Interposition Elbow Arthroplasty

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ABSTRACT

Pain and loss of motion associated with elbow arthritis is poorly tolerated and constitutes a major functional impairment. While total elbow arthroplasty reliably alleviates pain and improves motion, durability issues mandate restricted indications and light use. Interposition arthroplasty, combined with hinged external fixation, is an alternative and may be preferred in younger, more active patients anticipating heavier use.
Keywords: elbow, arthroplasty, interposition, external fixator

HISTORICAL PERSPECTIVE

Elbow arthritis, and its attendant pain and loss of function, has been a difficult problem to treat. A functional range of motion of the elbow is defined as approximately 30 to 130º.[1] Stiffness of the elbow is poorly tolerated and impedes basic daily functions such as feeding and grooming because of inability to reach the head and mouth.

Historically, the operative solutions for severe elbow arthritis have had mixed results. Semiconstrained total elbow arthroplasty (STEA) yields good early results, but survival issues and problems with revision and infection limit its application in younger patients.[2–4] Morrey's[4] admonition that STEA patients limit lifting to 5 kg summarizes the concerns and limitations of prosthetic elbow arthroplasty. Resection arthroplasty, resulting in a flail, unstable joint, is an unsatisfactory procedure with very limited function. External bracing cannot substitute for a stable joint. Similarly, arthrodesis is poorly tolerated. The last alternative is interposition arthroplasty, an old operation modified by the use of an interposition "membrane" of fascia or dermis and distraction with an articulated external fixator.[5]

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Interpositional arthroplasty has been performed on many joints, including the hip and temporomandibular joints, and is considered a preprosthetic alternative for younger patients. It has been cited in the literature from Verneuil[6] in 1860 and Campbell[7] in 1924. The addition of hinged distraction is new and was first reported by Volkov and Oganesian[5] in 1975 and Deland et al[8] in 1983. Bony anatomy is maintained and ligaments are preserved, repaired, or reconstructed, as stability is a prerequisite for a good result. Good, durable results have been reported in younger, rheumatoid patients and although the indications are limited, it may be the best solution for treating severe forms of elbow arthritis in the young patient. Pain relief and motion are not as good as STEA, but durability may be better and revision to STEA is possible because bone stock is preserved.

Elbow stability is the key determinant of a good outcome following interposition elbow arthroplasty. Kita[9] reported 31 patients with fascia lata interposition without distraction. The 19-year follow-up showed prolonged pain relief and best results with rheumatoid patients. Poor outcomes were all associated with instability. Knight and Van Zandt[10] had 45 cases with a 14-year follow-up; 50% of the patients had good results and a 20% failure rate was associated with instability.

More recent series of interpositional arthroplasty of the elbow with distraction have been reported. Fox et al[11] had a series of 11 patients with distraction arthroplasty. Eight of 11 had pain relief. Again, the 3 poor results were associated with instability. Cheng and Morrey[12] studied 13 patients (10 posttraumatic and 3 inflammatory) with an average age of 33 years. Nine of 13 had satisfactory pain relief and 4 of 13 required revision to STEA. Nine of 9 stable elbows had a good result and 4 of 4 unstable elbows had an unsatisfactory result. Patients with unsatisfactory results were easily converted to STEA.

INDICATIONS

Distraction interposition arthroplasty of the elbow (DIAE) is a salvage procedure with limited indications for the painful and stiff arthritic elbow. Severe, posttrau-

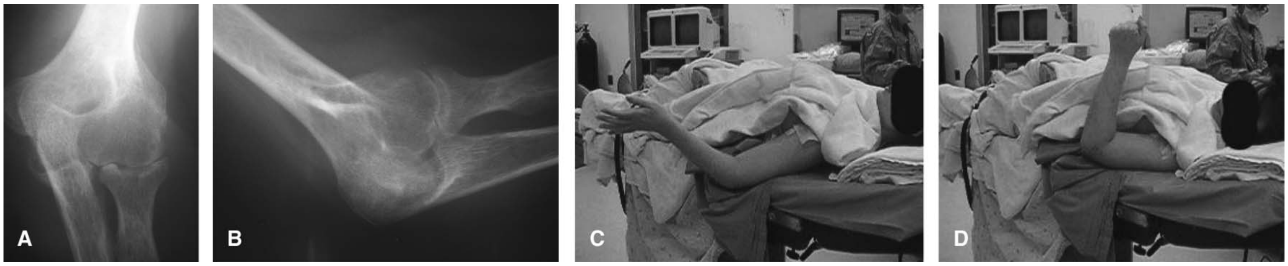

FIGURE 1. A and B, Anteroposterior and lateral radiographs of a 29-year-old patient with rheumatoid arthritis. The elbow is classified as a Mayo stage II, with loss of joint space, but relative preservation of bony architecture. C and D, The patient has pain and a severe functional deficit, because she cannot reach her mouth or head.

