

Total Elbow Arthroplasty for Posttraumatic Arthrosis

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Abstract

Total elbow arthroplasty can be effective in treating acute injuries and posttraumatic conditions of the elbow, although typically it is considered a salvage procedure. The ideal prosthetic implant appears to be linked and semiconstrained, with an anterior flange to resist posterior and rotatory forces. The ability to fix the stem without condyle preservation is important in treating a posttraumatic condition. The results of total elbow arthroplasty can deteriorate over time because of periprosthetic fracture, implant fracture, bushing wear, or other mechanical failure. The rate of aseptic loosening is less than 10% after 10 years, which is lower than had been anticipated. Elbow replacement can be extremely effective for a properly selected patient with posttraumatic arthrosis. However, approximately 25% of patients have a complication.

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Trauma to the elbow often causes stiffness, joint deformity, contracture, bone loss, or instability. Surgical procedures can lead to the development of a poor soft-tissue envelope, infection, or dysfunction. In contrast to patients with rheumatoid arthritis, patients with posttraumatic arthrosis usually are younger and more active, with otherwise normal joints. These patients often expect to return to their previous level of activity. As a result, posttraumatic arthrosis can be more difficult to treat than rheumatoid arthritis.^{1,2}

Few surgical treatments are available for severe posttraumatic arthrosis. Arthrodesis of the elbow reliably

relieves pain and restores strength, but the resulting functional impairment is unacceptable for most patients.^{3,4} Arthrodesis is considered suitable only for a patient who performs strenuous physical labor or one with sepsis.³ Interposition arthroplasty achieves motion restoration and pain relief in approximately 80% of patients; it can be considered for a patient younger than 60 years, especially if stiffness is present.⁵⁻⁹ However, interposition arthroplasty is not suitable for a patient who performs strenuous physical labor, has a deformity, or has pain at rest.^{6,9,10} Although allograft replacement of the entire elbow joint has been de-

scribed,^{11,12} concerns about the complication rate, continued degeneration, and long-term neurotrophic changes have prevented its wide acceptance.

Total elbow replacement is a suitable and reliable salvage treatment for patients with severe posttraumatic arthrosis. Several implant designs have been extensively investigated.

Elbow Prosthesis Designs

Constrained Linked Prostheses

The highly constrained, linked metal-on-metal total elbow prostheses used during the 1970s were associated with high rates of early loosening.^{11,13,14} This disappointing result was attributed to the rigid hinged implant mechanism, which transmitted great forces across the elbow joint directly to the prosthesis-bone interface. The use of these first metal articulations also led to complications from wear debris (Figure 1).

Unlinked Prostheses

The unlinked prosthesis design is more anatomic. Because the implant is not linked, the forces are absorbed by the soft tissues, and less force is transmitted to the prosthesis-bone interface.¹⁵⁻²⁶ The unlinked implant

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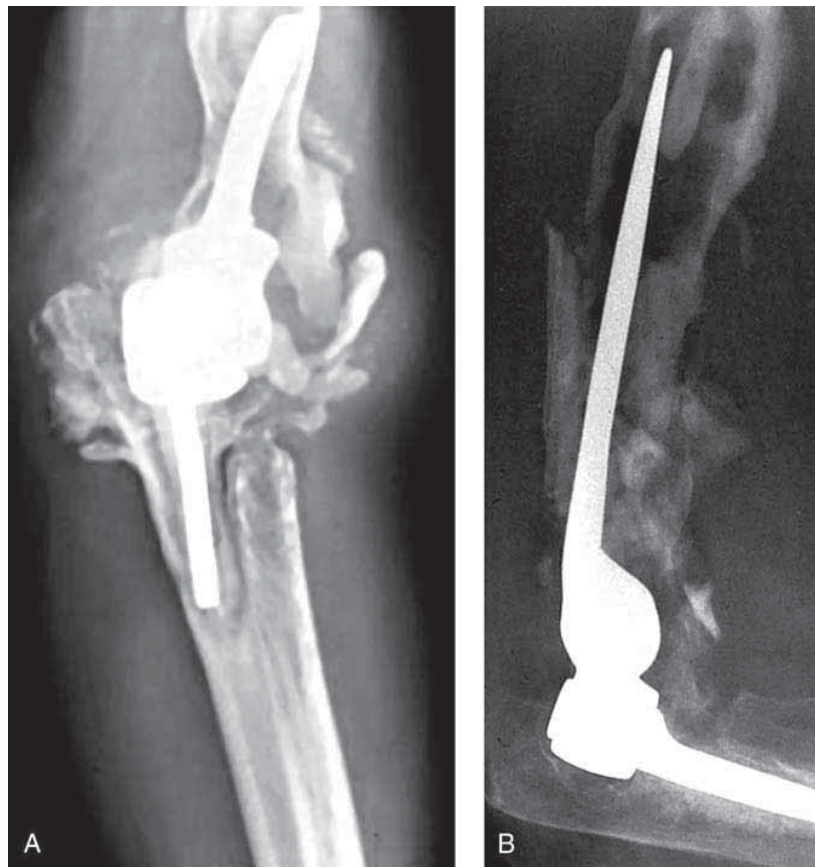


