Elbow Arthritis: Treatment Options

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Abstract

The treatment of elbow arthritis is conceptually similar to that for arthritis of other major joints. The treatment of elbow arthritis has been evolving rapidly due to advances in arthroscopic techniques and surgical treatment for contractures and improved prosthetic designs. The reliability of total elbow replacement is approaching that of total replacement of the knee, hip, and shoulder. There remain a number of controversies and unanswered questions that require further experience and longer follow-up for resolution.

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Although pain is the most common complaint, patients with elbow arthritis may also complain of stiffness, weakness, instability, or cosmetic deformity. The combination of complaints and their relative severity determine the treatment options and the likelihood of patient satisfaction.

Rheumatoid Arthritis

Rheumatoid arthritis affects the elbow less frequently than other joints, but when it does occur, it results in painful impairment of function that for years we have tended to overlook or minimize because of a general pessimism regarding treatment options and results. The severity of the disability is profoundly realized by patients who have had bilateral elbow involvement for an extended period of time and then have one elbow replaced. They usually request surgery on the contralateral side within a few months.

The pattern of involvement of the elbow is similar to that of other joints, with the primary involvement in the ulnohumeral articulation. Loss of bone stock, with or without associated destruction of the periarticular soft tissues, causes joint laxity that results in mechanical wearing and further destruction due to malalignment or subluxation. Eventually, the elbow can become flail, with excessive motion in the coronal plane.

Osteoarthritis

Primary osteoarthritis of the elbow, only recently recognized and described in the English-language literature, is characteristic in its clinical and radiographic presentations.[1] Originally recognized in Japan, where its treatment was also first described, osteoarthritis of the elbow is most commonly seen in men with a history of heavy use of the arm, weight lifters, and throwing athletes. In fact, it is a disorder almost exclusive to men. They present in their third to eighth decades with a characteristic history of mechanical-impingement pain at the extremes of motion, classically in extension more so than in flexion. Carrying anything, such as a briefcase, with the elbow extended is painful. Pain in the midportion of the arc of motion is present only in the late stage. A flexion contracture of approximately 30 degrees is typical and may be associated with some loss of flexion as well. There may be crepitus in the elbow, but the characteristic finding is pain on forced extension or flexion.

On the radiographs there are osteophytes on the olecranon and coronoid processes, osteophytes filling in the olecranon and coronoid fossae, and usually loose bodies (which may not actually be loose) (Fig. 1). In the advanced stages the radioulnar joint and finally the radiohumeral joint may become involved.

The etiology of this condition is still not known. The fact that both degenerative arthritis and osteochondritis dissecans are so prevalent in throwing athletes suggests a link between the two. Also, many patients with osteoarthritis have loose bodies, indicating that loose bodies might be causally related to the arthritis.

Posttraumatic Arthritis

Posttraumatic arthritis can occur following various injuries, but is most common with distal humeral fractures that involve intra-articular comminution. Stiffness is common. Nonunions in this region usually result in a flail dysfunctional elbow. Treatment is dictated by the patho-

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Fig. 1 Primary degenerative arthritis of the elbow has a classic pattern of radiographic changes, characterized by osteophytes on the coronoid and olecranon processes (arrows); coronal osteophytes encroaching on the margins of the coronoid and olecranon fossae, with thickening of the normally thin bone separating these two fossae; and eventually loss of the articular cartilage and involvement of the radioulnar and radiohumeral joints. Loose bodies (often adherent to the soft tissues) are common, though not seen on these anteroposterior **(A)** and lateral **(B)** radiographs.

logic findings, complaints, and age of the patient.

Nonsurgical Treatment

The nonsurgical management of elbow arthritis includes the standard medical treatment and physical therapy for most other joint disorders. Acetylsalicylic acid and nonsteroidal anti-inflammatory agents are used unless precluded by gastrointestinal side effects. More potent agents, including antimalarial agents, gold salts, immunosuppressive drugs, and corticosteroids, are resorted to when necessary. Intra-articular injections of corticosteroids are easily performed and should be considered before surgery. Radioactive synovectomy, performed by sterile intra-articular injection of a radioisotope, is also minimally invasive and should probably be recommended as a more conservative treatment option to young patients with inflammatory arthritis, those with early inflammatory arthritis, and those who are candidates for surgical synovectomy.

Physical therapy includes pain-control measures, such as avoidance of activities that place excessive stresses on the elbow, intermittent periods of rest, and application of heat or cold. Splinting is sometimes useful. Lightweight hinged splints that permit active range-of-motion exercises protect the elbow from varus-valgus stresses and minimize pain. Resting or night splints also can be helpful. Gentle exercises should be performed on a regular basis to maintain mobility and strength in the muscles. Occupational therapy interventions with aids for activities of daily living are useful. These would include handle extensions to cope with elbow-flexion contractures.

