Total Wrist Arthroplasty

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Design and Development of Total Wrist Prostheses

Total wrist prostheses appeared relatively late in the history of articular prostheses, mainly because arthrodesis is a reliable procedure for the treatment of advanced painful destruction of the wrist. However, for the management of rheumatoid arthritis, in which both wrists are commonly involved, arthroplasty is becoming increasingly popular.

In 1967 Swanson [19, 20] developed a silicone rubber flexible hinge implant for the radiocarpal joint. Our first total wrist prosthesis was designed in 1970. It was introduced clinically in 1971. A preliminary review was published in 1973 [11]. Until that time the Silastic spacer by Swanson was the only implant available. In the design and development of the total wrist prosthesis we were guided by following criteria: (a) the prosthesis must imitate as closely as possible the function of a normal wrist, (b) the materials used must be those with proven worth as components of other joint arthroplasties, and (c) the operative technique must be reproducible and performed in such a way that in case of failure acceptable salvage procedures are possible.

It became clear in the early stages of the design that the very complex joint kinematics of the wrist could not be simply copied, and we had to find a compromise. The fact that the center of motion is located within the head of the capitate bone inspired the design of a ball-and-socket joint, the simplest approach possible. A ball joint is easily made and presents no material problems. It is unconstrained, permitting motion in all planes as well as a slight distraction. The unconstrained design greatly reduces any unfavorable stresses on the anchorage of the parts in bone because impingement occurs only at the very limits of motion. It is also advantageous that the use of a ball joint compensates for technical rotational failures of implantation.

During the past two decades descriptions of numerous wrist prostheses have been reported, which demonstrates the interest and the need for such implants [1, 2–4, 6–10, 16, 21–23]. Better understanding of the functional anatomy and kinematics of the carpus were decisive for this evolution. In the course of the time our original prosthesis has been continuously improved. The range of motion was considerably increased by making the socket shallower, without sacrificing stability. In the final design the anchoring prongs were located
eccentrically to simplify the precise centering of the prosthesis. The refinements of the surgical technique, careful selection of the patients, and strict observation of the indications and contraindications have substantially reduced the failure rate and therefore the need of subsequent revision surgery [12–14].

However, some problems still had to be solved, such as centering of the prosthesis, fixation of the prosthesis in the carpus, the use of cement and the problems associated with polyethylene wear. Exact positioning of the center of rotation is extremely important for the prosthesis to function well, and a prerequisite for adequate tendon balance. Fixation of current prostheses in the carpus is difficult because, instead of one solid bone, only an assemblage of several small bones with joint spaces between them is present. Cementing is therefore difficult and often insufficient. In case of instability the wear products of cement leads to granulomatous soft-tissue reactions resulting in local osteolysis with severe subsequent reduction of the bone stock. Furthermore, the polyethylene ball in our former prosthesis was considered inadequate because of increased wear rate, deformation and the inherent consequences of polyethylene debris. To reduce these problems a new prosthesis was developed in 1986. It is the result of a completely new technology and manufacturing process and is made from state-of-the-art materials.

The Meuli Wrist Prosthesis III

The third revised implant Meuli Wrist Prosthesis (MWP III) is composed of titanium 6-aluminium 7-niobium wrought alloy Protasul 100. The surface is corundum rough blasted. The ball head is coated with titanium nitride, which is exceptionally hard and therefore has excellent wear resistance. The cup inset is made of ultrahigh molecular weight Polyethylene Chirulen. The prosthesis consists of two components: the proximal ball (radius part) and the distal socket (carpal part). There are two sizes in right- and left-hand versions. The radius part can be used for both the right- and left-hand prosthesis, the head being offset to the ulnar side. The anchoring prongs of the carpal part are inclined at an angle of 15° dorsally to the median axis. Both anchoring prongs are straight, the stem for the second metacarpal bone is in a radial offset position helping to center and balance the prosthesis (Fig. 1).

Although the prosthesis can be alternatively cemented into the bone with methylmethacrylate, it is designed for use without cement. The prongs, which can be contoured to adapt to the position of the metacarpals, the anchorage flanges, and the accurate fit provide excellent primary stability in the previously prepared bone stock. Secondary fixation is expected as a result of bony on-growth to the titanium implant [18]. The ball joint remains unchanged. Its fixed base at the radiolunate junction guarantees stability of the system and maintains carpal height. Ligamentous support is therefore no longer necessary. The mobility of the system is ensured by free movement within the ball and socket joint.