Figure 1 Metal-on-metal constrained articulation can generate many particles, resulting in extensive osteolysis, as seen in radiographs of total elbow arthroplasty using a Dee (A) or GSB II (B) prosthesis.

has been almost exclusively used for the treatment of rheumatoid arthritis; the design requires the presence of intact condyles and collateral ligaments for stability. The use of unlinked implants is significantly limited by the incidence of postsurgical instability, which was reported in 5% to 10% of elbows,^{15,18-20,22,26} as well as the technical difficulty of the implantation. The relative contraindications to using an unlinked device are presurgical deformity, asymmetric soft-tissue contractures, bone loss, and marked instability, all of which are characteristic of traumatic elbow dysfunction.

Semiconstrained Linked Prostheses

A semiconstrained implant is a linked device that allows laxity within the mechanism, thus diminishing the forces on the prosthesis-bone interface (Figure 2). The reported rates of loosening for these devices are lower than comparable rates for either constrained linked or unlinked implants^{1,11,21,27-29} (Figure 3). The greatest advantages of this prosthesis design are that it allows stability to be restored and deformity to be corrected^{2,30} (Figure 4).

The first reports of elbow arthroplasty included only a few patients

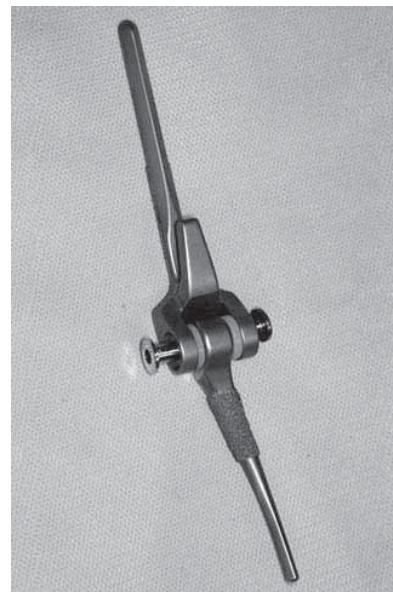


Figure 2 The most recent version of the Coonrad-Morrey prosthesis has a hollow pin-within-a-pin articulation, which allows 7° to 10° varus and valgus and axial rotation at the captured articulation.

with posttraumatic arthrosis,^{28,29,31-34} who often had an unfavorable result.^{29,31,33,34} A 1997 study using the semiconstrained Coonrad-Morrey Total Elbow Prosthesis (Zimmer, Warsaw, IN) found that posttraumatic arthrosis can effectively be treated with artificial joint arthroplasty, although the use of this device has some important limitations.¹

Indications for Total Elbow Arthroplasty

Total elbow arthroplasty using a semiconstrained prosthesis is the recommended treatment for posttraumatic arthrosis in carefully selected patients. Patients must have advanced destruction of the ulnohumeral joint, with marked narrowing or loss of the joint space. The patient typically is older than 60 years. For a younger patient, total elbow replacement should be

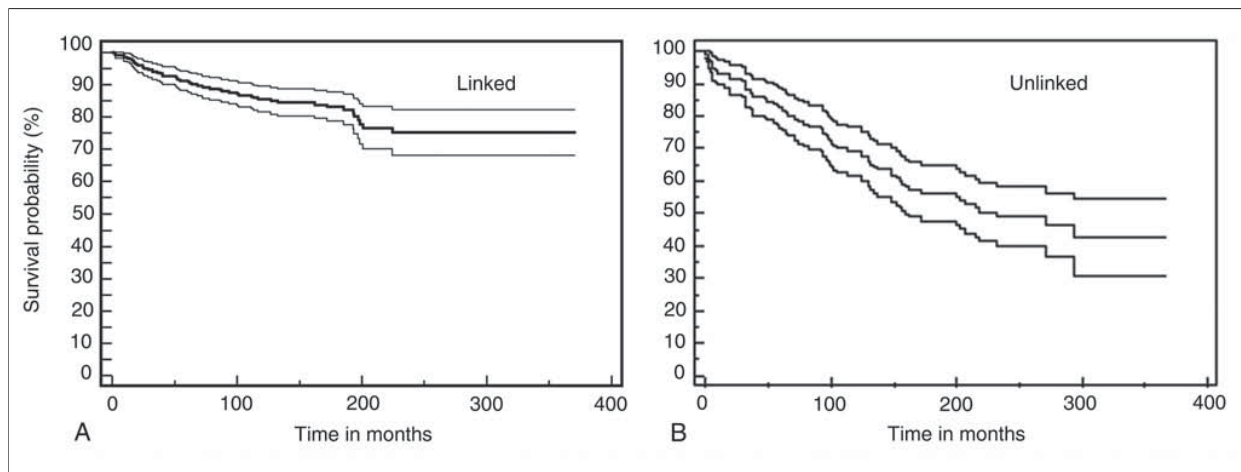


Figure 3 Kaplan-Meier survival curves showing the results of using semiconstrained linked (A) and unlinked (B) implants at the Mayo Clinic over a 30-year period. Of the patients with a linked implant, 42% had a posttraumatic condition, compared with only 8% of those with an unlinked implant.

