Elbow Arthritis

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Abstract
Patients with elbow arthritis typically present with complaints of pain and stiffness. Rheumatoid arthritis is the most common cause of elbow arthritis, followed by posttraumatic arthritis and primary osteoarthritis. Nonoperative management consisting of oral analgesics, intra-articular steroid injections, physical therapy, and splinting may provide symptomatic relief in the majority of patients. If these modalities fail, operative treatment is guided by the severity of disease as well as several patient-related factors such as age, activity level, and expectations. Total elbow arthroplasty can provide satisfactory results in the majority of patients with significant degeneration of the elbow. However, due to issues regarding prosthesis longevity, this procedure is generally avoided in young active patients. Other operative treatment options for such patients include arthroscopic or open synovectomy, debridement arthroplasty, and interpositional arthroplasty. As all of these operations may provide a satisfactory outcome for the appropriate patient, a thorough preoperative evaluation is essential in choosing the suitable surgical procedure for each individual patient.

The most common complaint associated with elbow arthritis is pain. The severity of pain, along with the degree of limitation in motion, guides the treatment of such patients. Age and overall functional status of the patient are also important factors to consider when formulating a treatment plan. The causes of elbow arthritis are varied and include rheumatoid arthritis (RA), posttraumatic arthritis, primary osteoarthritis (OA), septic arthritis, crystalline arthropathy, hemophilia, and ochronosis. The three most common types are RA, posttraumatic arthritis, and primary OA.

Anatomy
The elbow is a modified hinge joint comprised of three articulations contained within one synovial lining. The three articulations include the ulnotrochlear, radiocapitellar, and proximal radioulnar joints (Fig. 1). The proximal ulna provides the major articulation against the distal humerus and is responsible for the majority of joint stability. The proximal aspect of the ulna consists of the greater sigmoid notch, which articulates with the trochlea of the distal humerus. The sigmoid notch provides inherent bony stability in both the coronal and sagittal planes. Bony stability is provided by the coronoid in flexion and by the olecranon and the radiocapitellar joint in extension.

The ulnar collateral ligament (UCL) is located on the medial aspect of the elbow. The UCL consists of three bands, including the posterior band, the transverse band, and the anterior band. The transverse band appears to contribute little to the overall biomechanical properties of the UCL. When the elbow is flexed, the posterior band is under tension. In extension, however, the anterior band is under tension and, hence, believed to provide restraint against valgus stress. Morrey and colleagues performed a biomechanical study evaluating the constraints of the elbow to valgus stress. With the radial head removed and the UCL intact, the result was approximately 20% valgus instability. With the radial head removed and the UCL released, the result was 100% valgus instability. From these data, they concluded that the anterior band of the UCL is the primary constraint to valgus stress, and the radial head is a secondary constraint.

The lateral collateral ligament complex is located on
the lateral aspect of the elbow. It is comprised of the radial collateral ligament, the lateral UCL, the accessory collateral ligament, and the annular ligament. The annular ligament secures the proximal radioulnar joint. The lateral collateral ligament complex provides static stability to varus stress, while the anconeus is thought to add some dynamic varus stability. Hence, injury to the lateral UCL results in posterolateral rotatory instability of the elbow.

The elbow joint has two degrees of freedom. There is flexion-extension at the ulnotrochlear joint and pronation-supination through the radiocapitellar joint as well as the proximal and distal radioulnar joints. Although variable, the normal range of motion approximates 0° of extension to 145° of flexion and 80° of pronation to 85° of supination. The functional range of motion of the elbow has been shown by Morrey and associates to be 30° of extension to 130° of flexion and 50° of pronation to 50° of supination.

**Etiology**

**Rheumatoid Arthritis**

Rheumatoid arthritis is an inflammatory condition typified by synovial proliferation that can affect multiple joints, including the elbow. Up to 50% of patients with RA will present with elbow synovitis. In addition, patients can also present with extraskeletal manifestations, such as anemia, pulmonary conditions, cardiac disease, and vasculitis. A thorough history and physical examination are essential when treating these patients. Patients with RA of the elbow usually complain of pain throughout the arc of motion. The ulnotrochlear articulation is generally affected first although patients may display limitation in forearm rotation as the disease process becomes advanced. Instability may also play a role in elbow dysfunction. The loss of bony congruency, with or without destruction of soft tissue stabilizers, can often result in severe and symptomatic instability. The elbow may then become incongruent, which can lead to increased mechanical wear and possibly a flail elbow, with excessive motion in the coronal plane.