Surgical Treatment Options

Surgery is indicated following failure of nonsurgical management. There are a number of surgical options, including arthroscopy, open synovectomy, osteotomy, resection and interpositional arthroplasty, arthrodesis, and total elbow arthroplasty (TEA). Total elbow arthroplasty provides the most consistent results. However, the stage of the disease, the age of the patient,

and the presence of other joint involvement are important determinants of treatment choice.

Arthroscopy

Arthroscopy is assuming a greater role in diagnosis and management of elbow problems, as it is in other joint disorders. It is useful to perform a synovial biopsy. Undiagnosed painful snapping of the elbow can be associated with cartilaginous loose bodies that do not appear on radiographs, posttraumatic arthritis, primary degenerative arthritis, dense soft-tissue adhesions (e.g., following radial-head excision), and ulnohumeral rotatory instability. Patients with spontaneous onset of contracture are often found to have a form of inflammatory arthritis.

Patients with localized posttraumatic arthritis sometimes benefit from debridement of the area and localized synovectomy. A complete synovectomy is technically possible for the management of inflammatory or septic arthritis, although technically highly demanding and associated with a theoretical risk to neurovascular structures. One must be constantly aware of the fact that the nerves may be within a few millimeters of the operating instruments in the anterior part of the elbow. Although the safety of this procedure has not yet been proved, we believe that the risks are minimal if certain safety precautions are observed. The advantages of arthroscopic over open synovectomy are impressive. It is done as an outpatient procedure, causes minimal morbidity, and permits rapid return of motion, and a complete synovectomy is technically possible. Treatment of primary degenerative arthritis is possible in the early stages by removal of the osteophytes from the olecranon and coronoid as well as from the olecranon fossa (Fig. 2).[2,3] Removal of osteophytes from the coronoid fossa is more difficult.

Open Synovectomy

Synovectomy with or without radial-head excision is a well-recognized and accepted form of treatment for rheumatoid arthritis. Satisfactory pain relief is obtained in about 70% to 90% of patients.[4] The good results are reported to persist. Increased range of motion is less likely than pain relief. There is controversy regarding its success in later stages after joint destruction has occurred. Also unclear is the role of radial-head excision. Progressive articular destruction following synovectomy and radial-head excision has been noted and is thought to be due to increased ulnohumeral loading. Late valgus instability has been a problem in the experience of some surgeons.

In general, surgeons experienced with both TEA and synovectomy favor TEA in the later stages because the patients are so much more satisfied and the functional improvement is so much greater.

Osteotomy

Treatment of osteoarthritis consists of decompressing the impinging areas. Currently this is being performed with use of the Outerbridge-Kashiwagi (ulnohumeral) arthroplasty,

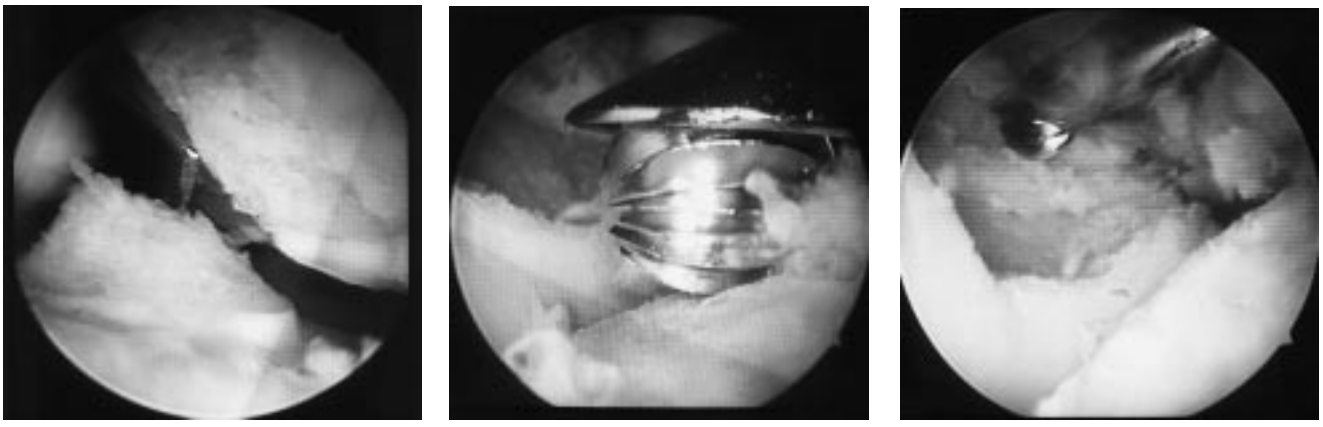

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Fig. 2 Arthroscopic treatment of osteoarthritis. **A,** Osteophytes are removed with a small osteotome and graspers. A bur is used to smooth off the olecranon **(B)** and to recreate the olecranon fossa, removing any osteophytes and thickened bone **(C)**. (Reproduced with permission from O'Driscoll SW, Morrey BF: Arthroscopy of the elbow, in Morrey BF (ed): *The Elbow and Its Disorders.* Philadelphia: WB Saunders, 1993, p 128.)

which is really a core osteotomy of the distal humerus and osteotomies of the tips of the olecranon and coronoid[1] (Fig. 3). It is performed through a triceps-splitting approach using the Cloward drill to go through the humerus (Fig. 4).