matic elbow arthritis in the young, high-demand patient with adequate bone stock is an indication for DIAE. Another indication is the younger adult with stage II or IIIA rheumatoid arthritis (Figs. 1, 2).[13] It is believed that there must be adequate bone stock and no gross joint instability for posttraumatic and rheumatoid elbows. In fact, multiple series refer to the importance of stability.[9–12] We feel that ligament insufficiency, in and of itself, is not a contraindication, because both medial and lateral collateral ligaments may be reconstructed with grafts. Instability due to loss of bone stock may be a contraindication, although in some cases bone reconstruction can be performed using tricortical iliac crest grafts or allografts.

The presence of active infection, open growth plates, and absence of flexor motor power are contraindications for DIAE.[14] Patients older than 60 years of age who place lower demands on their severely arthritic elbows are not contraindicated, but might be better served with STEA.[15–17]

■ TECHNIQUE

The patient is placed in either the supine or lateral decubitus position. We use an articulated shoulder positioner attached to the forearm, to help suspend the forearm over the chest, permitting the operation to be performed in the supine position (Fig. 3). A regional anesthetic is administered via an indwelling axillary catheter. A sterile tourniquet is applied. There are 2 general approaches described for DIAE: the medial–lateral and the posterior approaches. Although the Mayo-modified extended posterolateral approach is a good option and is commonly used for joint exposure, a posteromedial approach may be preferable for protecting the ulnar nerve and reconstructing the medial collateral ligament (MCL).

A posterior incision is made over the midline of the triceps and is extended distally in a longitudinal fashion over the olecranon and ulnar crest (Fig. 3). The incision should be sufficiently long to expose the medial and lateral aspects of the joint easily without tension on the skin. Thick flaps should be raised between the triceps/forearm muscle fascia and subcutaneous tissue (Fig. 4). The ulnar nerve is identified medially and is released from the cubital tunnel. It should be freed proximally at the arcade of Struthers and distally into the flexor carpi ulnaris (Fig. 5). The medial intermuscular septum is dissected free and excised.

The medial epicondyle is exposed. The flexor/pronator attachment and medial collateral ligament can be released in two different ways. It can be either dissected off subperiosteally, forming a distally based flap, or it can be released by performing an osteotomy of the me-

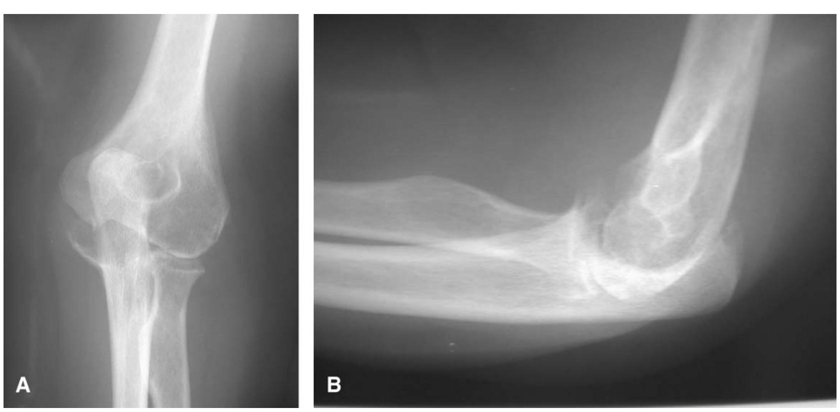

FIGURE 2. A and B, Another young rheumatoid patient with a Mayo stage IIIB elbow. This demonstrates alteration of the subchondral bone. This patient would do well with a total elbow arthroplasty, but is quite young (31 years old). Interposition arthroplasty is an option only if stability can be restored by reconstructing the MCL and LUCL at the time of surgery.