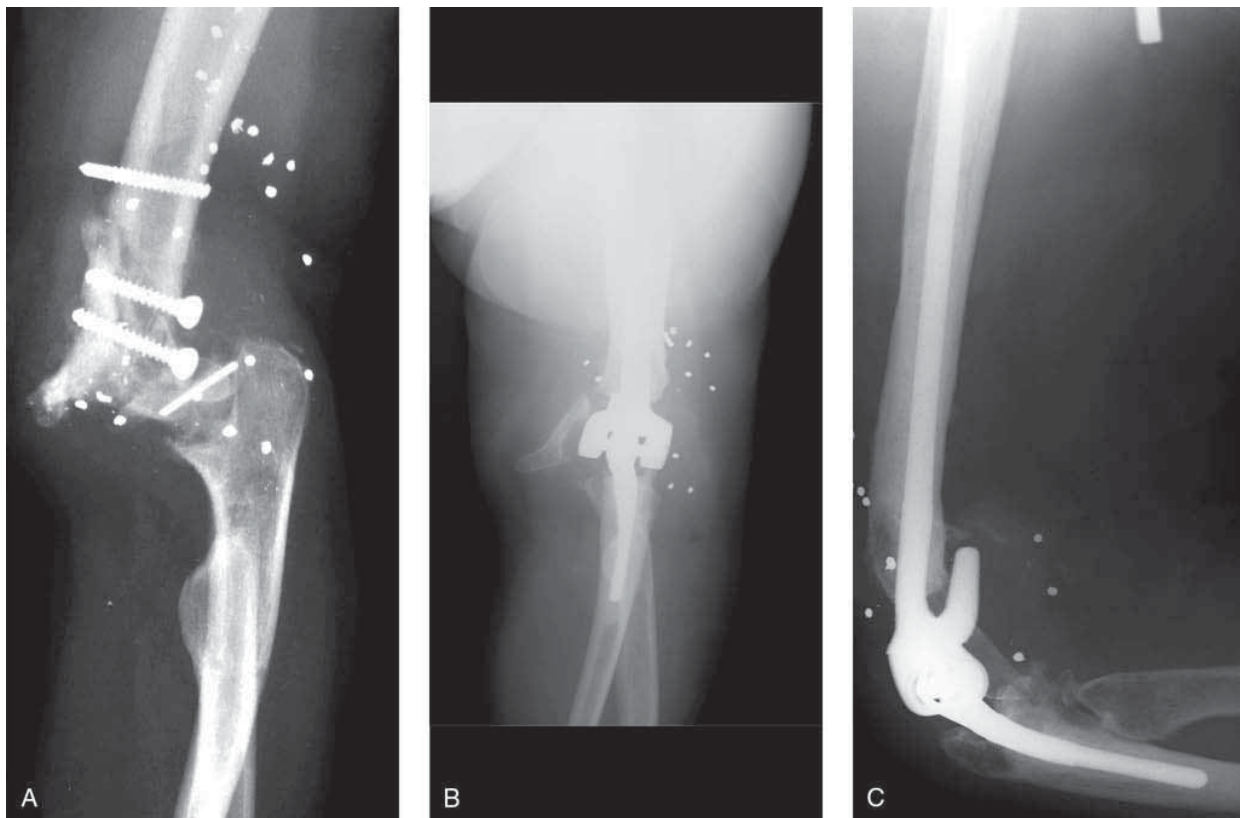


Figure 4 A, Radiograph showing gross deformity of the elbow 3 years after the repair of a gunshot wound. Radiographs of the elbow 9 years after arthroplasty using a semiconstrained linked prosthesis showing that the bushings have not worn (B) and both ulnar and humeral components are well fixed (C). The bone graft has matured behind the flange.

performed only if no suitable alternative surgical treatment is available or earlier reconstructive procedures have been unsuccessful. Interposition arthroplasty is preferred to total joint arthroplasty for a younger patient with severe posttraumatic arthrosis; total joint arthroplasty is recommended if interposition arthroplasty is unsuccessful.

