Guest editorial

The development of an implant for the metacarpophalangeal joint of the fingers

Arthroplasty of the metacarpophalangeal joints of the fingers was begun by Brannon and Flatt with metallic devices first in the 1950s. It was not until the development of silicone devices in the late 1960s that the concept of prosthetic replacement of the metacarpophalangeal joints became widely used and accepted. The original Swanson implant with the concept of utilizing a flexible hinge as a joint spacer has stood the test of time and remains a viable option for the treatment of arthritic disease of this and other joints (Swanson 1972). The silicone Swanson implant has been an acceptable but certainly "imperfect" implant for joint replacement and, over the last 30 years of its use, there have been a myriad of spacers and true "joint" implants that have been developed seeking to provide a more normal joint function, with a greater arc of motion and greater durability and longevity. Unfortunately, this pathway has been littered with many cleverly designed and manufactured implants that have failed. The metacarpophalangeal joint, with its intricately balanced musculo-tendinous units, its unusual mobility and stability and its large applied stresses, has proved to be a most difficult challenge in joint replacement design.

Niebauer's prosthesis was a true hinge and, unlike the "pistoning" stems of Swanson, had a Teflon webbing attached to its stem to induce fibrous ingrowth for fixation (Derkash et al. 1986). In fact, ingrowth did occur and the device functioned. Early fracture occurred, however (as with the Swanson device), demonstrating the strong volar subluxation and rotation forces that are applied to metacarpophalangeal finger joint replacements (Beckenbaugh et al. 1976). Thus, despite extensive testing which demonstrated extreme durability of the Swanson and Niebauer devices in flexion and extension in laboratory machines, the devices in the body broke early and often in vivo, although not always associated with failure. The fibrous fixation of the Niebauer joints was found to result eventually in reactive bone resorption and the concept was abandoned in the 1970s.

At the same time that the silicone devices were being developed in the U.S. for the finger joints, Charnley, Mueller, and Ring were developing "total" joint replacement devices for the hip in Europe. The success of these devices with the concept of fixed fulcrum bi-articular joint replacement with cement fixation was truly dramatic. The concept was introduced by Coventry in the U.S. in 1969. Shortly thereafter with the admittedly increasing failure rate of silicone implants and the outstanding results with cemented "total joint" arthroplasty of the hip, a number of clever designs incorporating the concept of metal on plastic articulation with partial constraint and cement fixation were developed in the U.S. in the mid-1970s.

These devices which were cleverly engineered, functioned well for a time, but the difficult metacarpophalangeal joint proved too stressful for their durability. For one thing, the center of motion of the devices was noted to be very sensitive to location and displacement of even 1–2 mm resulted in abnormal arcs of motion, with extension or flexion lags and/or contracture. The most difficult problem encountered, however, was the solid-stem fixation in these semi-constrained devices. Three adverse and unacceptable problems were encountered. The first was prosthetic failure due to polyethylene cold flow or fractures and even metallic fatigue and fracture associated with the large forces. Secondly, stress-shielding was identified as bone that would resorb adjacent to the articulations, occasionally to the point of loosening and severely restricting potential salvage. Thirdly, cases of component loosening were encountered in large numbers, as the forces applied to the implant stems proved too great, even with partial poly-metal constraint. Most of these devices were gone by the early 1980s (Adams et al. 1990, Steffee et al. 1981). The principles learned from such device-failures were that the forces were truly great at the metacarpophalangeal joint of the fingers and a "fixed" constrained implant will fail from fracture/deformity or stem loosening with cement and plastic-metal devices.

In the next period in the 1980s, new concepts were developed in Sweden and the U.S. Lundborg, Hagert and others expanded the concept of implant fixation by "osseointegration" (Hagert 1978). In the two-stage procedures, a stem grommet was screwed into bone, allowed to fix and, in a second stage, an articulated

constrained device was seated into the now bone-fixed stems. The fixation was successful, but again the stress was too great, resulting in interface failure. At the same time, this author developed a nonconstrained "ball and socket" designed implant made of specially treated carbon material that induced appositional bone fixation. The device was successful in achieving bone fixation, but on the early implantations, the motion achieved was so great (90 degrees) that soft tissue failure was encountered. Unfortunately, financial support for the project was lost and use of the implant was temporarily abandoned (Linscheid and Beckenbaugh 1991). Thus, by 1990 it had been shown that osseointegration was a successful form of fixation and a more normal surface replacement (ball and socket) could provide for desired motion. While joint replacement concepts were being developed around the world, the standard had remained as the "strengthened" Swanson and the "Sutter" silicone devices.

In this issue (pp 109–115), Möller et al. have carefully reviewed a group of arthroplasties utilizing the concept of osseointegration of stems with a flexible silicone "band" as an articulation. As expected, the osseointegration has been successful in a "single" stage. The silicone joining band, however, has functioned, but with a significant failure rate, as reported.

As we approach the millennium, it is likely that new successful joint replacements for the metacarpophalangeal joints of the fingers will be developed. The work of the multiple inventors over the last 30 years has suggested that the implant will need to be made of materials capable of biologic fixation and to have a more anatomical nonconstrained articulated design. Hopefully, biologic developments and the skills of surgeons will allow proper soft tissue envelope reconstruction around these devices.

Robert D Beckenbaugh
Orthopedic Surgery, Surgery of the Hand, Mayo Clinic, 200 First Street SW, Rochester, Minnesota 55905, USA

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