**Osteoarthritis**

Primary OA of the elbow is a relatively rare condition that comprises only 1% to 2% of patients with elbow arthritis. Primary OA of the elbow is a disease that is almost exclusive to males, and has a strong association with strenuous use of the arm in activities ranging from weight lifting to operating heavy machinery. In 1936, Rostock reported a nearly 33% incidence of primary OA in a large population of coal miners. Similarly, Stanley and Sakakibara and coworkers also reported a clear association between symptomatic primary OA of the elbow and manual labor as well as the prolonged use of industrial tools.

The pattern of pain in patients with primary OA is quite different than that of patients with RA. OA patients classically complain of impingement pain at the extremes of motion, most notably in extension. During the early course of the disease, when the joint space is still maintained, osteophytes in the olecranon fossa and the proximal portion of the olecranon cause pain in maximal extension. Similarly, if osteophyte formation occurs in the trochlea or in the coronoid process, impingement pain may be noted in extreme flexion. Patients may complain of pain throughout the arc of motion, but this is typically a late finding when the disease is more advanced.

**Posttraumatic Arthritis**

Posttraumatic arthritis may occur after any traumatic insult to the elbow, regardless of severity. It can occur in patients of either gender and of any age, but is most common in young males. The risk of developing this condition correlates with both the injury pattern and the energy of the injury.
Intra-articular distal humerus fractures, for example, are most often associated with the development of degenerative joint disease over time.\(^7\)

Similar to patients with RA, patients who suffer from posttraumatic arthritis will complain of pain throughout the arc of elbow motion. In contrast, as a result of both articular incongruity as well as soft tissue contracture, instability is rarely a concern. When treating patients with posttraumatic arthritis of the elbow, the surgeon may also be faced with the management of nonunions, heterotopic ossification, and previous hardware. It is important to take note of previous surgical scars for the planning of appropriate incisions and operative approaches.

**Presentation**

**History**

As mentioned above, the complaints of patients who present with elbow arthritis will vary, depending on the specific arthritic condition from which they suffer. However, universally, patients with elbow arthritis complain of pain and, to a certain extent, stiffness. As mentioned previously, it is important to determine if the patient experiences pain throughout the arc of motion or only at the end ranges of motion. Pain at night or at rest is suspicious for infection. Patients with advanced RA or with untreated ligamentous injuries may complain of elbow instability. They may also describe weakness, but this is more likely a perceived weakness, secondary to pain or instability. Carrying heavy objects may also be problematic.

**Physical Examination**

One should expect to find pain and crepitus with elbow range of motion in the majority of patients. Patients with pain only on forced flexion or extension are more likely to have OA. Limitation in elbow flexion and extension should be carefully measured with a goniometer. The examiner should also attempt to discern involvement of the radiocapitellar joint by assessing forearm rotation. A joint effusion may be appreciated by palpation of the “soft spot” marked by the radial head, lateral epicondyle, and proximal olecranon. These patients should be checked for instability, particularly in the coronal plane. The ulnar nerve should be examined for signs of irritation. It is also important to document the presence and the location of previous surgical incisions and healed wounds.

**Radiographic Evaluation**

Radiographic evaluation should begin with plain roentgenographs. Standard anterior-posterior (AP) and lateral views should be obtained as well as a radiocapitellar, or Greenspan view.\(^13\) Radiographic findings typical for RA include symmetric joint space narrowing, periaricular erosions, and disuse osteopenia. The Mayo classification\(^14\) is useful when radiographically describing rheumatoid disease of the elbow. Grade I denotes synovitis without articular destruction and is characterized, radiographically, by soft tissue swelling and osteopenia. Grade II disease demonstrates mild to moderate joint space narrowing. Grade III applies when there is significant arthrosis and architectural changes, with a variable degree of joint space narrowing. Finally, grade IV is reserved for gross articular destruction with extensive loss of subchondral bone.

No such radiographic classification systems exist for primary OA or posttraumatic arthritis. However, there are typical radiographic findings for each disease. The radiographic characteristics of osteoarthritis include ulnotrochlear joint space narrowing, olecranon and coronoid osteophytes, and osteophytes of the olecranon and coronoid fossae. Loose bodies may also be present. Radiocapitellar and proximal radioulnar involvement may be seen in advanced stages of disease. The radiographic appearance of posttraumatic arthritis can be variable. Joint space narrowing and arthrosis are the hallmarks of disease; other potential findings include malalignment, subluxation, nonunion, heterotopic ossification, and hardware from previous surgery.

For the majority of patients, plain radiographs are sufficient for a complete evaluation. In patients with significant bony deformities or intra-articular loose bodies, noncontrast CT scan may also be considered.

**Nonoperative Treatment**

Nonoperative management of elbow arthritis is similar to that of other arthritic joints. If not medically contraindicated, patients should be prescribed analgesics, such as nonsteroidal anti-inflammatory drugs (NSAIDs) or acetaminophen for pain control. Many classes of drugs exist that can aid in the medical management of RA, including oral steroids, disease-modifying anti-rheumatic drugs (DMARDs), and tissue necrotic factor (TNF) blockers.\(^6\) Intra-articular steroid injections can be very effective in the management of acute rheumatoid flares and also have been successful as maintenance therapy in patients with degenerative joint disease.