Age, Occupation, and Physical Activity

A total elbow prosthesis is a mechanical device, and its polyethylene articulation is subject to wear. In a study at the Mayo Clinic, patients with posttraumatic arthrosis who were younger than 60 years had a higher rate of complications (35%) than older patients (17%) and a correspondingly lower rate of satisfactory results (78% compared to 89%).³⁵ The prosthesis cannot tolerate the stress of heavy physical work. Patients who have undergone total elbow replacement therefore are advised to avoid single-event lifting of an object heavier than 5 kg or repeated lifting of an object heavier than 1 kg. Golf and other impact sports are discouraged. Participation in heavy physical work and anticipated noncompliance are relative contraindications for the procedure.

Instability

Acute or chronic instability with deformity is not a contraindication to elbow replacement with a semiconstrained prosthesis.^{1,36} The implant's coupled articulation yields immediate and durable stability. This is particularly important because both collateral ligaments are released during the approach to the arthroplasty, and no attempt is made to repair them. In contrast to an unlinked implant,³⁷ a semiconstrained device provides valgus-varus and ax-

ial stability without risking disassembly of the components.

Bone Loss

Significant humeral bone stock deficiency was present in 16 of the 41 patients with posttraumatic arthrosis in the initial Mayo study,¹ as well as 8 of the 16 patients in a study conducted in Balgrist, Switzerland.³⁶ Only the humeral diaphysis is required to obtain secure fixation of the semiconstrained prosthesis; rotational and anteroposterior stability is maintained by the anterior flange and bone graft. Because the implant does not require the condyles or the distal humerus for mechanical support, the nonunited parts of the distal humerus can be resected before the prosthesis is inserted and do not need to be reconstructed.³⁸ This design facilitates total elbow replacement and has a great advantage over designs that require the condyles for stability.^{28,37} If the bone loss extends into the supracondylar area and the humeral shaft, the humeral component of the semiconstrained prosthesis can be cemented more proximally into the shaft. As much as 8 cm of distal humeral deficiency can be compensated for by using the long flange device (Figure 5), but doing so results in a shortening of the humerus. The humerus should be shortened no more than 2 cm; any greater shortening can weaken the muscles crossing the elbow joint.³⁹

A traumatic loss of the proximal ulna is difficult to treat. The reconstruction requires allograft or autograft from the iliac crest to restore the site of insertion of the extensor mechanisms. A deficiency in the triceps can be effectively treated using an allograft Achilles tendon with a calcaneal graft to the ulna (Figure 6).

Deformity

Deformity in posttraumatic arthrosis usually appears as marked translation or angular abnormality of more than 30°. Long-standing deformity results in asymmetric soft-tissue contractures. An unlinked prosthesis usually cannot correct this type of deformity, and instability is common. A hinged semiconstrained prosthesis is able to correct deformity, but the correction may cause the distorted soft tissues to impart persistent or increased asymmetric loads, increasing the wear on the prosthesis. A marked presurgical deformity was found to be associated with a significantly higher rate of complications ($P = 0.02$), which were directly related to bushing wear of the articulation rather than implant loosening.⁴⁰

Total Elbow Replacement Using the Coonrad-Morrey Prosthesis

Surgical Technique

The Coonrad-Morrey Total Elbow Prosthesis is a noncustom device; the humeral and ulnar components are available in three interchangeable sizes. The 10-, 15-, or 20-cm humeral stem has a standard short flange as well as a long anterior flange that is useful for defects of the distal humerus. The 15-cm stem usually is used for a patient with posttraumatic arthrosis. The prosthesis is made of a titanium alloy, and cement fixation is used for both stems. The articulation consists of three high-density polyethylene bushings rotating around a cobalt-chromium pin; it allows a play of 7° to 10° of varus and valgus and 7° of rotation⁴¹ (Figure 1).

Morrey and Adams³⁸ described the surgical technique for implanting the semiconstrained Coonrad-Morrey prosthesis. A posterior mid-

