A Review Paper

Indications for Ulnar Head Replacement

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Abstract

Implanting an endoprosthesis is a clinically proven means of reestablishing mechanical contact between the distal radius and ulna, thus providing the foundation for stability of the entire forearm. The indications for, contraindications to, and outcomes of ulnar head replacement are discussed, together with the underlying mechanics, pathomechanics of ulnar head excision, the theoretical basis for implant arthroplasty, and the designs that have been employed.

Historically, resection of the ulnar head has been an accepted treatment for painful arthrosis of the distal radioulnar joint. Although patients can be satisfied with the result, painful convergence instability is a common outcome. Attempts to counter such instability with soft-tissue procedures have been largely unsuccessful. Implantation of an endoprosthesis is a clinically proven means of reestablishing mechanical contact between the distal radius and ulna, thus providing the foundation for stability of the entire forearm joint. Implants have been based on hemiprosthesis, multicomponent unconstrained surface replacement arthroplasty, or semiconstrained total joint arthroplasty designs.

Anatomy

The ulnar head forms the distal end of the ulna. Under normal circumstances, it articulates with the medial surface of the distal radius and provides attachments for the soft tissues that contribute in no small part to the stabilization of the distal radioulnar joint (DRUJ) and the ulnocarpal relationship. The ulnar head can be further divided into bony regions, namely, the styloid process and the seat. The ulnar styloid process is a cylindrical projection along the posterior cortex extending distally a variable distance from the head. The seat of the ulna is a cylindrical expansion formed by the distal epiphysis of the ulna. Approximately two thirds of the seat is covered by articular (hyaline) cartilage for articulation with the sigmoid notch throughout the range of forearm pronation and supination, as well as interfacing with the proximal surface of the triangular disc of the triangular fibrocartilage complex (TFCC). Between the base of the styloid process and the seat of the ulna is a depression, the fovea, which is a key attachment point for stabilizing soft tissues.

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Am J Orthop. 2008;37(8 suppl):17-20.

Mechanics

Hagert[1] reminded us that the DRUJ is merely part of the overall forearm joint, which is essentially a bicondylar joint. The axis of rotation of the forearm passes obliquely through the forearm from the radial head proximally through the ulnar head distally.[2] Forearm rotation occurs about this axis in a manner that pivots the radius around the fixed ulna—which necessitates a gliding motion through the DRUJ, combining rotation and translation.

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This motion is facilitated by a differential radius of curvature between the sigmoid notch and the ulnar head (larger vs smaller radius of curvature, respectively).

DRUJ constraints, which have been studied extensively, include static and dynamic stabilizers. The primary constraints of the DRUJ are found in the TFCC as the dorsal and palmar radioulnar ligaments. These ligaments attach to the radius at the margins of the sigmoid notch and converge to form a single attachment at the fovea. There are several different interpretations of the position- and motion-direction–specific roles of these ligaments, but it is clear that the integrity of both ligaments is a requisite for a stable DRUJ.[3-5] The DRUJ joint capsule is an important stabilizer of the DRUJ, most evident in positions of extreme pronation and supination. The entire soft-tissue envelope of the ulnar side of the distal forearm and wrist forms an important secondary stabilizer, as does the interosseous membrane. Finally, merely having contact between the ulna and the radius through the DRUJ has been shown to generate up to approximately 30% of the total constraint of the DRUJ.[5] As long as the ulnar head is in contact with the sigmoid notch, the muscles that cross the axis of forearm rotation stabilize the forearm and DRUJ by compressing the ulnar head to the radius within the arc of the sigmoid notch.

Pathomechanics of Ulnar Head Excision

When the ulnar head is removed, the foundation of the DRUJ undergoes alterations. The radius and ulna are "uncoupled," creating an intrinsically unstable construct. No longer is the radius in contact with the ulna, and therefore there is a complete loss of the "up to 30%" constraint created simply by having the radius and ulna in contact with each other. There is a disruption of soft-tissue attachment of the TFCC and DRUJ joint capsule with excavation of the bony support for the soft-tissue envelope of the distal forearm and ulnar wrist, as already noted. The dynamic stabilizers are unopposed in their action to draw the radius and ulna together, resulting in convergence instability and loss of tension in the interosseous membrane, further destabilizing the forearm joint.[6]

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Theoretical Rationale of Implant Arthroplasty

There is no doubt that resection of the ulnar head (Darrach resection) or creation of a distal diaphyseal pseudarthrosis with fusion of the ulnar head to the radius (Sauvé-Kapandji procedure) can result in clinical success, as noted extensively in the literature. These procedures have been shown to be efficacious in patients with intractable pain for arthrosis and complications resulting from caput ulnae syndrome. However, most patients dramatically alter use patterns after such procedures and are limited by painful convergence instability. Interestingly, though grip strength has been shown to improve after ulnar head resection under appropriate conditions, little is known about the effects on torque strength.

