INTRODUCTION

Total wrist arthroplasty (TWA) provides a motion-preserving alternative to total wrist arthrodesis for low-demand patients with debilitating arthritis. Palmer and Werner\(^1\) determined the functional range of motion of the wrist to be 30° of extension and 5° of flexion. To perform most activities of daily living, including hygiene and food preparation, Ryu and colleagues\(^2\) suggested that wrist flexion and extension of 40° are required. The first description of a wrist prosthesis was by Gluck, who placed an ivory wrist implant for tuberculosis of the wrist in 1891.\(^3\) Swanson introduced the first commercially available total wrist implant with a hinged silicone interpositional spacer prosthesis in 1967.\(^4\) Significant improvements have been made with TWA prosthesis design over the past 2 decades, which has simultaneously allowed for both improvements in clinical outcomes with TWA, and the expansion of clinical indications for this procedure.

INDICATIONS AND CONTRAINDICATIONS

TWA is classically described for patients with rheumatoid arthritis, especially those with bilateral wrist involvement. Its use has expanded to pan-carpal wrist arthritis in patients with nonrheumatoid inflammatory arthritis, posttraumatic arthritis, osteoarthritis and avascular necrosis. Ideal surgical candidates are patients who have failed nonoperative management with persistent debilitating pain that limits the ability to perform activities of daily living, have low-demand lifestyles, and are seeking a pain-free wrist with preservation of moderate motion. Patients with arthritis involving multiple joints of the upper extremity, including limitations in elbow motion or forearm rotation, often find activities of daily living easier when some wrist motion is preserved and thus may have greater benefit from a TWA over a wrist arthrodesis.\(^5\)

Absolute contraindications include a lack of neuromuscular control of the hand, laborers, those
with high-demand use of the upper extremity for ambulation and transfer, previous surgery with implant or bone loss that limit adequate carpal or radial fixation, and patients with an active infection. One relative contraindication is inadequate carpal bone stock to support the implants from severe erosions or osteopenia. In addition, inadequate treatment of soft tissue contractures or imbalance can lead to persistent instability or motion restriction after TWA.

**OPERATIVE PROCEDURE**

A dorsal longitudinal midline incision is made over the wrist. Full-thickness skin flaps are raised with attention paid to protecting the branches of the radial sensory and dorsal ulnar cutaneous nerves. The retinaculum over the sixth dorsal compartment is incised followed by elevation of the flap radially to the septum between the first and second extensor compartments. The dorsal capsule is raised as a broad, distally based flap off the distal radius from proximal to distal, through the floors of the first and sixth extensor compartments. Care is taken to elevate full-thickness capsular flaps to allow for closure. Alternatively, the distal portion of the extensor retinaculum can be placed under the finger extensors to augment the capsular closure.

Once the dorsal capsule is raised, the wrist can be flexed to expose the joint and perform synovectomies if necessary. A distal ulnar resection can now be performed if there is an arthritic distal radioulnar joint. The order of preparation of the carpus and radius varies. The distal radius is cut, broached, and trialed according to the specific implant, and care is taken to protect the volar radiocarpal ligaments. The technique for carpal bone preparation varies among implants, and Kirschner wires are often used to temporarily pin the carpal bones to facilitate the carpal bone cuts. The distal radius cut is usually made perpendicular to the long axis of the forearm while the carpal cut is made perpendicular to the axis of the third metacarpal. Care is taken to protect the volar capsule and radiocarpal ligaments. Soft tissue balance is extremely important. With the trial radial component in place, trial polyethylene carpal components can be introduced so that both stability and range of motion can be assessed and adjustments made as necessary. Intraoperatively, there should be wrist flexion and extension of 30° in each direction. With limited wrist extension, more distal radius should be resected. If there is volar instability, a larger polyethylene should be used. Repair of the volar radiocarpal ligaments can also be considered. Patients with severe wrist flexion contractures may benefit from step cut lengthening of the wrist flexors.

**PROSTHETIC DESIGN**

Themistocles Gluck performed the TWA using an ivory implant in a 19-year-old patient with tuberculosis of the wrist in 1890. This subsequently developed a chronic fistula and was recognized as a failure despite reported good range of motion. Since then, there have been significant advances in prosthetic design, materials, fixation, and surgical techniques that have led to remarkable improvements in clinical outcome and implant survivorship and decreased complications. Newer implants have more anatomic design, involve minimal bony resection, and have more stable fixation.

**First-generation Implants**

Often described as a first-generation implant, the first commercially available Swanson implant was designed in 1967 as a silicone rubber, 1-piece, flexible, hinged implant that primarily serves as an interpositional implant (Fig. 1). The implant stems are mobile in the medullary canals, fitting into the radius proximally and passing through the capitate and seats in the third metacarpal distally. Long-term follow-up studies have demonstrated prosthetic fracture, implant subsidence, silicone synovitis, and progressive radiologic and clinical deterioration.

Fatti and colleagues retrospectively reviewed 47 patients with Swanson TWA and found that at average follow-up of 5.8 years postoperatively, only 51% of patients reported pain relief compared with their initial 1986 review of the same cohort demonstrating pain relief in 67% at average follow-up of 4.8 years, suggestive of continued clinical deterioration. Long-term studies have shown considerable problems with implant fracture, which most often occurs at the distal stem and barrel junction. Jolly and colleagues found an implant fracture rate of 52% and also showed a trend toward progressive radiologic and clinical deterioration at an average follow-up of 6 years. Silicone synovitis is a well-documented complication of the Swanson implant, with studies reporting rates of radiologic silicone synovitis as high as 30%.

In 2005, Kistler and colleagues reviewed 12 patients with rheumatoid arthritis treated with the Swanson implant with a minimum 10-year follow-up. Interestingly, they reported good to very good subjective results in 75% of patients despite a high number of implant fractures and expected silicone synovitis, suggesting that the correlation between clinical results and implant