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Proximal Ulnar Reconstruction with an Achilles-Calcaneus Allograft in Revision Total Elbow Arthroplasty: A Case Report

Running title: Achilles-Calcaneus Allograft Proximal Ulnar Reconstruction

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The frequency of total elbow arthroplasty (TEA) in the treatment of an arthritic elbow has been increasing. TEA is considered an effective treatment method for various conditions, such as inflammatory arthritis, acute fractures, and osteoarthritis. Although the outcomes are improving, TEA has lower survival rates and higher complication rates than other joint arthroplasties, ranging from 24% to 44%. Moreover, revision rates for TEA are reported to be as high as 12.8%, with the most common reason being aseptic loosening, followed by deep infection and periprosthetic fractures.

It is likely that the frequency and complexity of revision procedures for TEA will increase as the population ages. The complexity is often related to major bone loss in the distal humerus and proximal ulna. Several methods have been described using long stem components, including a cancellous autograft, impaction graft, allograft-prosthesis composite, and cortical strut allograft. These methods have variable implant survival rates with a high complication rate. Triceps attachment can also cause major problems in proximal ulnar bone loss. This report describes a new method for reconstruction of a proximal ulnar bone defect in revision TEA using an Achilles-calcaneus allograft.

Keywords: proximal ulnar reconstruction; total elbow arthroplasty; revision total elbow arthroplasty; Achilles-calcaneus allograft; allograft; case report

Case report

A 48-year-old female visited the emergency room with painful limitation of the left elbow. She had a history of TEA due to arthrosis at the age of 20 years. Ten years after the initial
surgery, she started having motional disturbance but did not undergo any treatment. A day before visiting our hospital, she hit her elbow against a pole, which aggravated her symptoms. A radiographs were obtained and revealed a periprosthetic fracture of the TEA in the mid level of the humeral stem. There was significant osteolysis and loosening of the humeral component while the ulnar component appeared stable. Contralateral humerus radiographs were obtained and revealed the significant shortening of the left arm (Fig. 1). She did not present any infection symptoms on physical examination and inflammatory markers of blood tests were normal (6980/μL of wbc count, 16mm/hr of ESR, 0.16mg/dl of CRP). Treatment options were discussed with the patients to include elbow fusion and revision TEA. A fusion was considered given her age and pre-injury elbow motion, but the patient desired mobility in the elbow and she was indicated for a revision TEA using an Achilles-calcaneus allograft.

The patient was placed in a prone position, and an incision was made over the dorsal aspect of the elbow. The humeral stem was removed easily, but the ulnar stem was firmly fixed and required extended osteotomy for removal. Major bone defects were observed on the proximal ulna including coronoid process and olecranon process. There is no infectious sign at intraoperative finding. An Achilles-calcaneus allograft was shaped similar to the proximal ulna and ulnar stem [Coonrad/Morrey total elbow revision prosthesis (Zimmer, Warsaw, IN, USA), ulnar component, 4.5 inches] was cemented and inserted into Achilles-calcaneus allograft (Fig. 2). The allograft was fixed with an ulnar shaft using a locking plate (2 bicortical and 1 unicortical fixation) and wires. Then, with the patient’s elbow hyperflexed, the triceps and Achilles tendon from the allograft were sutured tightly using the Pulvertaft weave technique. The humeral bone defect was filled with an autogenous bone graft from the posterior superior iliac spine, one femoral head allograft, and the ground remained calcaneus allograft. The fracture of the humerus was fixed with a 6 holes miniplate (5 unicortical
fixation), and the humeral stem [Coonrad/Morrey total elbow revision prosthesis (Zimmer, Warsaw, IN, USA), humeral component, 8 inches] was changed and fixed using cement (Fig. 3). Humeral and ulnar components were linked and 20 to 100 degrees passive range of motion (ROM) was checked. Long arm splint was applied after surgery immediately.

Postoperative radiography showed adequate fixation and lengthening of the arm (Fig. 4). Due to excision of the distal humerus, extrinsic finger flexor and extensor were retensioned, and as a result, the patient complained of limitations in finger extension and flexion with ulnar nerve symptoms (numbness). The patient was treated with long arm splint for 8 weeks for immobilization and started elbow ROM rehabilitation at 2 weeks after surgery. Radiography performed 9 weeks postoperatively showed no displacement of the fracture site and stable fixation of the stems (Fig. 5A, B). The patient’s ROM was 25° of extension to 90° of flexion (Fig. 5C). In addition, her finger motion improved to near normal range and ulnar nerve symptom had disappeared. Sixteen months postoperatively, the humeral defect had healed well, and the allograft had incorporated radiographically. At the 5-year follow-up, radiography showed stable fixation of the stems (Fig. 6). The patient’s Mayo Elbow Performance score (MEPS) was 85, and the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score was 11.4. The latest follow-up at 11 years postoperatively was conducted over the phone, and the patient reported that she occasionally characterized her pain as 1 on the 10-point visual analog scale and had no limitations in daily activity. For this reason, the patient did not desire further follow-up visits to the hospital.