FIGURE 3. After an indwelling axillary catheter is inserted, the patient can be placed in the lateral decubitus or supine position. We prefer to place the patient in the supine position with a shoulder positioner attached to the forearm, suspending the elbow over the chest. A sterile tourniquet is applied and, after exsanguinating the limb, the posterior skin incision is made. Use of the shoulder positioner facilitates operating in the supine position, for greater patient comfort.

dial epicondyle (Fig. 6). It is important to recognize that the anterior band of the medial collateral ligament attaches onto the anterior inferior aspect of the medial epicondyle. The posterior band attaches onto the posterior inferior aspect of the medial epicondyle and forms the floor of the cubital tunnel. The osteotomy must be deep and proximal enough to include the medial collateral ligament and the pronator attachments respectively.

The anterior capsule is separated from the brachialis muscle and is released. Posteriorly, the triceps muscle is

FIGURE 4. An extended posterior exposure is made with thick skin flaps raised medially and laterally. We prefer an extended posteromedial exposure, which helps identify and protect the ulnar nerve. More important, this approach permits easy preservation of the MCL (by means of osteotomy of the medial epicondyle) or reconstruction with a graft, if necessary.

FIGURE 5. The ulnar nerve is released proximally at the arcade of Struthers and distally at the ulnar belly of the flexor carpi ulnaris.

reflected away from the posterior capsule, and this capsule is released as well. The extent of capsular release is dependent on how much motion is restricted in the flexion/extension plane. An attempt to hinge the joint open is made and, if exposure is adequate, the lateral collateral ligament can be spared. If exposure is inadequate, the lateral collateral ligament and extensor attachments are released subperiosteally from the lateral epicondyle. It is possible to perform these releases from the medial side with the joint hinged open.

The joint is hinged open and the articular surface of the distal humerus is evaluated. A synovectomy is performed anteriorly and posteriorly. Osteophytes are debrided with a rongeur, and the distal articular surface is smoothed with a large burr (Fig. 7). Care should be taken not to penetrate subchondral bone, because it is the strongest osseous portion that withstands load. Decortication increases the chance of late subsidence. At this point, the axis pin for external fixation can be placed.

The axis of the fixator must coincide with the axis of rotation of the elbow joint to prevent binding, incongruous motion, or wearing and shearing of the graft. The pin must pass through the axis of rotation of the elbow, which is approximately the center of circles defined by the circumferences of the trochlea and the capitellum. With good exposure of the distal humerus, the pin may be passed freehand (Fig. 8A) using a large ACL drill guide, or by the radiographic method described previously.[18,19] Fluoroscopy confirms proper placement of the axis pin (Figs. 8B, C).

A variety of fascial grafts are available, but we favor either a fascia lata graft or AlloDerm. The graft can be fashioned to the dimensions of the distal humerus covering areas of articular surface. Drill holes are arranged with a power-driven K-wire or drill (Fig. 9A). The holes

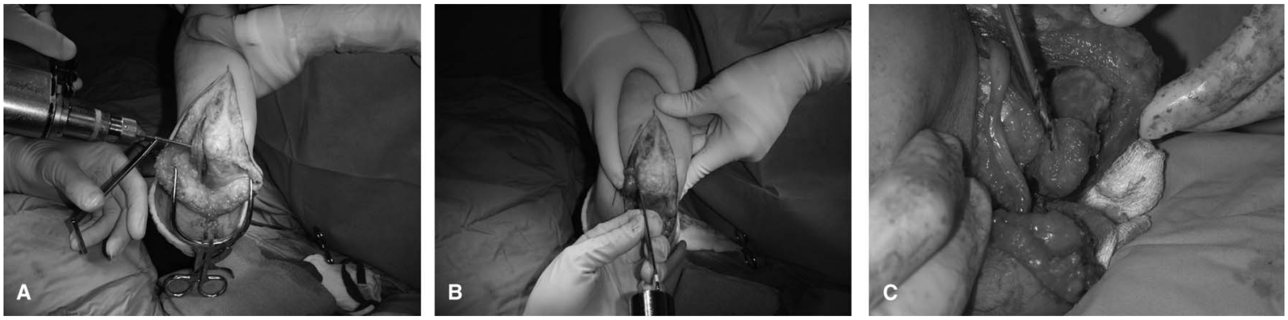

FIGURE 6. A and B, In this case, the MCL is intact. The medial epicondyle is predrilled and osteotomized at the medial edge of the trochlea, protecting the MCL. C, If the MCL is deficient, as in this case, tunnels are prepared to receive a palmaris longus tendon graft for reconstruction.