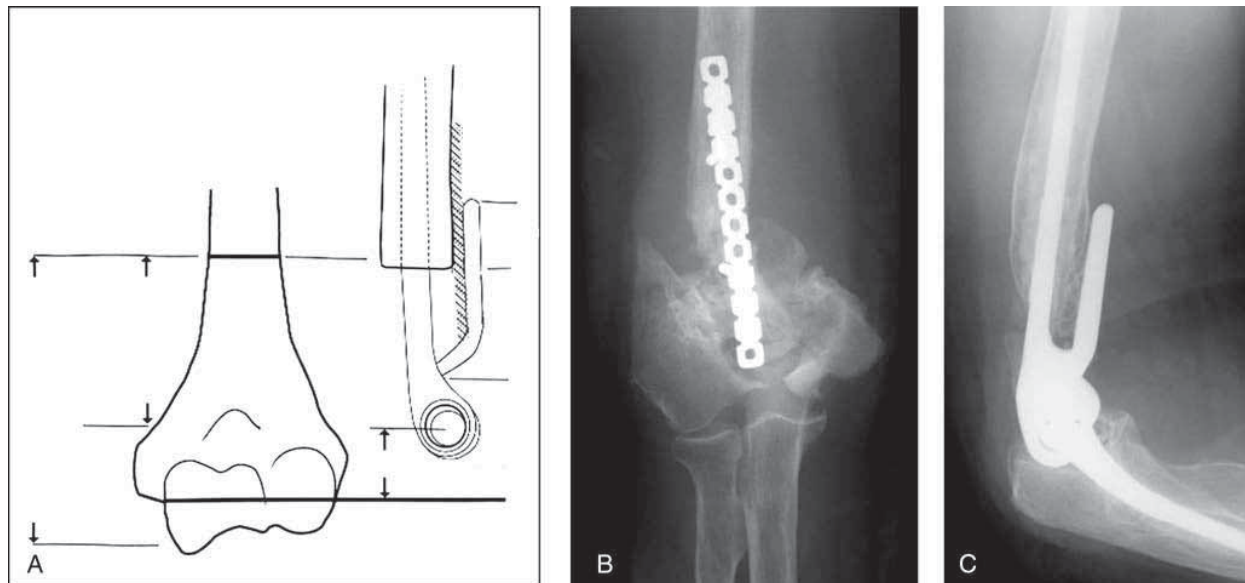


Figure 5 **A**, Schematic drawing showing the treatment of as much as 8 cm of distal humeral loss using the extended-flange version of the Coonrad-Morrey implant. Note that the distal 3 cm are not required for routine cementation. An additional 2 cm of shortening can be accepted without causing excessive triceps or biceps weakness. By allowing 3 cm of the extended flange to remain uncovered, a total of 8 cm distal humeral deficiency can be treated. **B**, AP radiograph showing a distal humeral nonunion and 6 cm of bone loss. **C**, Lateral radiograph taken 5 years after replacement of the extended flange. The patient had excellent function and no pain.

line incision should be used and should include any posterior scars from earlier procedures. The ulnar nerve always is transposed anteriorly into a subcutaneous pocket. The recommended triceps-sparing approach is accomplished by release and lateral reflection of the triceps from the olecranon in continuity with the ulnar periosteum and the fascia of the forearm along with the anconeus (as described by Bryan and Morrey⁴²). The use of an intramedullary injecting system ensures optimal insertion of the cement, which contains 1 g of vancomycin per 40 g of cement. A bone graft must be placed between the anterior flange and the distal part of the humerus to resist posterior displacement and rotational stresses on the humeral component after ingrowth. Resection of the tip of the coronoid process usually is necessary to avoid

impingement with the anterior flange, which would cause considerable distraction force on the ulnar component. Anterior impingement also can be caused by too-deep insertion of the ulnar component. The lack of one or both epicondyles does not change or complicate humeral component implantation. Proper tensioning of the soft tissue allows for proper depth of insertion (Figure 7). Nonunited condyles can be resected. If the entire distal humerus is deficient, the approach does not require the triceps to be detached from the olecranon (as described for total elbow arthroplasty in patients with a distal humerus nonunion).³⁸

Results

Mayo Clinic Studies

At the most recent follow-up of the 41 consecutive patients with post-

traumatic arthrosis or dysfunction in the initial Mayo Clinic study, 16 patients had an excellent outcome, 18 had a good outcome, 5 had a fair outcome, and 2 had a poor outcome, as measured using the Mayo Elbow Performance Score.³⁵ Thus, 34 of the 41 patients (83%) had an objectively measured satisfactory outcome. Two patients had an infection, and 1 had a broken ulnar component; of the 38 patients with a functioning implant, 89% had a subjectively measured satisfactory outcome. Before surgery, 90% of the patients had moderate or severe pain; after surgery, 29 of the 38 patients with a functioning implant (76%) had no or mild pain ($P < 0.0005$). At 12-year follow-up, the mean arc of flexion-extension was 27° to 131°, and the mean arc of pronation-supination was 66° to 66°. The patients were able, on average,