The rationale for implantation of an endoprosthetic ulnar head is based on the need for direct contact between the distal ulna and the radius, which completes the mechanical linkage of the forearm joint. Attempts to use soft-tissue procedures to stabilize the forearm joint after ulnar head resection have been found to be mechanically ineffective[7] because of the inability to create a soft-tissue stabilizing procedure based on a vector that holds the radius and ulna apart. Thus, the principal purpose of implanting an ulnar head endoprosthesis is simply to hold the diaphyses of the distal radius and ulna apart.[6,8] This process retensions the interosseous membrane, counters the converging tendencies of the dynamic forearm stabilizers, restores improved muscle tension profiles, reestablishes a stable architecture for the axis of rotation, and provides the endoskeletal support for the envelope of soft tissues associated with the ulnar aspect of the distal forearm and the ulnocarpal joint.

Design

Ulnar head endoprostheses can be divided into unconstrained and semiconstrained categories. Unconstrained prostheses can be further grouped into hemiarthroplasty and total (surface replacement) arthroplasty designs. Unconstrained prostheses are designed to simulate characteristics of the natural ulnar head; they separate the radius and ulna and provide a convex articular surface for contact with the sigmoid notch. At the same time, unconstrained implants depend on soft-tissue stabilization to keep the ulnar head in contact with the sigmoid notch.

Hemiarthoplasty implants make contact directly with the native sigmoid notch. Each device is implanted into the medullary canal of the distal ulna through a stem or shaft. Universally, but with minor variations, a soft-tissue envelope is developed, creating essentially a soft-tissue socket around the semispherical head to stabilize the implant relative to the radius. Ulnar head endoprostheses vary in their design characteristics, including full-radius curvature, partial radius curvature, centered alignment of the head on the shaft, and eccentric alignment of the head on the shaft. It has been shown in the laboratory that the full radius head with centered alignment is efficacious in restoring normal kinematics and stabilizing characteristics of the forearm joint.[6,8] No studies have shown any change in these results with introduction of alternative designs. The various materials that have been used range from silicone rubber, pyrolytic carbon, ceramic, and cobalt-chrome. Silicone rubber has been withdrawn from use because of an unacceptable fracture rate and incidence of particulate silicone synovitis.

Recently, a sigmoid component designed to interface as a surface replacement arthroplasty with an ulnar head endoprosthesis was introduced. This design is based on a metal backing secured to the distal radius and a high-density polyethylene (HDPE) wafer integrated into the metal back. The concave curvature of the HDPE wafer matches the curvature of the ulnar head implant. Again, creating a soft-tissue envelope around the construct is necessary for stability.

An alternative to implant arthroplasty for stabilizing the forearm joint is the semiconstrained design, in which radial and ulnar components are connected through a sliding gimbal that allows rotation and translation sufficient for forearm rotation. Because the radius and ulna are linked, the need for soft-tissue stabilization is minimized. Rather, the soft-tissue envelope is used to provide coverage for the implant from the overlying extrinsic tendons.

Indications

An obvious prerequisite for implantation of an endoprosthetic ulnar head is a missing native ulnar head. If there is pain, and lack of an ulnar head is its root cause, implantation of the endoprosthesis should be considered. Typically, instability related to loss of constrained contact between the distal radius and distal ulna is found to be the root cause of the pain. Although anterior–posterior instability of the

Figure 1. Preoperative anteroposterior film.

Figure 2. Postoperative anteroposterior film.

radius on the ulna can be painful, it more typically results in a conscious sense of instability and weakness, sometimes accompanied by a clicking sensation. Some describe this as "piano key" or "shuck" instability. What is more often an actual cause of pain is contact between the stump of the ulna and the distal radius, that is, convergence instability.