This procedure is indicated for primary osteoarthritis in patients with pain at the extremes of motion, but not in the midportion of the arc of motion or at rest. The procedure characteristically relieves impingement pain and frequently permits some improvement in range of motion, especially when the rehabilitation program involves the use of patient-adjusted static braces postoperatively. Successful results (pain and motion improved) have been reported in 85% of patients.[1]

Resection and Interpositional Arthroplasty

Resection arthroplasty is an option for salvaging an elbow, particularly following failed TEA. Its success (relatively pain-free functional arc of motion with reasonable stability) is more likely if the medial and lateral columns of the distal humerus and the olecranon and coronoid remain in place.[5] If the elbow becomes flail or grossly unstable, the limb remains nonfunctional, and the result is unsatisfactory.

For younger patients (typically less than 60 years of age), interposition arthroplasty is recommended for posttraumatic arthritis if bone loss does not preclude it.[6,7] The procedure involves removal and/or reshaping of the articular surfaces and resurfacing with an interposition tissue such as autogenous fascia lata or dermis. Distraction arthroplasty involves the use of a hinged external fixation device that holds the elbow joint slightly distracted, stable, and aligned while permitting full motion in the first few weeks following interposition arthroplasty (Fig. 5). The results are satisfactory in most cases, although the techniques are demanding and require substantial expertise.

In young patients I have used periosteum from the proximal tibia for "biologic resurfacing" because of its potential to regenerate articular cartilage (Fig. 6). The indications and contraindications as well as results to be expected are not yet fully known; thus, it remains experimental.

Arthrodesis

Arthrodesis of the elbow is incompatible with satisfactory function due to the fact that range of motion of the elbow is essential for use of the hand. There is no single optimal position. It is indicated when intractable sepsis is present and when reconstruction by revision TEA is no longer possible. It is probably never indicated as a primary procedure, although controversy exists in the case of young male patients who perform heavy labor. Fortunately, this situation is rare.

Total Elbow Arthroplasty

The evolution of TEA has had similarities to that of total knee arthroplasty. Biomechanically, there are three types of prosthetic joint

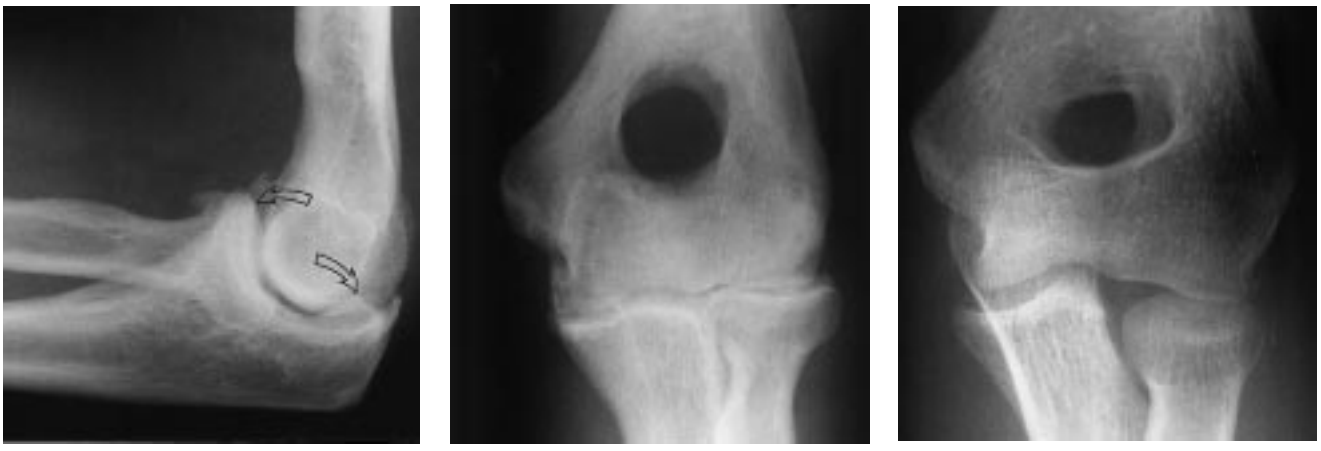

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Fig. 3 Outerbridge-Kashiwagi (ulnohumeral) arthroplasty (same patient as in Fig. 1). **A,** Procedure involves excision of the osteophyte from the olecranon (arrows), core osteotomy of the humerus to remove the marginal osteophytes from the olecranon and coronoid fossae, and excision of the coronoid osteophytes through the hole in the humerus. Loose bodies are removed anteriorly and posteriorly. In the elbow shown, there are also osteophytes on the capitellum and radial head. **B,** Fenestration created by the arthroplasty mimics a congenital fenestration seen in some patients **(C)** and does not significantly weaken the humerus.