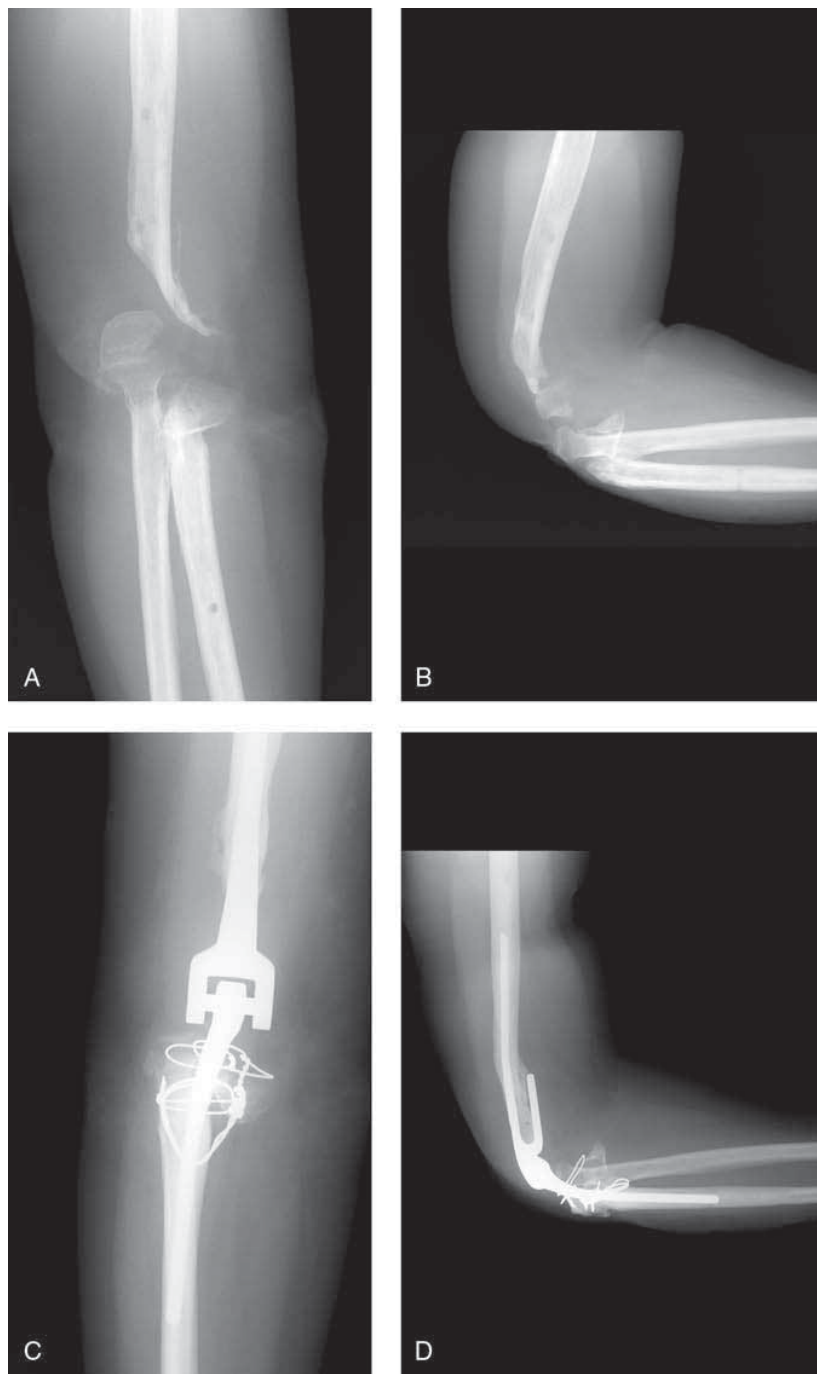


Figure 6 A and B, AP and lateral radiographs, respectively, showing a sideswipe fracture resulting in a flail extremity; there is no evidence of infection. The patient was in severe pain and did not want an allograft replacement. The patient lacked a triceps mechanism. C and D, AP and lateral radiographs, respectively, taken 1 year after reconstruction using a semiconstrained implant with an allograft Achilles tendon and a calcaneal graft to the proximal ulna. The patient was able to extend the elbow against gravity.

to perform 4.8 of the 5 activities of daily living.

No aseptic loosening was identified during the 12 years after surgery. Only four patients had periarticular ossification, which was smaller than 1 cm and had no clinical significance.

In a review of 30 years' experience with the semiconstrained prosthesis, 58 of 75 patients (78%) had an objectively measured satisfactory outcome at a mean 10-year follow-up; 62 (82%) indicated they would choose to undergo the procedure again.³⁵ The patients' mean proximal arc of motion was 30° to 140°. However, the complication rate exceeded 20% as documented by Schneeberger and associates.¹

Experience at Balgrist

Schneeberger and associates³⁶ evaluated outcomes after implantation of the Coonrad-Morrey prosthesis in 16 patients with posttraumatic arthrosis in Balgrist, Switzerland. At latest follow-up, 12 of the 16 patients (75%) were considered to have an objectively satisfactory result, as measured using the Mayo Elbow Performance Score: 5 patients had an excellent result; 7, a good result; 2, a fair result; and 2, a poor result. One patient required revision because of loosening and another because of infection; 88% of the remaining patients had a satisfactory objective outcome. The mean arc of flexion at follow-up was 27° to 131°. Loosening with more than 2 mm of lucency around the entire interface was found in two humeral and two ulnar components in three patients (19%). Inadequate cementation was found in two humeral components, one of which was loose. However, no loosening was found in implants cemented after an advanced technique was implemented in 1998.