Physical therapy is important for the maintenance of elbow range of motion, along with the institution of a joint protection program. A program of this type instructs the patient in techniques to perform activities of daily living (ADLs) with reduced joint reactive forces. This approach serves to reduce pain, minimize further joint deterioration, and conserve energy. Some of the basic techniques are to avoid aggravating activities, to respect pain and use it to guide physical activity, to avoid deforming positions, and to strike a balance between use of the elbow and rest.\(^15\) Hinged braces can serve to protect the elbow from stresses in the coronal plane while still permitting active range of motion. Night splints act to both rest and protect the elbow during sleeping hours. For maximal benefit, most patients are advised to utilize all or some combination of these modalities and other assistive devices.

**Operative Treatment**

When nonoperative modalities fail and surgical intervention is indicated, the type and severity of arthritis, as well as the
age and activity level of the patient, will strongly influence the type of surgery best suited for the patient: open versus arthroscopic synovectomy, open versus. arthroscopic debridement, radial head excision, interpositional arthroplasty, total elbow arthroplasty (TEA), or arthrodesis.

**Open Synovectomy**
Open synovectomy, with or without radial head excision, is a well established treatment option for patients with RA of the elbow. It is usually performed through the standard Kocher interval, although the skin incision may vary based upon previous incisions or in planning for future surgery. The primary goal of synovectomy is to provide pain relief, with only a minor improvement in motion. It is therefore best performed during the early phase of disease (Mayo grades I and II), prior to articular destruction. In theory, synovectomy should alter the course of the rheumatologic process and prevent destruction of the elbow joint although this remains a controversial assertion. However, Jensen and colleagues published a series of cases with statistically significant radiographic progression of disease after open synovectomy, despite clinical improvement in both pain and function. Mäenpää and associates compared early and late synovectomy in a series of 103 patients and found that patients who underwent late synovectomy had a higher rate of subsequent TEA. They concluded that although synovectomy provided pain relief in both early and late disease, only early synovectomy may prevent further deterioration of the elbow joint.

Controversy also exists as to when to perform radial head excision. Radial head excision may be appropriate when forearm rotation is painful and limited to less than 100°. The risks of radial head excision include increased rate of ulnotrochlear disease progression as well as late valgus instability. When the radial head is excised, increased load is applied to the ulnotrochlear articulation, presumably due to a transfer of axial forces from the radius to the ulna via the interosseous membrane. As RA is a destructive process, loss of the radial head, which acts as a secondary stabilizer to valgus stress, may place the elbow at an increased risk to develop late valgus instability. Lehtinen and coworkers, for example, examined the radiographs of a large cohort of rheumatoid elbows over a 15-year period and found that the usual pattern of destruction entailed proximal migration of the ulna into a valgus alignment.

In general, patients who undergo open synovectomy with or without radial head excision experience satisfactory results. It is difficult to draw definitive conclusions from the literature regarding isolated synovectomy, as most large series include patients who have had their radial head excised. Ferlic and colleagues reported a 77% rate of excellent or improved results on 57 elbows in 46 patients at a mean follow-up of 86 months. Tulp and Winia similarly reported satisfactory results in 70% to 90% of their patients. Although most patients report good relief of pain shortly after the procedure, the long-term data is somewhat mixed. According to Porter and associates, pain relief can last beyond 10 years in up to 80% of patients. However, Lonner and Stuchin found that the majority of patients experience recurrence of pain five years after surgery.

There are also mixed reports as to whether previous open synovectomy has an effect on the outcome after TEA. Schemitsch and coworkers published a retrospective review comparing a series of 23 elbows that had undergone TEA after a previous open synovectomy and radial head excision against a series of rheumatoid elbows that had undergone primary TEA. According to their experience, the surgical procedure was more difficult and the functional outcomes were inferior in patients with previous surgery. In most cases, the causative factor of a poor outcome was postoperative instability. Of note, these investigators used a nonconstrained total elbow prosthesis that relies heavily upon soft tissue balancing for stability. In contrast, van der Lugt and colleagues reported comparable results with a comparable complication rate among the two groups, in a similarly designed study. Whaley and associates found no difference in functional outcome or survivorship in patients who underwent primary or revision semiconstrained TEA after synovectomy. They reported a higher complication rate in the revision group, but this did not have an effect on long-term outcome.