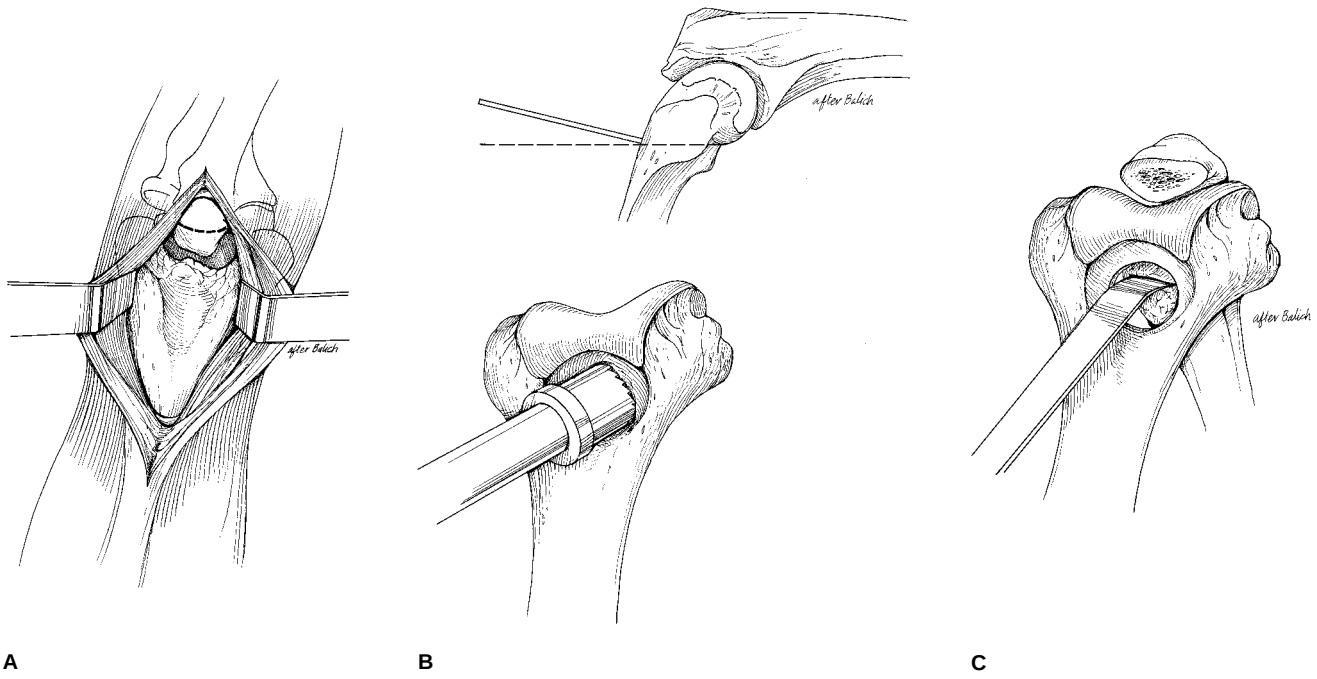

Fig. 4 Surgical technique of ulnohumeral arthroplasty. **A,** Olecranon is exposed through a triceps-splitting approach, and osteophytes are removed. **B,** Large trephine (large Cloward drill) is used to fenestrate the distal humerus, angling it proximally to exit at the margin of the joint. **C,** Coronoid osteophyte is removed under direct vision through the fenestration.

designs: nonconstrained, semiconstrained, and constrained.

Over two decades ago, it was observed that satisfactory pain relief could be provided to patients with arthritis by replacing the elbow joint with a hinged prosthesis. This type of constrained prosthesis transfers all of the stresses directly to the prosthesis-cement-bone interfaces. It is therefore associated with a very high failure rate due to mechanical loosening. The same was found to be true of hinged designs in the knee and ball-and-socket designs for the shoulder. A major degree of bone destruction accompanies such loosening, making salvage difficult. Although it is rare in medicine to be able to state categorically that there is no indication for a certain procedure, this is true for arthroplasty with the constrained-hinge type of elbow prosthesis, which has now been abandoned. All the theoretical advantages of a constrained arthroplasty can be provided by a semiconstrained design with a permanent coupling-bolt type of articulation.