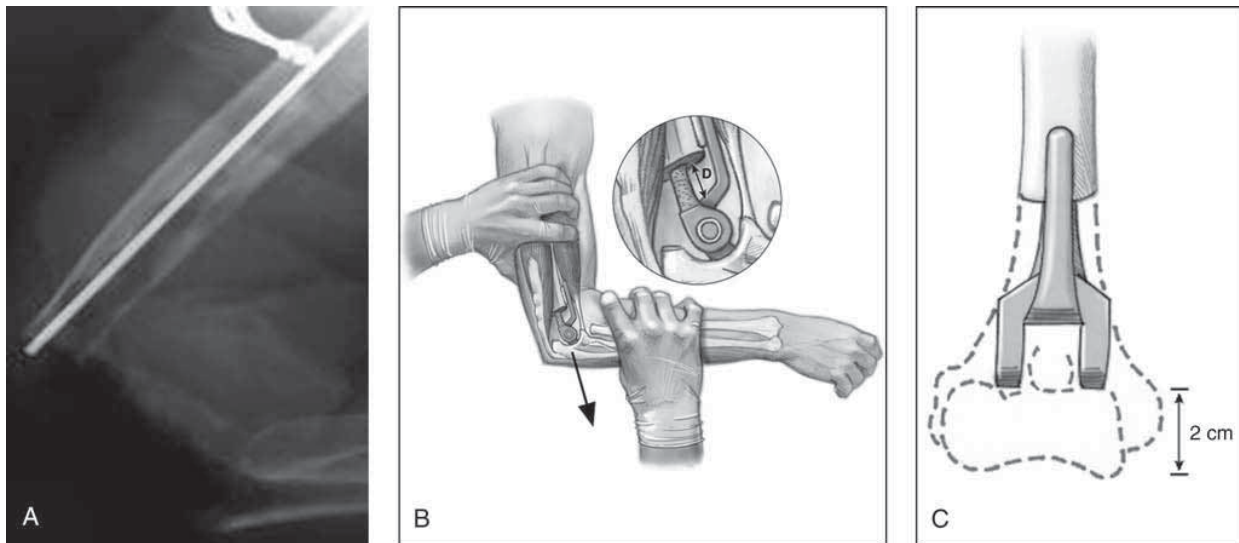


Figure 7 **A**, Lateral radiograph showing severe distal humeral and proximal ulnar bone loss that poses problems with proper depth of seating of the implant. **B**, In the so-called chuck test, the forearm is brought distal after articulation of the trial components, allowing estimation of the proper depth of insertion of the humeral component. **C**, Drawing of an extended-flange implant that is not fully seated, as determined by the findings of the chuck test. (**B** and **C** reproduced with permission from the Mayo Foundation for Medical Education and Research.)

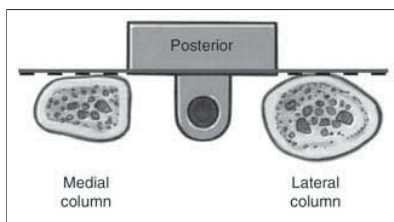


Figure 8 The proximal axial rotation of the implant is approximated by aligning the implant with the plane formed by the posterior surfaces of the medial and lateral columns. (Adapted with permission from the Mayo Foundation for Medical Education and Research.)

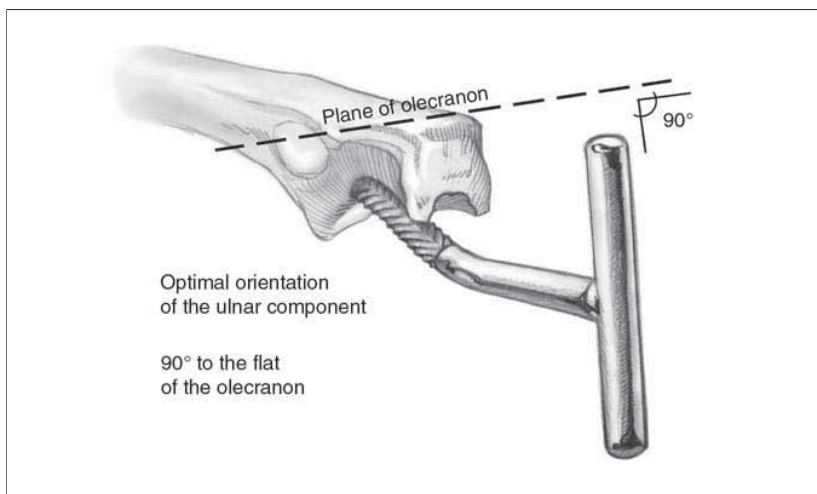


Figure 9 The proper flexion and extension rotational plane is perpendicular to the so-called flat surface of the proximal ulna. This plane is identified and replicated with the rasping technique. (Adapted with permission from the Mayo Foundation for Medical Education and Research.)

