Technical Note

Outerbridge-Kashiwagi Procedure for the Treatment of a Supracondylar Humerus Fracture Malunion (O-K Procedure)

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Abstract: The Outerbridge-Kashiwagi (O-K) procedure has conventionally been used for the treatment of osteoarthritis of the elbow and to treat posttraumatic sequelae including posttraumatic arthritis, stiffness, contracture, and ulnar neuritis. The procedure involves exposure of the posterior elbow joint as well creating a window posteriorly through the olecranon fossa to target anterior aspects of the elbow. Several case series have shown the O-K procedure to have good functional outcomes with minimal complications. Used mostly for the surgical treatment of adult osteoarthritis, the O-K procedure has not been previously described for the treatment of a pediatric supracondylar humerus fracture malunion. This article and accompanying video will present the pearls and discuss the technique of the O-K procedure used to treat the loss of elbow flexion as a sequelae of supracondylar humerus fracture malunion.

The Outerbridge-Kashiwagi (O-K) procedure was introduced by Kashiwagi in 1978[1] to treat early primary osteoarthritis of the elbow and was first described in the English language literature in 1990 by Stanley and Winson.[2] Osteophyte formation on the olecranon, olecranon fossa, and coronoid can result in impingement and pain. Fenestration of the olecranon fossa allows for removal of loose bodies and osteophytes of both the anterior and posterior compartments of the elbow without extensive soft tissue dissection. In 1992 Morrey[3] described the ulnohumeral arthroplasty, a modification of the O-K procedure that elevates rather than splits the triceps and uses a trephine slightly larger than the olecranon fossa to open the anterior part of the joint.

The O-K procedure has been used with favorable results for primary and posttraumatic osteoarthritis as well as elbow flexion contractures in brachial plexus birth injuries.[1,4-7] However, there is a paucity of literature on the use and outcomes of the O-K procedure for the treatment of the sequelae of supracondylar fracture malunion. This article and accompanying video (Video 1) illustrates our technique for the O-K procedure used to treat the sequelae of loss of elbow flexion due to extension malunion of a supracondylar humerus fracture.

Surgical Technique

Indications and Imaging

The patient was a skeletally mature 12-year-old girl who had sustained a supracondylar humerus fracture

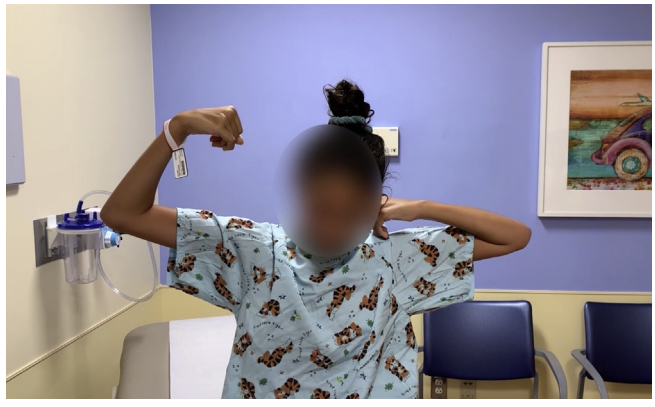

Fig 1. In this preoperative photo, the right elbow has decreased elbow flexion as a sequelae of a supracondylar humerus fracture extension malunion. The right hand is unable to reach the patient's face due to lack of elbow flexion.