**Discussion**

In revision TEA, loosening of the stems is the most common cause of failure. Loosening is often accompanied by a substantial amount of bone loss due to periprosthetic
osteolysis. This bone loss can cause a dual challenge during elbow reconstruction; the absence of a proximal portion of the ulna compromises component fixation, and a lack of attachment sites for the triceps tendon can result in weakness in extension.  

Several alternative surgical techniques have been suggested for patients with massive bone loss after TEA, and allograft-prosthetic composite reconstruction has been widely used with several types of allografts. Morrey et al\textsuperscript{7)} reported 25 cases of revision TEA with allograft-prosthetic composites, wherein they performed TEA with 15 fibulae and 4 ulnae on the ulnar side and 7 humeral allografts on the humeral side. The fibula allograft was chosen because the fibular head provided a pseudo-olecranon for triceps attachment. Recently, Burnier \textit{et al.}\textsuperscript{2)} reported 10 revision TEA using proximal ulnar allografts with intact triceps tendon allografts, resulting in six reoperations and eight elbows with intact ulnar reconstruction.  

Preserving the triceps in TEA is a major factor in regaining function of the elbow. Patients with triceps insufficiency struggle to reach over their head, lift themselves from a chair using their arms for support, and push open doors because adequate extension of the elbow is dependent on the triceps.\textsuperscript{3)} An overall triceps failure rate of 3\% (47 of 1,676 elbows) after TEA has been reported from 35 studies.\textsuperscript{6)} Reconstruction of the triceps is especially difficult in patients with bone defects in the proximal ulna, wherein there is no adequate attachment site for triceps linkage. The majority of other methods of reconstructing the proximal ulna in revision TEA use bone to ligamentous suture for attachment of the triceps.  

In our study, the ulnar stem was firmly fixed and required extended osteotomy for removal. After the osteotomy, major bone loss occurred in the ulna. Considering the bone defect in the ulna and triceps attachment, we considered the ulnar allograft as the first option. However, it was difficult to obtain an ulna allograft that was ipsilateral with a similar size and attached with the triceps. Then, we considered using a cortical iliac crest autograft,\textsuperscript{1)} but the
attachment of the triceps was not adequate. As an alternative to the ulna allograft, we proposed a calcaneus allograft with an Achilles tendon attached to it. Achilles-calcaneus allografts have several advantages. It is familiar to manipulate and easy to obtain due to its use in anterior cruciate ligament reconstruction. Considering its shape and size, it is well matched in any size or any side depending on the design. In addition, because it is mostly composed of cancellous bone, it is expected to be well substituted into the bone. The Achilles tendon attached to the calcaneus allograft works as an anchor for triceps linkage. Recently, Kwon et al\textsuperscript{5} reported 14 cases of reconstruction using Achilles allografts and the keyhole technique in patients with postoperative chronic triceps insufficiency.

In our case, the patient’s pain was relieved to a visual analog scale score of 1 and MEPS of 85 (indicating great functional outcome), Quick DASH score of 11.4. However, the ROM was limited to 25° in extension and 90° in flexion. This may have been caused by extreme tightening in the linkage of the triceps and Achilles tendon, although it was performed in the hyperflexion position of the elbow. We recommend less tightening of the linkage via more hyperflexion of the elbow.

**Conclusion**

We treated a patient with a periprosthetic fracture around a TEA with significant bone loss successfully with an Achilles-calcaneus allograft. The patient showed excellent outcomes in MEPS and Quick DASH scores with a moderate ROM. An Achilles-calcaneus allograft with prosthesis can be a suitable option for revision TEA with major bone defects.
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Figure Legends

Fig. 1) Initial simple radiographs of patient who had undergone total elbow arthroplasty 30 years ago. Preoperative anteroposterior (A) and lateral (B) radiographs show loosening and osteolysis around the humeral stem with periprosthetic fracture. Scanogram of both upper arm (C) showed significant shortening of the left humerus.

Fig. 2) Ulnar stem was inserted into the Achilles-calcaneus allograft in the design of proximal ulna.

Fig. 3) Intraoperative pictures shows fixation of the proximal ulna with locking plate and wire. Bone defect of the distal humerus was filled with autograft from PSIS, one femoral head allograft, and remained calcaneus allograft. The fracture of the humerus was fixed with miniplate.

Fig. 4) Postoperative anteroposterior, lateral, scanogram radiographs show adequate fixation and lengthening of the humerus.

Fig. 5) 9-week follow-up anteroposterior(A), lateral(B) radiographs showed stable fixation of the implants. The patient’s range of motion(C) was 25° of extension and 90° of flexion.

Fig. 6) 5-year follow-up anteroposterior, lateral radiographs showed well healed humerus defect and stable implants.