Complications

The rate of complications after implantation of the Coonrad-Morrey total elbow prosthesis is significant. Eleven of the 41 Mayo Clinic patients (27%) had a major complication, and 9 (22%) required further surgery. Five patients (12%) had a fracture of the ulnar component. However, the mechanical properties

of the implant were improved by two modifications of the ulnar component surface: in 1995, from sintered beads to a precoating; and in

2000, to a plasma spray coating. Fatigue fractures of the proximal ulna were not found after relatively recent prosthesis implantation.

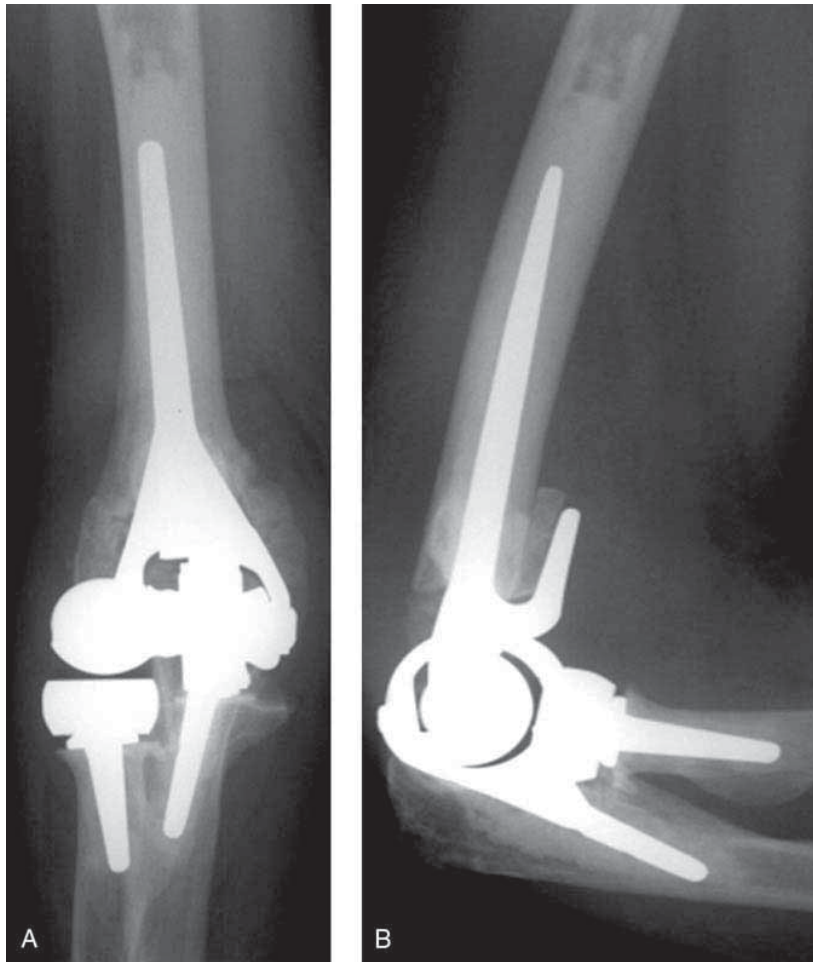


Figure 10 The Latitude prosthesis can be inserted as a semiconstrained linked or unlinked implant. This three-part device uses a flange to help stabilize the humeral component. **A**, AP view. **B**, Lateral view.

Wear

Bushing wear is of particular concern in younger, active patients.⁴³ All Coonrad-Morrey elbow prostheses implanted at the Mayo Clinic from 1981 through 2000 were retrospectively reviewed to analyze polyethylene wear.⁴⁰ Of the 919 patients (34% of whom had received an implant for a trauma-related condition), 12 (1.3%) had required an isolated exchange of the articular bushings as a result of polyethylene wear. The bushings were revised an

average 8 years after implantation. Nine of the 12 patients (75%) had extensive deformity. The review emphasized the osteolysis and loosening caused by the precoated ulnar surface.⁴⁰ Careful control of humeral and ulnar implant positioning is also required (Figures 8 and 9).

The polyethylene-metal design of newer prostheses such as the Latitude (Tornier, Montbonnot, France; Figure 10) and the Discovery (Biomet, Warsaw, IN) is intended to increase the longevity of

the polyethylene and allow greater loads to be placed on the prosthesis. It has yet to be determined whether the use of these different contact surfaces will succeed or produce a large quantity of wear debris.

Summary

Severe posttraumatic arthrosis can be reliably treated using a noncus-tomized, semiconstrained linked prosthesis. High rates of patient satisfaction and restoration of stability and function have established total elbow arthroscopy using a semi-constrained linked implant as a viable salvage option for a posttraumatic elbow. Correct cementation and surgical technique are important. The high complication rate reflects the limitations of the procedure and the complexity of the elbow pathology. Because of the likelihood of mechanical complications, total elbow replacement in younger patients should be restricted to those who do not perform strenuous physical activity and are not candidates for an alternative procedure.

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