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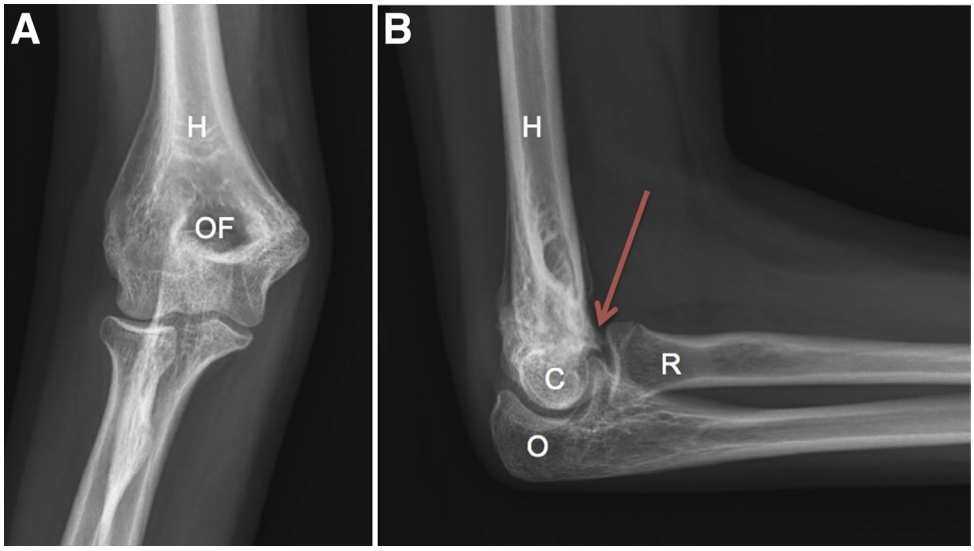

Fig 2. Anteroposterior (A) and lateral (B) radiographs of a right elbow showing extension malunion of the distal humerus with heterotopic bone anteriorly as depicted by the red arrow. (C, capitellum; H, humerus; O, olecranon; OF, olecranon fossa; R, radius.)

2 years before presentation that was treated without surgery and presented with a chief complaint of decreased elbow flexion on the injured side (Fig 1). Plain radiographs reveal extension malunion of the distal humerus with some heterotopic bone anteriorly (Fig 2). Computed tomography scanning with 3-dimensional reconstruction confirms extension malunion with heterotopic bone in the coronoid fossa (Fig 3). A procedure with a quicker recovery as compared with conventional flexion osteotomy was desired, so the decision was made to proceed with an O-K procedure to restore elbow flexion.

Patient Positioning

The patient was positioned supine, and general anesthesia was administered. A hand table was used, and a tourniquet was placed high in the right arm (Fig 4A). The extremity was cleaned, and sterile drapes were placed (Fig 4B).

Exposure

The olecranon, medial and lateral epicondyles, and the proposed incision were outlined (Fig 5A). A 5-cm incision beginning at olecranon and extending proximally was made through skin and curves medial to avoid the olecranon tip. Dissection was carried down the subcutaneous tissues, and small flaps were elevated medially and laterally to expose the triceps tendon (Fig 5B). The tendon was incised longitudinally along its midline, and the deeper soft tissue was elevated off of the distal humerus both medially and laterally to expose the olecranon fossa (Fig 5 C and D). Care was taken to avoid damage to the cartilage.

Bone Excision

A 2-mm drill was used to create circumferential fenestrations in the olecranon fossa to guide a more-precise and -controlled osteotomy (Fig 6A). The use of burs to create a window was avoided to decrease the theoretical risk of heterotopic bone formation. Next, an osteotome and mallet was used to complete the osteotomy of the olecranon fossa (Fig 6B). A mixture of