**Debridement Arthroplasty**
Debridement arthroplasty was described by Outerbridge and later popularized by Kashiwagi for the treatment of primary OA of the elbow. Therefore, although there are various associated names, this surgery is now referred to as the Outerbridge-Kashiwagi procedure, or the “OK” procedure. This surgery is indicated in those patients with primary OA who have failed nonoperative management and have continued pain at the extremes of motion and radiographic evidence of impinging osteophytes. Patients with pain throughout range of motion who have severe degenerative changes on radiographs are not candidates for this type of procedure. The procedure is typically performed through a triceps-splitting posterior approach to the elbow and consists of a core osteotomy of the distal humerus, along with osteotomies of the tips of the coronoid and olecranon. The core osteotomy through the olecranon fossa creates a communication between the anterior and posterior compartments of the elbow, while maintaining the medial and lateral columns of the distal humerus for stability. After removal of all impinging bone and loose bodies, anterior capsular release can also be performed if a significant flexion contracture persists.

Forster and coworkers retrospectively reviewed the results of their series undergoing this procedure and found that improved outcomes tended to occur in patients who had 1) symptoms for less than two years, 2) pain that was not controlled with oral analgesics, 3) formation of at least one posterior loose body, and 4) concomitant cubital tun-
nel syndrome. Patients without preoperative locking of the elbow were inclined towards having inferior outcomes. History of trauma, preoperative range of motion, and extent of radiographic disease progression had minimal effect on outcome.

With appropriate patient selection, debridement arthroplasty can provide pain relief and gains in range of motion, with relatively low morbidity. However, much like synovectomy, results appear to deteriorate with time. Minami and Ishii published an initial report at a mean follow-up of five years and demonstrated that 65% of patients had minimal or no pain. In a second publication reporting a mean follow-up of 12 years, Minami and colleagues noted that results deteriorated, with 55% of patients reporting minimal or no pain. Morrey published a study with short-term results on 15 patients, in which 80% had good or excellent results, with a mean gain in the arc of motion of 21°. Antuña and associates similarly reported satisfactory long-term results in 46 elbows, treated at the Mayo Clinic, with a mean follow-up of 6.6 years. In this study group, 76% of patients had minimal or no pain with an average improvement in motion from 79° to 101°. They noted that 28% of their patients complained of ulnar nerve symptoms that adversely affected the outcome scores. Based on their findings, they recommended either ulnar nerve decompression or transposition 1) in patients with preoperative ulnar nerve symptoms and 2) in patients whose preoperative flexion was less than 100°. Postoperative elbow manipulation should also be avoided unless the ulnar nerve had been surgically addressed.

Wada and coworkers proposed an alternative technique for debridement arthroplasty of the elbow. Based on the notion that elbow motion is most limited by medial osteophytes, they advocated a posteromedial approach. This technique allows direct access to overhanging coronoid and olecranon osteophytes that may otherwise be difficult to address with the posterior approach. They reported on their experience of 33 elbows with a mean follow-up of 10 years and noted that 85% of their patients were satisfied with the result, and that 76% were able to return to heavy labor. The overall arc of motion improved from 70° to 90°. Regardless of the surgical approach, the literature supports the notion that debridement arthroplasty can be a useful treatment for mild to moderate primary OA of the elbow and may delay total elbow arthroplasty.

**Arthroscopy**

Arthroscopic techniques have recently come into favor in the treatment of arthritic conditions of the elbow. Synovectomy, capsulectomy, radial head resection, loose body removal, and osteophyte debridement have all been performed arthroscopically. Elbow arthroscopy is contraindicated in patients with significant arthrofibrosis or ankylosis and in patients with severe capsular contracture that prevents adequate joint distension. Although significant potential complications, including nerve transection, compartment syndrome, and joint space infection exist, elbow arthroscopy has been demonstrated to be safe and effective in the hands of experienced surgeons. Kelly and colleagues, for example, published a series on the complications following 473 elbow arthroscopies, and found that there were only four major complications (0.8%) and 50 minor complications (11%). All four major complications were joint space infections, and the minor complications varied from persistent drainage to transient nerve palsy. The investigators concluded that, although the rate of minor complications was higher than previously reported, the risk of serious permanent complication was very low.

For appropriate RA patients that require synovectomy, the procedure can be performed using arthroscopic techniques. Arthroscopic radial head resection can also be performed in those patients with clinically significant radio capitellar disease. The advantages of arthroscopic synovectomy include improved intraoperative visualization, decreased morbidity, and improved rehabilitation. Numerous publications have shown good short-term results, particularly when performed early in the course of the disease. Lee and Morrey reported 93% good or excellent initial results after arthroscopic synovectomy. Unfortunately, these results deteriorated rapidly to only 57% good or excellent results at a mean follow-up of 3.5 years. Recently, Tanaka and associates compared arthroscopic versus open synovectomy in two groups of patients with a mean follow-up of 13 years. In their study, 48% of patients who underwent arthroscopic synovectomy had mild or no pain, as compared to 70% of patients who underwent an open synovectomy. Despite this surprising trend, due to the small patient numbers, statistical significance could not be demonstrated.

