandinavian Total Ankle Replacement (STAR)

- this is also a three-component design with a mobile bearing polyethylene component
- there are two dowels for tibial fixation. This reduces the surface area for stress distribution in the distal tibia compared to the Buechel-Pappas ankle. However the advantage is that stress shielding is likely to be minimal due to the absence of a stem
- the flat upper surface of the mobile bearing may reduce anteroposterior stability



STAR total ankle
Image courtesy of Waldemar Link



Radiographs after surgery
Image courtesy of Waldemar Link

- talar fixation is enhanced by medial and lateral resurfacing. This maximises the surface area for load distribution but removal of medial and lateral facets of the talus decreases the amount of remaining cortical bone.

CONCLUSION

- total ankle replacement is emerging as a viable alternative to ankle arthrodesis for patients with symptomatic ankle arthritis
- the stimulus for total ankle replacement derives from the success of total hip and total knee replacement. However total ankle arthroplasty is more challenging and technically more demanding with a higher complication rate.
- the bone strength is limited with relatively large forces across the ankle. The strongest bone is eccentric. Forces may be eccentric with unequal distribution of stresses on the prosthesis. The surface area is comparatively small.
- first generation total ankle replacements were initially successful but failed on longer follow-up. New designs are promising, especially BP and STAR, with good design features and 91-96% survivorship over 12 years. Patient selection and counselling are important.
- it is estimated that within a decade demand for total ankle replacement will increase and total ankle replacement will equal 10% of total hip and knee arthroplasties. In Morecambe Bay we need to develop the expertise to provide this surgery for present and future patients.

REFERENCE

1. Pappas MJ, Buechel FF Principles of condylar joint replacement: Design and design evaluation. Sir John Charnley International Arthroplasty Symposium, June 2002, Wrightington Hospital UK