Convergence instability typically has presented as increasing pain with simply bearing a load in the hand when the forearm is parallel to the ground in a neutral rotation position. Gravity-induced convergence is essentially created between the hand–wrist–radius unit and the fixed ulna. In the clinic, the distal ulna and radius can be squeezed together to try to recreate the patient's pain and demonstrate convergence instability. Radiographs can also confirm the presence of convergence instability, though they are not pathognomonic. There may be excessive tapering of the distal end of the ulna, and there may be a depression formed in the medial cortex of the radius at the point of contact between the tip of the ulna and the radius.

Thus, the main indication for implanting an ulnar head endoprosthesis or semiconstrained DRUJ endoprosthesis is painful instability after resection of the ulnar head. Instability alone, without pain, can also be a valid indication at the discretion of the surgeon in careful consideration of the functional expectations of the patient. The procedure can be considered for all resection conditions, including Darrach resection, Sauvé-Kapandji pseudarthrosis, and even some wide ulnar excision situations. Excessive loss of ulnar length may compromise the ability to secure a proper fit of the ulnar component.

This procedure can be performed either as a revision after a failed resection arthroplasty or as a primary procedure the same time that a resection arthroplasty is being performed (Figures 1, 2). Given the inherent instability after resection of the distal ulna, in patients with degenerative arthritis of the ulnar head or sigmoid notch, I typically plan on performing an immediate endoprosthesis implantation as a primary procedure unless it is contraindicated. It is indicated for any type of arthritic condition, though when there is significant ongoing inflammation with soft-tissue involvement, medical management should be optimized before prosthetic implantation is considered. In my experience, endoprosthesis implantation in a very limited number of patients with marginally controlled inflammatory arthropathy has had limited success because of progressive loss of soft-tissue stabilization.

Painful convergence instability can occur as frequently with a Sauvé-Kapandji procedure as with an ulnar head resection because of the same mechanical uncoupling noted earlier. Endoprosthetic options can be divided into maintaining the ulnar head in situ and excising the ulnar head. For maintaining the ulnar head in situ, implanting an endoprosthesis into the pseudarthrosis has been reported, but this procedure would be limited to using an implant that has either a convex distal geometry for stable articulation with the neck of the ulna or the ability to rotate at the head–stem interface. Excision of the ulnar head can be revised to an implant arthroplasty using either a semiconstrained implant or a hemiarthroplasty. However, it is advised that, when revising a Sauvé-Kapandji procedure

to an implant arthroplasty, use of the hemiarthroplasty technique should also involve implantation of a sigmoid component. The reason is that, with excision of the ulnar head, cancellous bone within the region of the previous sigmoid notch is exposed because the subchondral bone of the sigmoid notch was likely excised during preparation for the ulnar head fusion procedure. The mismatch of hardness of the ulnar head endoprosthesis and the cancellous bone may predispose to subsidence of the endoprosthesis into the distal radial epiphysis, undermining the cancellous bone supporting the lunate fossa.

Contraindications

Contraindications, the same as with any other implant, include active infection, insufficient soft-tissue coverage, insufficient muscle control of the forearm joint, lack of predictable gain of function as a result of the procedure (including likely severe limitation for forearm motion), excessive loss of ulnar length, and other considerations, including patient compliance, comorbidities, and unrealistic expectations of outcomes. It cannot be overemphasized that removal of a nonarthritic ulnar head for treatment of "ulnar wrist pain" should be avoided and cannot be justified simply because there are now adequate endoprosthetic implants available. These implants do not create a normal joint and should not be expected to. Removing a nonarthritic ulnar head is seldom justified.

Outcomes

Although silicone rubber implants had their problems, newer implants are showing great promise. Because of space limitations, I refer the reader to the relevant original articles.[9,10] Very few complications have been reported with the implants. Residual pain, instability, and loosening have all been reported but seldom have required surgical revision. One comforting fact is that if indeed the implant must be removed (for whatever reason) and if the procedure is performed properly, then the patient will be left with a resection arthroplasty, no worse of a situation than what he or she would have experienced having undergone a primary procedure without implant arthroplasty.

Author's Disclosure Statement

The author wishes to note that he is a co-holder of the patent on the uHead™ Ulna Head Implant (SBI, Morrisville, PA).

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