Arthroscopic debridement and loose body excision is reserved for patients with degenerative arthritis and clinical symptoms of impingement pain, limited motion, and intermittent mechanical locking. Arthroscopic debridement offers similar risks and benefits as those of arthroscopic synovectomy. In 1993, Redden and Stanley described a modified arthroscopic version of the Outerbridge-Kashiwagi procedure and reported relief of pain in all 12 patients who underwent the surgery. Since that time, numerous studies have shown satisfactory results in patients undergoing similar arthroscopic procedures. Phillips and Strasburger, for example, reported on a small series of patients with either OA or posttraumatic arthritis who experienced satisfactory short-term results, with a mean 41° improvement in the arc of motion. Savoie and coworkers published good short-term results in terms of both pain relief and improvement in range of motion in 24 patients who underwent arthroscopic ulnohumeral arthroplasty. Of note, 18 of these 24 patients also underwent arthroscopic radial head excision for significant radiocapitellar arthritis. In a direct comparison of open versus arthroscopic debridement arthroplasty, Cohen and colleagues showed that the cohort of patients who underwent open debridement had a statistically significant improvement in arc of motion (19°
vs. 8°) at a mean follow-up of three years. The patients who underwent arthroscopic debridement, however, demonstrated a trend toward improved pain relief.

In general, studies investigating the use of arthroscopic alternatives to open procedures have reported either equivalent or slightly inferior clinical results. Currently, there are few comparison studies and even fewer studies with long-term follow-up. It stands to reason that as arthroscopic techniques improve so should the clinical outcome. Nevertheless, long-term comparison studies between arthroscopic and open techniques are required to establish a firm guideline.

**Interpositional Arthroplasty**

Interpositional arthroplasty attempts to create a painless pseudarthrosis of the elbow by resecting and resurfacing the articular surfaces. This approach is indicated in young, active patients with refractory elbow pain that is secondary to any of the aforementioned causes of elbow arthritis. This procedure is contraindicated in patients with active infection or gross instability. Interpositional arthroplasty can serve to relieve pain, preserve bone stock, and possibly delay total elbow arthroplasty. This can also be performed as a salvage procedure after failed total elbow arthroplasty.

Hinged elbow external fixators have been combined with interpositional arthroplasty to distract the joint, thereby permitting the maintenance of the space created for the interposition material.

From a historical standpoint, resection arthroplasty of the elbow first came into practice in the 19th century for the treatment of tuberculous ankylosis. In the 20th century, resection arthroplasty was combined with interposition of various materials for the treatment of elbow arthritis. Currently, the most commonly used materials for biologic resurfacing of the elbow include the tensor fascia lata, cutis, and Achilles tendon. Morrey supports the use of Achilles tendon allograft due to its ready availability, its large size and thickness, and the absence of donor site morbidity. This procedure is typically performed through a posterior longitudinal incision that allows access to the ulnar nerve, medially (should the patient be symptomatic) and to the Kocher interval, laterally. Once the articular surfaces have been resected through this interval, the biological graft is secured to the distal humerus, anteriorly, using sutures and bone tunnels. If the collateral ligaments to the elbow have been compromised, a portion of the graft can also be used to reconstruct these ligaments. In such instances, however, application of a hinged external fixator is recommended in order to provide temporary stability to the joint while the graft heals in place.

Several published studies have shown satisfactory short-term results after elbow interpositional arthroplasty, both with and without distraction. Kimura and Vainio, for example, performed cutis interpositional arthroplasty in 155 rheumatoid elbows and reported relief of pain in 67%, with an average arc of motion of 96°. Ljung and associates reported similar results using bovine collagen membrane in a smaller series of rheumatoid elbows, with 75% of patients having minimal or no pain at six years. However, more than 50% of patients in their series were found to have either moderately or severely unstable elbows at the final follow-up evaluation. Shahriaree and coworkers performed interpositional arthroplasty with Gelfoam in 30 patients, the majority of whom suffered from posttraumatic arthritis. After four years, 77% of the patients were pain free and 93% had been able to return to work. All elbows in this series exhibited some degree of coronal plane instability, most of which were not clinically symptomatic. Cheng and Morrey reported five-year follow-up of 13 patients who underwent fascia lata interpositional arthroplasty with distraction. The majority (67%) of their patients were satisfied with their degree of pain relief, and that outcome did not vary between different types of arthritis. Pignatti and colleagues performed elbow resection with distraction in 12 patients, with only two receiving interposition of allograft dura mater. Eleven of the 12 patients were satisfied with their functional gains and a mean flexion-extension arc of 91° and 127° of mean forearm rotation was found to be noteworthy.