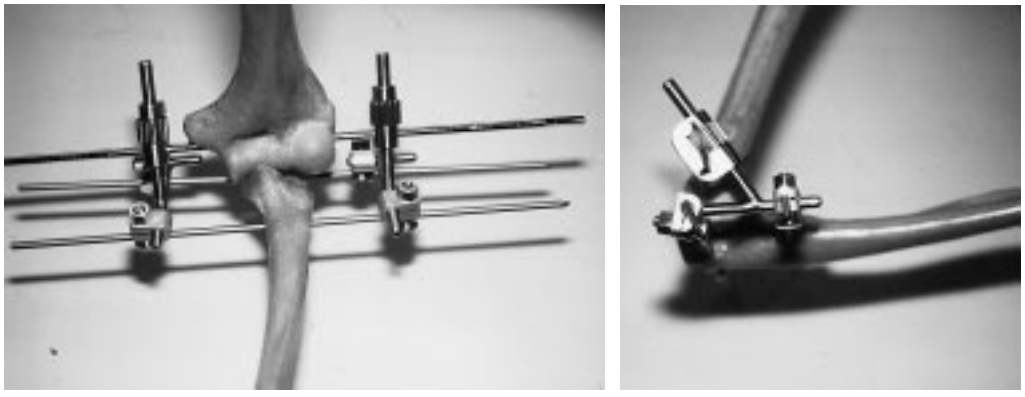

Fig. 5 The hinged elbow distraction device designed by Morrey permits stable alignment of the elbow, variable distraction, and motion in both flexion-extension and pronation-supination arcs. (Reproduced with permission from Morrey BF: Post-traumatic contracture of the elbow: Operative treatment, including distraction arthroplasty. *J Bone Joint Surg Am* 1990;72:601-618.)

Fig. 6 The patient, a 22-year-old woman, had a painful stiff elbow with posttraumatic arthritis secondary to an open fracture-dislocation 4 months earlier. Photographs obtained 3 weeks after surgery show active motion from 20 to 130 degrees with the hinged elbow distractor in place. (Reproduced with permission from O'Driscoll SW: Surgery of elbow arthritis, in McCarty DJ, Koopman WJ [eds]: *Arthritis and Allied Conditions*, 12th ed. Philadelphia: Lea & Febiger, 1993, p 957.)

Less-constrained prostheses should be less prone to mechanical loosening, because the stresses are absorbed by the soft tissues rather than being transferred to the bone-prosthesis interface. A true nonconstrained joint replacement provides little or no inherent stability by virtue of its shape and articulation, therefore relying solely on the periarticular soft tissues for stability (Fig. 7). The current surface-replacement prostheses are not truly nonconstrained and would be better termed "minimally constrained," as there is a degree of constraint afforded by the articulation itself. Examples include those designed by Ewald (capitellocondylar) and by Pritchard, the two most popular in North America, as well as those by Sorbie, Souter, Lowe, Liverpool, London, Wadsworth, and Kudo. These designs have been in use since 1972.

There was an initial trend to simply replace the articular surfaces of the distal humerus and proximal ulna, but these components without intramedullary stems had a tendency to loosen and displace. Kudo and Iwano[8] reported a 70% incidence of loosening for nonstemmed humeral components. The majority of components now available have intramedullary stems that help to prevent the rocking or tilting type of motion that causes loosening. Loosening is no longer a common problem with nonconstrained replacements. Instability (dislocation, subluxation, or maltracking) has been a problem in 5% to 20% of nonconstrained TEAs. This is particularly true when loss of bone or soft-tissue integrity is significant.

A loose-hinge or sloppy-hinge semiconstrained prosthesis offers a compromise between the stability provided by a hinged prosthesis and the low incidence of loosening of a nonconstrained surface replacement. In most designs the ulnar and humeral components are linked so that they do not dislocate, but the linkage allows for a degree of laxity that permits the soft tissues to absorb some of the stresses that would normally be applied to the prosthesis-cement-bone interface. Such designs include the Pritchard-Walker, Pritchard Mark II, Coonrad II, Morrey-Coonrad (Mayo-modified Coonrad)(Fig. 8), GSB III, triaxial, and AHSC (Volz). This is the most commonly used class of elbow replacements today.

The indications for use of a semiconstrained prosthesis include all cases in which bone-stock or soft-tissue integrity is not adequate for use of a minimally constrained device. Although it might be theoretically more likely to loosen than a minimally constrained device, this is not turning out to be so in clinical experience and reports in the literature.[6,8-12] Thus, some consider a semiconstrained prosthesis to be indicated in any patient requiring TEA. Others reserve minimally constrained devices for patients under the age of 60.

Indications

The general indication for surgery is the same as that for replacement of the hip, knee, or shoulder—improvement in the quality of life by restoration of pain-free function (motion, stability, and strength) in a joint that is causing functional impairment. This is indicated when such a goal cannot be met by nonsurgical means or other, less invasive surgical options.

The most common diagnosis for which TEA is performed is rheumatoid arthritis. The typical patient undergoing TEA is in American Rheumatism Association class III or IV (i.e., capable of performing only some or none of the usual occupational or daily activities).[13] Other indications include the treatment of supracondylar or intercondylar nonunions of the distal humerus, severely comminuted acute supracondylar or intercondylar fractures of the distal humerus in elderly patients with osteoporotic bone that cannot be reduced and fixed adequately, and flail elbow caused by posttraumatic loss of bone or structural integrity.