FIGURE 7. The joint is then dislocated, exposing the distal humerus. The anterior and posterior capsules are released, if necessary. A burr is used to excoriate the surface and remove any cartilage, but the humerus is not decorticated to preserve bone stock and prevent late subsidence.

need to be large enough to drive a Keith needle through (Fig. 9B). They should be arranged in a horizontal mattress fashion and should be located just proximal to the articular surface. Typically, 2 sets of drill holes are made just medial and lateral to the center of the articulation. Two additional sets are made over the medial and lateralmost aspects of the joint, adjacent to the condyles. Free Keith needles are used to pass braided, nonabsorbable suture (Figs. 9C, D). The graft needs to be incorporated with each pass of suture, ensuring that there is enough tension on the graft to adhere to bone. Also, if enough graft is available, it can be doubled up. Suture ends to the medial and lateral-most aspects of the joint should remain long after knot tying. They can be incorporated into the repair of the collateral ligaments. Suture anchors are another option for collateral ligament repair. If a medial epicondylectomy is performed, screw fixation is preferred (Fig. 10).

If the medial and lateral collateral ligaments require reconstruction, this is performed prior to application of

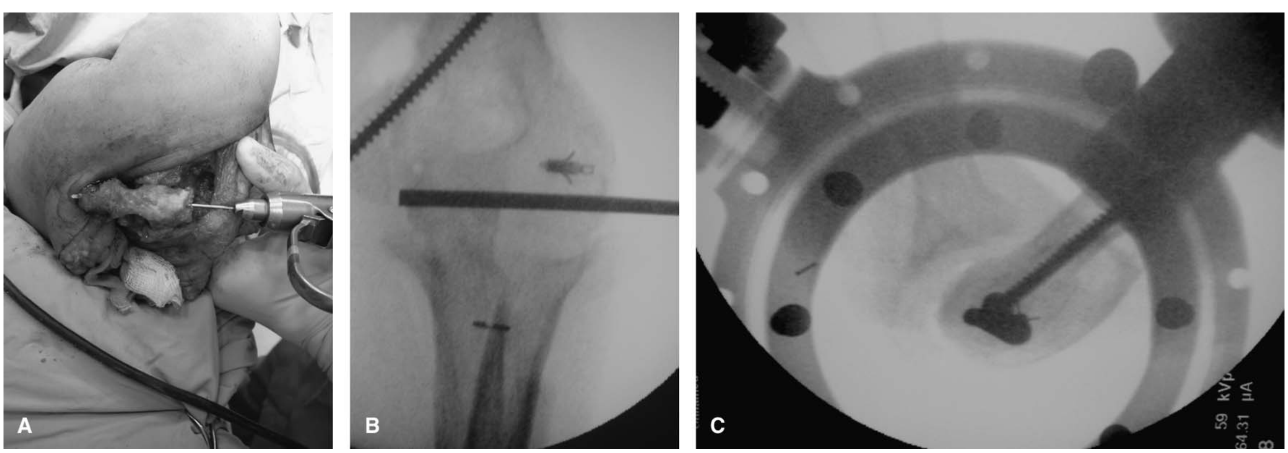

FIGURE 8. A, The axis pin is placed through the center of the axis of rotation of the elbow. With good exposure, this can be done freehand or with an ACL-type drill guide. Correct placement of this pin is critical and its position should be confirmed by direct and radiographic inspection. B and C, Anteroposterior and lateral radiographs showing correct placement of the axis.