Interpositional arthroplasty appears to be a good surgical alternative in young patients with significant arthritic changes of the elbow that have failed nonoperative management. It has been suggested that this procedure is better suited for patients without inflammatory arthritis, as these patients are at higher risk for disease progression and for potential compromise of soft tissue stabilizers. Concomitant application of hinged distraction has come into favor and may play an important role in patient outcome. Performing interpositional arthroplasty in young patients raises the question of whether that procedure would compromise the results of a future total elbow arthroplasty. Blaine and associates addressed this specific issue by reviewing their series of 12 patients who underwent semiconstrained total elbow arthroplasty, retrospectively, after a previous interpositional arthroplasty. From an objective standpoint, 9 of the 12 patients achieved good or excellent results, with an outcome and complication rate that were comparable to those after primary total elbow arthroplasty. Subjectively, all patients were satisfied with their surgical outcome and would undergo the procedure again. Despite this small series of patients, it appears that previous interpositional arthroplasty does not preclude a successful outcome with total elbow arthroplasty.

**Total Elbow Arthroplasty**

Total elbow arthroplasty (TEA) is indicated in patients with severe elbow pain and stiffness with significant loss of elbow function. In order to maximize implant longevity, patients who undergo TEA are instructed to avoid lifting objects greater than 10 pounds and to avoid repetitive lifting greater than 2 pounds. Due to these activity restrictions, TEA is best performed in low-demand patients. Active infection is an absolute contraindication to TEA. Relative contraindi-
cations include inadequate soft tissue and muscle support, and preexisting neurologic deficit that precludes functional use of the arm.

Total elbow prostheses may either be linked with a hinge (constrained/semiconstrained) or unlinked (unconstrained). Linked prostheses are either constrained with a rigid hinge or semiconstrained with a sloppy hinge. There are different prosthetic designs that are generally grouped as unconstrained, semiconstrained, and constrained (Table 1).

The first TEA was performed, in 1972, by R. Dee, who used a constrained prosthesis (as recalled by van der Lugt and coworkers). Through the use of a rigid hinge, a constrained implant was able to restore stability, but at the expense of significant bony resection. Despite good clinical results, the rigid design of these prostheses led to a high degree of force transfer that caused subsequent loosening at the cement-bone interface. In some series, the rate of early loosening exceeded 25%, with subsequent need for revision surgery. Most surgeons now agree that the indication for a constrained TEA is very limited.

The complications of constrained implants led to the development of unconstrained implants. Unconstrained prostheses have no linkage, and their stability relies upon both the inherent geometry of the components and the capsuloligamentous support surrounding the elbow. The benefits of unconstrained TEA include lower loosening rates and limited bony resection. However, as expected, these implants carry a significant risk of instability. In fact, elbow instability is now considered to be a contraindication for unconstrained TEA. Some of the initial non-stemmed, unconstrained implant designs suffered early failures (up to 70%), due to proximal migration of the components. The next generation of unconstrained TEA with stemmed humeral components has essentially eliminated this complication.

Semiconstrained implants were developed during a similar period as unconstrained TEA. A semiconstrained design attempts to create a so-called “middle ground” between constrained and unconstrained TEA. Through the use of a sloppy hinge that allows a predetermined amount of varus-valgus laxity, semiconstrained TEA can confer stability without the high degree of force transfer exhibited by a constrained device. The amount of laxity built into a semiconstrained hinge can vary from 7° to 10°. Coonrad developed semiconstrained total elbow prosthesis and reported good results in the majority of patients. Over time, however, he noted there was excessive loosening of the humeral components. Morrey collaborated with Coonrad, as reported by Ferlic (personal communication with Coonrad), to modify the design by adding an anterior flange on the humeral component to provide rotational stability. Subsequent clinical studies with this new design have all reported good to excellent outcome in the majority of patients.

The surgical approach to TEA can vary depending upon the type of prosthesis, presence of concomitant pathology, previous surgical incisions, and surgeon preference. While a lateral approach through the Kocher interval has been used for the insertion of some unconstrained implants, some variation of a posterior approach is now most commonly utilized. A triceps-splitting approach with side-to-side repair carries little morbidity and allows for good exposure of the elbow joint. On the other hand, a triceps-reflecting approach permits excellent exposure but carries a higher risk of triceps weakness and triceps avulsion. As described by Bryan and Morrey, a modification of the triceps-reflecting approach has gained much popularity for TEA. The procedure releases the triceps off of the olecranon from medial to lateral, while leaving it in continuity with the olecranon periosteum and the forearm fascia, with the anconeus muscle acting as a pedicle. Therefore, the risk for subsequent triceps related complications is greatly reduced. In order to reduce the occurrence of triceps related complications even further, Pierce and Herndon advocated a triceps-sparing approach that utilizes a medial window between the triceps and the brachialis and a lateral window between the triceps and the mobile wad of Henry. In their opinion, although technically demanding, this approach maximizes extension strength, allows early active elbow range of motion, and may decrease the rate of triceps avulsion.