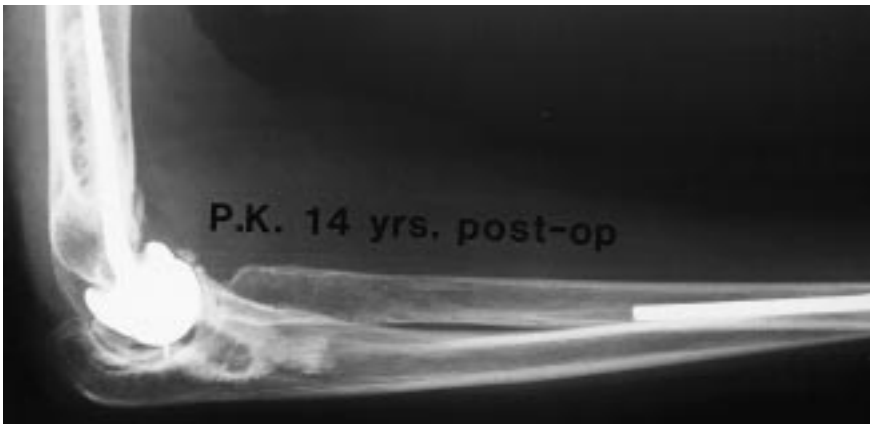

Fig. 7 Patients with adequate bone stock and soft tissues for stability can be treated with a nonconstrained arthroplasty such as the capitellocondylar (Ewald) prosthesis. This is the oldest elbow prosthesis still in use and is reported by the originator to have excellent long-term results. It does not include a radial head component. Though a radial head might increase stability, its insertion would require precise alignment and sizing, making the operation more complicated. (Reproduced with permission from Ewald FC, Simmons ED Jr, Sullivan JA, et al: Capitellocondylar total elbow replacement in rheumatoid arthritis: Long-term results. *J Bone Joint Surg Am* 1993;75:498-507.)

The best results are often seen in patients who preoperatively have little or no use of the limb; postoperatively, they frequently have normal or near-normal motion, strength, and stability and no pain. Surprisingly, the rehabilitation is faster in a patient with a supracondylar nonunion because the operation can be done with less soft-tissue dissection and without detaching the triceps tendon. As a result, the patient can use the arm without restrictions immediately following surgery.

Contraindications

The contraindications are similar to those for replacement of the other major joints. The only absolute contraindication is active infection of the joint. A history of postseptic arthritis or osteomyelitis is a relative contraindication. Most would recommend reserving TEA for patients over the age of 60, although lesser age is not an absolute contraindication.[6] Of course, it is preferable to first exhaust all other treatment options, including distraction interposition arthroplasty.

Loss or destruction of bone or soft tissue is not a contraindication to TEA, for these problems can be dealt with surgically. Custom arthroplasties have been used for treatment of ankylosis or supracondylar nonunions.[9] With appropriate implant selection, however, custom components are rarely required, usually being reserved for revisions or patients with juvenile rheumatoid arthritis.[6]

Consideration of Other Joint Involvement

Patients with rheumatoid arthritis requiring TEA may have advanced involvement of the ipsilateral shoulder as well. Although the controversy over which joint should be replaced first continues, the joint that is more disabling should probably be operated on initially. The results for shoulder and elbow replacement are similar to those seen following replacement of each as an isolated joint.[13]

Similarly, the contralateral elbow may require replacement. Again, the more disabling joint should be operated on first. The second operation can be done as soon as the patient is able to look after himself or herself with the limb that has recently undergone surgery. The results of bilateral elbow arthroplasties in patients with rheumatoid arthritis are as good as those after single-joint replacements.[13] My limited experience with simultaneous bilateral elbow replacements has been very encouraging.

The elbow becomes a true weight-bearing joint in many patients with rheumatoid arthritis (as does the shoulder) because of arthritis in the lower extremities. Patients who undergo TEA generally have had previous operations.[13] The need for subsequent lower-extremity surgery, resulting in requirement of walking aids, is not a contraindication for elbow replacement. In fact, some patients are able to bear weight through the upper extremities far better after joint replacement of the elbow or shoulder than before.

Technique

"The front door to the elbow is at the back." Although there are many

Fig. 8 Coonrad II elbow prosthesis, as modified by Morrey, has a porous-material-coated anterior flange, under which a bone graft is placed to enhance fixation and resist the posterior forces and torsional moments on the humeral component. Incorporation of the bone graft and cortical remodeling are expected in 80% of cases or more. This design has proved highly versatile and clinically successful.

surgical approaches to the elbow, each with its own specific advantages and disadvantages, the versatility of the posterior approach makes it superior. A posteriorly placed (slightly medial or lateral) skin incision permits posteromedial and posterolateral arthrotomies as well as access to the ulnar nerve and the anterior elbow via the deep portion of the Kocher approach. It is therefore the most useful approach for the elbow. The skin incision should not cross the tip of the olecranon in patients with olecranon bursitis or rheumatoid arthritis, in whom the soft tissues over the olecranon are pathologically altered and more susceptible to wound breakdown and infection. It is analogous to the "universal" straight anterior approach to the knee.

Access to the elbow joint can be accomplished by reflecting the triceps with use of the Bryan-Morrey approach. Others have suggested reflecting the triceps with a flake of bone from the tip of the olecranon, but my personal experience with this method has been disappointing due to a high nonunion rate. Some still advocate a Kocher approach or a posterior triceps-splitting or triceps-tongue approach with careful closure. Ewald et al[11] strongly favor a modified Kocher approach for the capitellocondylar prosthesis. The olecranon is never osteotomized as it is for internal fixation of distal humeral fractures.