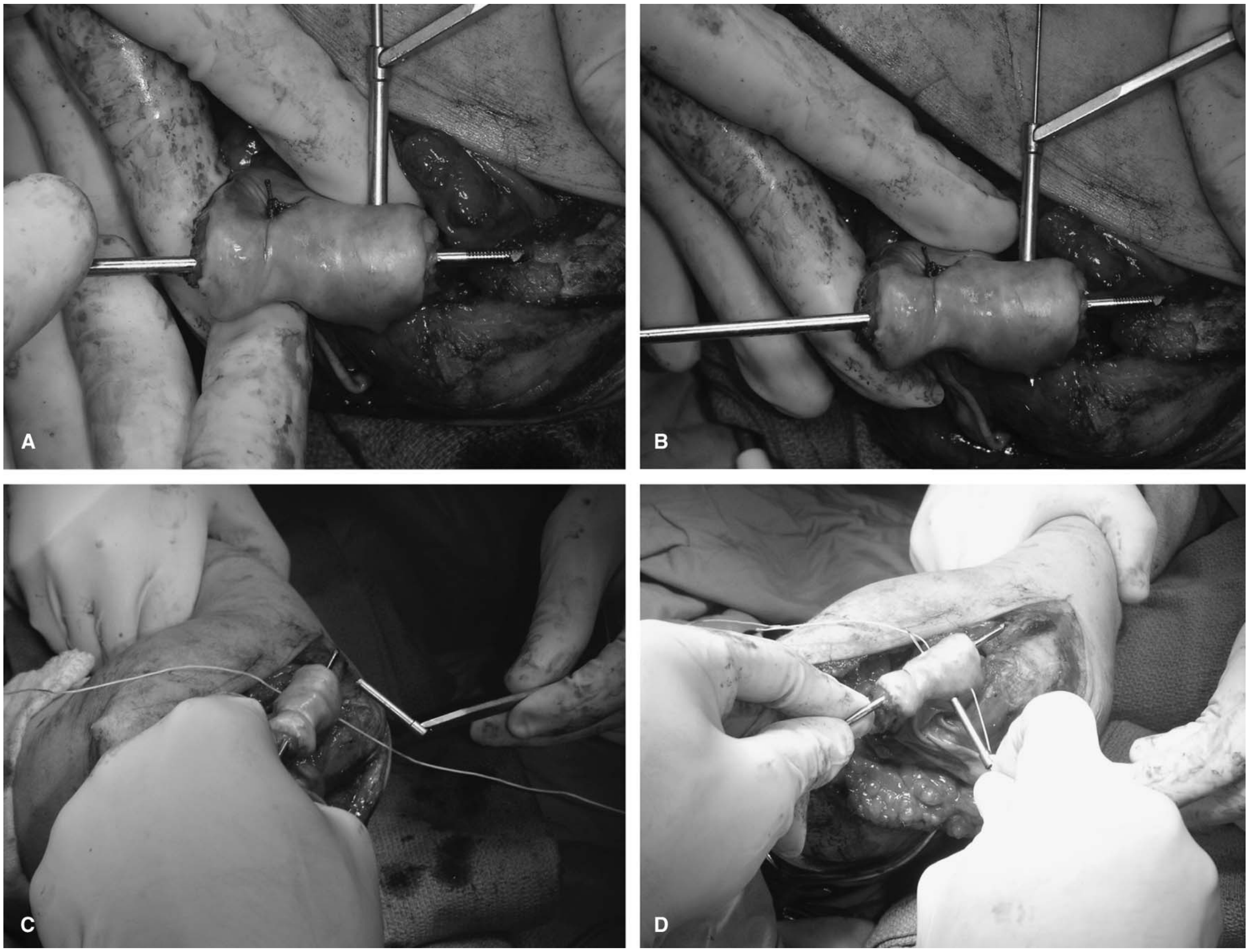

FIGURE 9. A through D, The membrane (in this case AlloDerm graft) is affixed to the distal humerus with multiple mattress sutures passed with a Keith needle. The graft should fit tightly and firmly.

FIGURE 10. A medial epicondylectomy, performed in this case, is reattached.

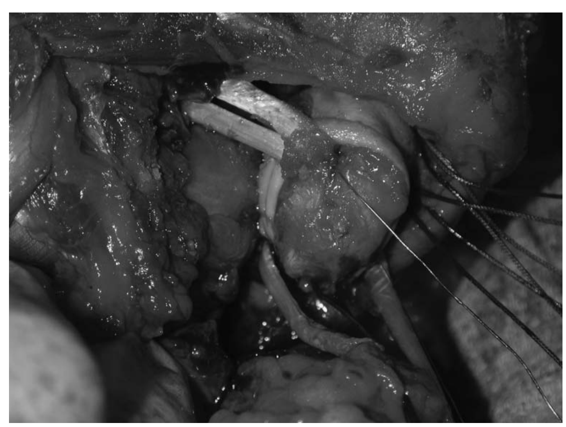

FIGURE 11. The MCL reconstruction, if necessary, is performed by passing the palmaris tendon graft through the ulnar tunnel and then by passing both ends into the distal-most hole in the medial epicondyle. Both ends are secured in each tunnel and the sutures attached are tied over a bony bridge. This is referred to as the *docking procedure*.