Another consideration during TEA is the management of the ulnar nerve. For patients with preoperative symptoms, there is a consensus that the ulnar nerve should be decompressed and possibly transposed. For patients with no symptoms, however, preemptive ulnar nerve transposition is associated with controversy. Critics of transposition argue that the rate of postoperative ulnar neuropathy is low (9% to 18%), and mostly transient. Intraoperatively, the ulnar nerve may experience ischemia secondary to use of a tourniquet, thermal injury from cement, mechanical irritation from dissection and retraction, or undue tensile forces during the procedure.

### Table 1 Types of Total Elbow Prostheses*

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<th>Semi-constrained</th>
<th>Constrained</th>
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elbow subluxation.53 Ulnar nerve transposition may lessen the risk of intraoperative ulnar nerve injury.64 Advocates of transposition, however, note that the ulnar nerve is vulnerable to various types of injury (ischemia secondary to use of a tourniquet, thermal injury from cement, mechanical irritation from dissection and retraction65) during the TEA procedure and that nerve transposition lessens these risks.66 Postoperatively, the ulnar nerve may be compressed by tight dressings, hematoma, or excessive swelling. The use of closed suction drains may help to prevent the accumulation of hematoma and interstitial fluid in the postoperative period. Morrey and Bryan56 noted that although some degree of paresthesia in the ulnar nerve distribution is not uncommon after TEA, any motor deficit is atypical and should be observed closely. They recommend that any patient with a motor deficit that has not resolved within 12 hours after surgery undergo exploration with decompression and neurolysis.

Patients who undergo total elbow arthroplasty can predictably expect to experience pain relief. The majority of patients also regain a functional range of motion as to allow meaningful use of the upper limb.7 When compared with population-based normative data, patients who undergo successful TEA report minimal or no pain and a normal quality of life, but without complete elbow function.55 The few studies that compare the clinical outcome after semiconstrained and unconstrained TEA have found them to have comparable results. Wright and colleagues,66 for example, reported no significant difference in outcome for patients undergoing either semiconstrained or unconstrained TEA, with satisfactory functional results in both groups. Little and associates67 performed a vast literature search in an attempt to compare semiconstrained and unconstrained total elbow implants. Although no firm conclusions could be drawn, they suggested that semiconstrained TEA may 1) restore a slightly better arc of motion, 2) provide a higher percentage of good or excellent results, and 3) have a lower rate of radiographic loosening. When examining individual studies, the data appear to slightly favor semiconstrained TEA in terms of implant survivorship and functional outcome. Tanaka and coworkers68 implanted an unconstrained Kudo prosthesis in 50 rheumatoid elbows and reported satisfactory outcome at a mean follow-up of 13 years, as well as a 90% survivorship rate at 16 years. On the other hand, van der Lugt and colleagues40 reported only a 65% survivorship of unconstrained Souter-Strathclyde implants in 204 rheumatoid elbows at a comparable follow-up interval. Malone and associates70 also performed Souter-Strathclyde arthroplasty in 68 patients (predominantly rheumatoid) and found the survivorship to be 74% at 10 years. As a comparison, Gill and Morrey71 performed semiconstrained Coonrad-Morrey TEA in 46 rheumatoid elbows and reported 92.4% survivorship at 10 years with good or excellent results in 83% of patients. Kelly and coworkers69 implanted the semiconstrained GSB III prosthesis in 28 rheumatoid elbows and found that only one prosthesis required revision at a mean follow-up of 7.6 years.

The majority of studies investigating the outcome and survivorship of TEA have involved patients with RA. As semiconstrained implants have evolved, TEA has become more popular for the treatment of posttraumatic arthritis, particularly in the setting of instability and/or deformity. Hildebrand and colleagues73 performed a retrospective review comparing the functional outcome of RA patients against that of posttraumatic arthritis patients and found no difference in patient satisfaction. Patients with inflammatory arthritis scored higher on the Mayo elbow performance index, while DASH and SF-35 functional outcome scores were similar between the two groups. Schneeberger and associates74 studied the outcome and survivorship of 41 patients with posttraumatic arthritis who were followed for an average of 5.7 years. They reported 83% good or excellent results, with a 95% satisfaction rate and a mean improvement in the arc of motion of 26°. However, nine patients required reoperation for either mechanical failure or trauma. The investigators noted that mechanical failure was often associated with excessive preoperative deformity and/or lack of compliance with lifting restrictions. It is apparent that patients who undergo semiconstrained TEA for the treatment of posttraumatic arthritis can expect results comparable to those for patients with inflammatory arthritis. However, some patients with posttraumatic arthritis may have unrealistic goals and expectations of their treatment with TEA, which may, in turn, lead to higher rate of complications and early failures.