The fine details of surgical technique will not be discussed here. However, there are several important considerations. Careful handling of the skin and soft tissues is important, and the skin incision must not devascularize a compromised region of skin created by previous incisions. The ulnar nerve is explored and retracted gently (usually transposed anteriorly as part of the procedure). The triceps mechanism is reflected in one of the ways mentioned unless there is significant laxity due to bone loss or soft-tissue laxity, in which case it can be preserved. The origin of one ligament is released, the joint is subluxated or dislocated, and the bones are prepared for the appropriate components. A synovectomy is performed, along with release of any contractures. The canal is prepared using current standard cementing techniques, and cement is injected and pressurized.

If a nonconstrained prosthesis is used, alignment of the components and proper soft-tissue balancing are critical for stability. This includes the ulnar part of the lateral collateral ligament, which must be properly repaired to prevent posterolateral rotatory subluxation of the ulnohumeral joint.[14] Repair of the triceps is critical for stability of nonconstrained devices. Some prefer 2 to 4 weeks of immobilization postoperatively.

With semiconstrained prostheses, early motion avoiding resisted extension is probably safe. In such situations, I start motion 36 hours after surgery and limit the patient only from actively extending the elbow against resistance for 6 weeks.

Positioning of the center of rotation of the prosthesis in alignment with that of the elbow is important for proper balancing of the muscle moment arms. With nonconstrained devices, it is also important for stability.

Results

Pain relief is dramatic and as predictable as that found after total hip or knee replacement.[10,13,15] At least 90% of patients are highly satisfied with pain relief. Functional improvement is predictable following TEA.[6,10,13,15] In a prospective study, Morrey et al[15] showed that strength increased 90% in flexion and 60% to 70% in pronation-supination. Extension strength remained relatively unchanged, which might be explained on the basis of surgical approach (detachment and reattachment of the triceps) and offset of the axis of rotation of the prosthesis.[10,15,16] The percentage of improvement in strength was greater in patients with rheumatoid arthritis.

Morrey et al have shown that the

functional arcs of motion of the elbow (i.e., those required to perform the activities of daily living) are 30 to 130 degrees of flexion and from 50 degrees of supination to 50 degrees of pronation. Before surgery, patients usually have less than these functional arcs, with preoperative ranges of motion averaging 70 degrees of flexion-extension and 90 degrees of pronation-supination.[13] These averages increase postoperatively to 100 degrees of flexion-extension and 130 degrees of pronation-supination. The "functional arcs of motion" are achieved by most patients. Excellent motion, close to the functional range, is also possible in patients with complete ankylosis of the elbow.[6]

Gains in motion, especially extension, are usually greater with semiconstrained prostheses than with minimally constrained prostheses. Use of the former permits complete release of contracted soft tissues and immediate unrestricted motion postoperatively, whereas such soft-tissue releases and unrestricted extension predispose to dislocation of surface-replacement prostheses.

Two problems that thwarted early progress in TEA were mechanical loosening of constrained (hinged) designs and dislocation of nonconstrained designs. The early hinged design was a fully constrained prosthesis that linked the ulnar and humeral components directly. This resulted in transfer of all forces and moments about the elbow directly to the prosthesis-cement-bone interface. The failure rate was unacceptably high, just as it was with this design concept in knee replacements.[17] Although the elbow has been commonly referred to as a non-weight-bearing joint, the forces that cross it can exceed three times body weight. The principal moments (rotational forces and torques) about the humeral component are posterior and rotational. These forces can be considered in the design of a prosthesis.

The problem of instability (recurrent dislocation or subluxation) of a nonconstrained elbow prosthesis appears to have decreased in more recent reports, but still is in the range of 5% to 20%. This problem will likely diminish as our understanding of the mechanism of elbow instability improves. Until recently, we were not aware of the fundamental posterolateral rotatory instability pattern by which an elbow subluxates or dislocates.[14] The important ulnar part of the lateral collateral ligament complex is violated during TEA and must be reconstructed. Also, the soft-tissue constraints depend on the integrity of the normal articular architecture to function properly. If the design of the ulnar and humeral prosthetic articular surfaces is not anatomic, the soft-tissue constraints might not maintain joint stability.

Despite these problems, the minimally constrained TEA prosthesis, such as the capitellocondylar device, has been used with satisfactory long-term success since 1974, with average follow-up periods of 6 to 7 years. Ewald et al[11] recently reported the results with 202 capitellocondylar prostheses after 2 to 15 years (mean, 6 years). Pain relief and functional improvement were excellent, with patients scoring an average of 26 preoperatively and 91 postoperatively on a 100-point rating score. Reoperation was required in only 5% of the cases for loosening, dislocation, and infection. It was the authors' impression that complications seen in earlier years had diminished. This report from the originator of the longest-used total elbow is extremely impressive and indicates that the results do not deteriorate much with time.