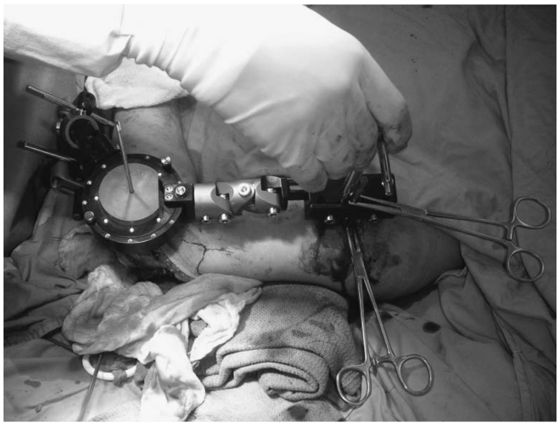

FIGURE 12. The first humeral pin is inserted near the deltoid insertion. Blunt dissection protects the radial nerve. Care must be taken to avoid torquing and shifting the axis while inserting the humeral pins. The centering guide helps to maintain the axis, but gentle technique is required. The centering guide should be lifted from the fixator after tightening the pin and fixator. It should maintain perfect "registration" and drop back into the fixator. Any shifting indicates that the axis has shifted and should be corrected at this point. The ulnar pins may then be inserted and the axis checked once again.

FIGURE 14. Flexion splinting.

the external fixator. On the medial side, the technique described by Jobe et al[20] is used with a palmaris tendon graft (Fig. 11). Laterally, options include reefing of the native capsuloligamentous complex, reconstruction with a tendon graft, as described by O'Driscoll et al,[21] or reconstruction with lateral triceps tendon, as described by Delamora and Hausman.[22] Attention is then turned to applying the external fixator.

The most important point in elbow external fixation is establishing congruous motion while providing distraction. Available fixators include the Morrey DJD, the Compass Hinge, the Orthofix, and the EBI fixator. We prefer a fixator that permits visualization of the joint, such as the EBI or Compass Hinge. The EBI fixator is unilateral and permits some adjustment of the axis once the humeral pins have been inserted. The Compass Hinge has a convenient clutch mechanism, allowing the patient to range the elbow by simply turning a knob on the fixator. However, the axis is fixed by the first posteromedial pin inserted and cannot be adjusted.

For the EBI fixator, the humeral and ulnar pins are "templated" on the extremity with the fixator assembled. The distraction mechanism is set up to begin distraction. The 2 humeral pins are placed laterally by dissecting bluntly down to bone to avoid injuring the radial nerve (Fig. 12). The axis position is confirmed once again based on the position of the fixator frame connected to the humeral and axis pins. If a circular inset guide is used and withdrawn from the guide pin and again readvanced, it should "register" perfectly. If it fails to align perfectly, adjustments should be made in the fixator frame so that there is perfect "registration" of the plastic axis pin insert into the EBI fixator ring. This fixes the axis of rotation. The 2 ulnar pins are then placed. The fixator is applied and the axis pin is centered with the targeting device under fluoroscopy. After centering, the axis pin is removed and the elbow is taken through range of motion, under fluoroscopy, visualizing the ulnohumeral and the radiocapitellar articulations. Distraction should be equally distributed on AP and lateral views (Fig. 13). Clinically, there should be no crepitus noted throughout range of motion, and the forearm should be angled just

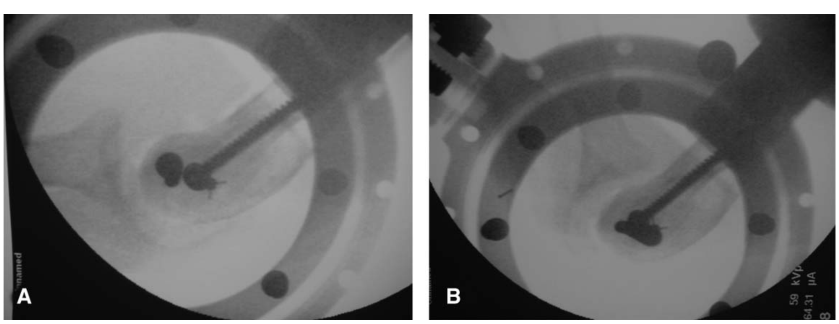

FIGURE 13. A and B, Distraction extension and flexion lateral radiographs.