There are numerous potential complications associated with total elbow arthroplasty. The most common is wound breakdown, and others include ulnar nerve irritation, deep infection, aseptic loosening, triceps deficiency, periprosthetic fracture, joint instability, and implant failure. Wound complications after TEA may occur in up to 6% of cases.75 The use of suction drains and immediate postoperative splinting of the elbow in relative extension can help prevent wound complications. When they do occur, however, wound problems are best treated aggressively, with early return to the operating room for irrigation and debridement. Full-thickness skin loss may occur and should be addressed with flap coverage when appropriate. The reported rate of deep infection of total elbow implants varies from 1%76 to 13%.77 Yamaguchi and coworkers78 reviewed over 700 cases of TEA and reported a 3.3% rate of deep infection. They attribute their fairly low rate of infection to the use of perioperative antibiotics, to the practice of hematoma prevention (hemostasis and suction drains), and to the use of antibiotic impregnated cement in all patients with a previous history of elbow surgery. In terms of management, these surgeons advocate surgical debridement with implant retention if infection is evident within 30 days of the initial surgery. If an infection is recognized later, they advocate a two-stage exchange. In their study, there was a higher failure rate in those patients infected with Staphylococcus epidermidis,
and they recommend that implant salvage and even two-stage exchange is best avoided in these instances. Resection arthroplasty is another surgical option that can be offered to these patients and may be preferable for patients with poor bone stock, those who desire definitive surgery, and those who are too frail to undergo multiple surgical procedures.

Aseptic loosening is a late complication of TEA and is usually separated into radiologic loosening and clinical loosening. The rate of radiologic loosening in an otherwise asymptomatic patient may be as high as 17%, while the rate of clinical loosening is significantly lower (6%). Aseptic loosening is characterized by osteolysis and defects in the cement mantle as a result of micromotion. Typically, this occurs at the cement bone interface and is usually managed with revision total elbow arthroplasty with larger stems. Unlike the hip and the knee, polyethylene wear does not appear to correlate directly with the amount of osteolysis. In cases of bushing wear, plain radiographs will reveal excessive coronal plane angulation that may be exaggerated by stress views. Lee and colleagues noted a higher rate of bushing wear in young patients and in those cases with excessive preoperative deformity. They investigated elective isolated bushing exchange in the setting of well fixed components and reported successful results in all of their patients.

Arthrodesis

Elbow arthrodesis is rarely indicated and most often performed as a salvage operation. It may be performed for the painful elbow in the setting of refractory sepsis or for the flail elbow in cases of severe bone loss after failed TEA. In such cases, bracing must first be instituted prior to considering arthrodesis. Arthrodesis in the rheumatoid patient may be particularly problematic, due to polyarticular disease. There is no consensus on an accepted position for an elbow fusion. A greater degree of flexion permits access to the face. On the other hand, a greater degree of extension improves interaction with the surrounding environment. Although most elbows have historically been fused in 90° of flexion, McAuliffe and associates feel that fusion in approximately 45° of flexion allows for improved cosmesis and better use of the hand to accomplish ADLs. They and others have recommended that patients be, first, immobilized in various degrees of flexion in order to identify the optimal position for their elbow fusion. Once the position has been determined, most utilize a posterior approach to the elbow in order to gain broad access to all elbow compartments. While multiple fixation options are available, the technique of choice for elbow fusion has become compression plate arthrodesis.

Conclusion

Although arthritic conditions of the elbow are relatively uncommon, they are often associated with significant pain and disability. The pathological processes most commonly associated with elbow arthritis are RA, posttraumatic arthritis, and primary OA. Once nonoperative management fails to provide symptomatic relief, surgical intervention should be considered. There is a broad spectrum of surgical options available to the treating physician. TEA has emerged as the ultimate option to treat a wide variety of clinical scenarios. That being said, alternative procedures such as synovectomy, débridement arthroplasty, and interpositional arthroplasty should be considered, as they can either prevent or delay total elbow arthroplasty. On appropriate patients, these procedures have been demonstrated to provide satisfactory functional outcome for a variable period of time. If necessary, TEA can be performed later, with predictable pain relief and functional use of the extremity. The complications of TEA may be minimized by patient compliance, good surgical technique, and prudent intervention when such situations arise. Elbow arthrodesis should be reserved for the small percentage of patients who fail total elbow arthroplasty and are not candidates for further reconstruction.

References

14. Morrey BF, Adams RA. Semiconstrained arthroplasty for the...

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