Both potential problems, loosening of the constrained-hinge type of prosthesis and dislocation of the nonconstrained type, might be overcome by use of the semiconstrained design.[6] The concept of this design is that the ulnar and humeral components are linked by a "loose hinge," so that they cannot dislocate or subluxate; however, the laxity built into the sloppy hinge permits some of the forces and moments applied across the elbow to be absorbed by the soft tissues around it. The static (ligamentous) and dynamic (muscle) soft-tissue constraints thus theoretically take on the role that they play in a nonconstrained design, decreasing the likelihood of loosening.

This concept has been in clinical use for over a decade and has predominated the field of elbow replacement surgery in the past decade. There are a number of semiconstrained designs, and all appear to be successful. They have been in use since 1976, and results after follow-up periods averaging up to 9 years have been reported, with mechanical (nonseptic) loosening rates of less than 5%.[6,9,10,12]

The usefulness of the semiconstrained concept has been confirmed in laboratory studies.[16] A Mayo-modified Coonrad design with a loose hinge (10 degrees of varus/valgus and rotational laxity) and an anterior flange to resist posterior forces and rotational moments was tested in cadaver elbows during simulated active motion and with maximum varus and valgus moments. Loading of the biceps, brachialis, and triceps muscles permitted reproduction of a nearly normal kinematic pattern and limited varus or valgus deflections. Thus, at least for the one type of semiconstrained prosthesis tested, the concept is feasible and not just semantically different from that of a constrained hinge. These data are thought to at least partially explain the low rates of loosening observed clinically in the past decade.

Morrey and Adams[12] reported a 95% Kaplan-Meier estimated survival at 7 years in 68 patients with rheuma-

toid arthritis treated with a Mayo-Coonrad prosthesis. There were no cases of mechanical loosening. Longer follow-up will determine whether the low incidence of loosening will parallel that in the hip and knee, as it has after intermediate follow-up.

Controversies and Future Challenges

The most rapidly evolving aspects of elbow surgery relate to the use of arthroscopy and arthroplasty. The indications are expanding for both of these procedures. With medium-term results (5 to 10 years) that are similar to those for hip and knee arthroplasty, TEA can be recommended with confidence to patients with the appropriate indications (similar to those for arthroplasties of the knee, hip, and shoulder).

Controversy still remains regarding the timing of shoulder and elbow replacement in a patient who requires both. Generally, the more symptomatic joint is replaced first.

The indications for minimally constrained surface-replacement arthroplasties versus semiconstrained ones are not clear. At the present time, loss of bone or ligamentous integrity, ankylosis, and the necessity of soft-tissue releases are indications for a semiconstrained prosthesis. The excellent clinical results with semiconstrained designs suggest that loosening might be no more common than with nonconstrained ones. The theoretical advantage of better preservation of bone stock with a resurfacing design is not necessarily true for elbows. They require more resection of bone from the ulna and, in some designs, from the humerus than do certain semiconstrained designs. The role of radial-head replacement in resurfacing designs has never been determined. Longer-term follow-up will resolve this matter. The theoretical advantages of a resurfacing design must be considered in light of the necessity for anatomic accuracy during insertion to avoid unbalanced eccentric forces and moments that can lead to instability and/or loosening.

The future of TEA is likely to include modifications to the current designs of both nonconstrained and semiconstrained prostheses. Each will likely continue to have its indications, with some overlap.

The role of biologic fixation using a porous coating, such as hydroxyapatite, is uncertain. The elbow does not have a large surface of structurally strong cancellous bone to fix to such a device, nor to support it once it is firmly fixed. Further laboratory and clinical research will be necessary to determine this.

Synovectomy continues to be used mainly for early stages of rheumatoid arthritis. There is controversy regarding its success in the later stages of arthritis and the indication for arthroplasty versus synovectomy. In general, the literature on synovectomy antedates that on arthroplasty and is from centers where arthroplasties have not been commonly performed on the elbow. Those surgeons skilled with both procedures with whom I have discussed this tend to regard the results of arthroplasty to be superior in advanced arthritis. Whether it should be done by radioactive isotope injection or by arthroscopic or open techniques is still debated. It seems wise to offer a trial of isotope injection, because of its low morbidity, followed, if necessary, by arthroscopic synovectomy by those skilled with this technique. The advantage of radial-head excision appears to reside more in the degree of surgical exposure than in any intrinsic beneficial effect.

There is also controversy regarding the indications for resection or interposition arthroplasty versus TEA in young patients with rheumatoid arthritis. Certainly, the former is more popular in Europe than in North America, while the opposite is true for TEA. It is argued that resection (preserving the epicondyles and olecranon) is a more conservative operation that is readily converted to TEA. However, TEA provides better pain relief and function and can usually be converted to a functional resection arthroplasty after failure. Both sides of this argument are sound, and there is no clear resolution. I currently favor reserving resection as a salvage option.

Finally, the role of arthroscopy in osteoarthritis of the elbow needs clarification. This will occur as our skills and experience grow.

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