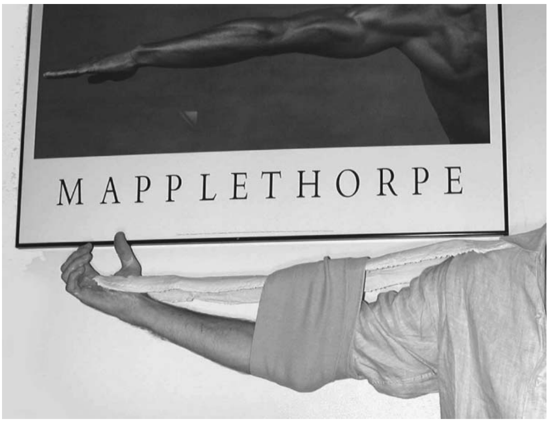

FIGURE 15. Extension splinting.

medial to the arm in the coronal plane on full elbow flexion.

The skin is then closed over a suction drain with a tight, running, subcuticular closure. A light and loose dressing is applied so as not to restrict motion postoperatively.

■ REHABILITATION

An indwelling axillary catheter is used for anesthesia and postoperative analgesia. Range-of-motion exercises are begun on the day of surgery and with long (approximately 1 hour) cycle times, with emphasis on obtaining the maximum range of motion, rather than number of cycle times. This is done to minimize tension and motion at the fresh incision sites, which increases inflammation and scarring. CPM is not used. As healing progresses, more cycles are permitted. The rate of infusion in the catheter can be decreased to permit some motor function and can be adjusted to provide the necessary amounts of pain relief without total anesthesia of the limb. Care must be taken to protect the ulnar nerve in the anesthetized limb to prevent prolonged pressure. At rest, the elbow is splinted in flexion or extension, alternating each with an emphasis on whether the patient is having more difficulty in flexion or extension.

If the fixator is used, it is left in place for 8 to 12 weeks, if possible. Following removal of the fixator, the elbow undergoes static splinting for 3 to 4 months. A simple elastic bandage is used for flexion (Fig. 14). Our extension splint is a simple plaster or firm plastic strip with an area cut out for the thumb (Fig. 15). It is arc shaped to increase the rigidity. Instead of molding the splint to the patient's arm, it is made straight, which is the desired position. In this way, the arm bowstrings across the splint and there is always a corrective force. Extending the splint from the hand to the shoulder increases the moment arms acting on the elbow and is well tolerated, because pressure is applied to the broad, well-muscled surface of the shoulder. Use of a single elastic bandage avoids uncomfortable pressure over the olecranon while again keeping the moment arms as long as possible.

■ DISCUSSION

Results of recent long-term outcome studies for STEA have improved from past studies of prosthetic elbow arthroplasty.[15–17,23,24] Most of the patients in recent series were elderly. The recommended activity restrictions, such as avoidance of more than 1 single-event lift of a 5-kg object and repetitive lifting of more than a 1-kg object, may not be acceptable to the young, high-demand patient.

Complications of total elbow arthroplasty have historically shown high loosening, wear, and infection rates.[2,3] Although more recent studies have shown much improved results in loosening[4] and infection rates[4,25] with evolving components and technique, wear rates are still a problem and some form of revision is usually necessary at 10 years.

DIAE is a viable alternative for elbow reconstruction for the young, active patient. The addition of distraction and external fixation, in conjunction with ligament reconstruction, has addressed the instability problem and therefore improved results.[11,12] Young patients with severe elbow arthritis can "buy time" with the DIAE procedure, and conversion to STEA in the future remains an option. Results have shown good pain relief and satisfactory range of motion with DIAE, making it a good preprosthetic alternative.

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