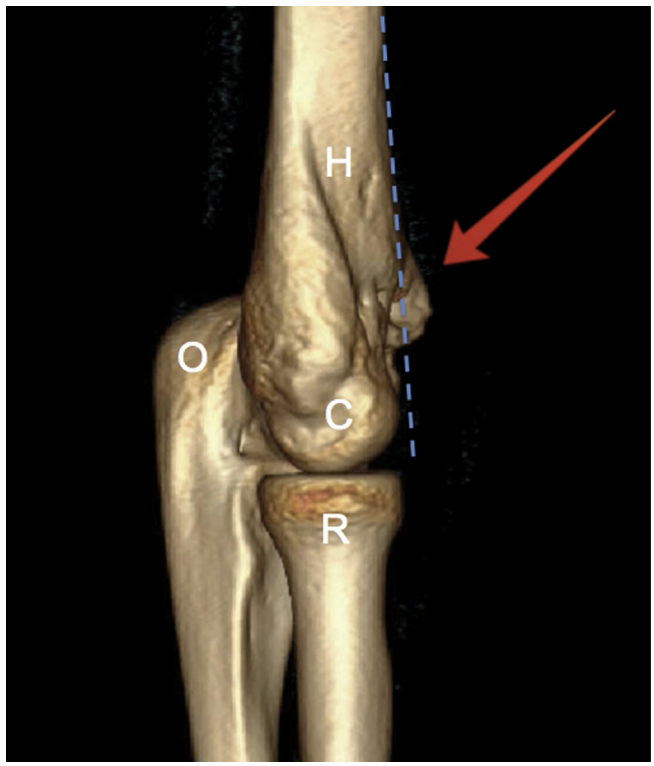

Fig 3. Computed tomography scan with 3-dimensional reconstruction of a right elbow showing extension malunion of the distal humerus with heterotopic bone in the coronoid fossa (red arrow), which is likely limiting elbow flexion. The dashed blue line represents the anterior humeral line. (H, humerus; O, olecranon; C, capitellum; R, radius).

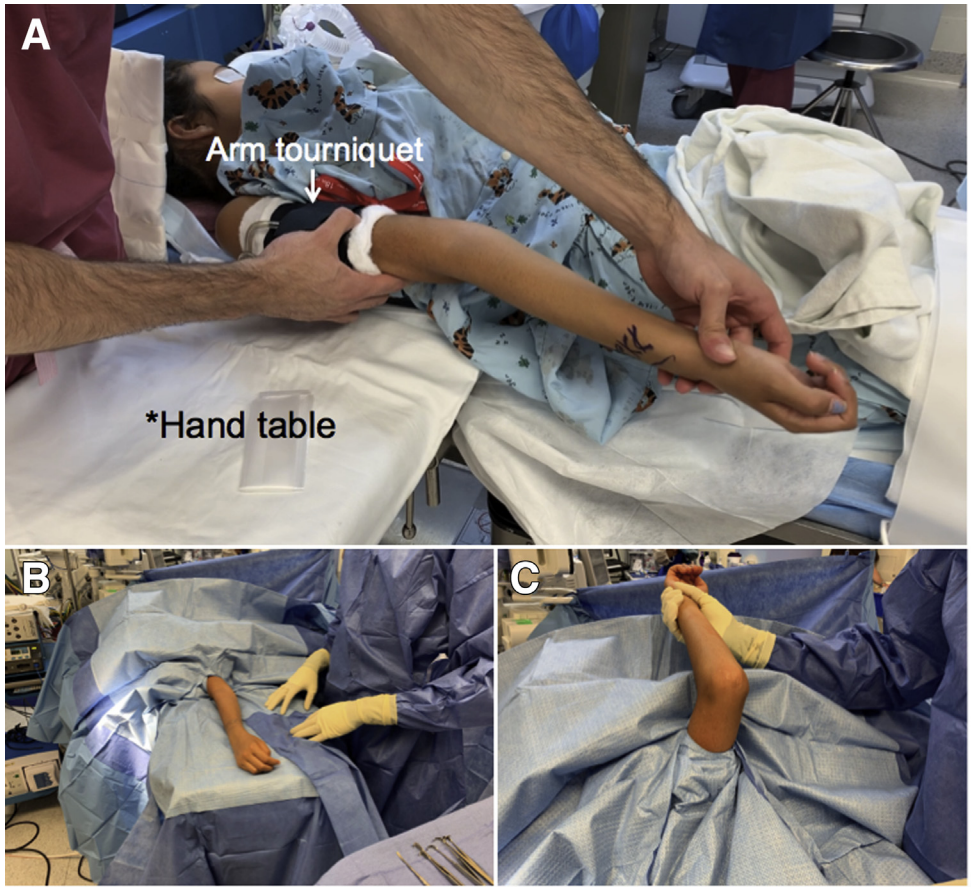

Fig 4. Patient is placed supine and the right upper extremity is placed over a hand table. (A) A tourniquet is placed high in the arm. (B) The right upper extremity is cleaned, and sterile drapes are placed. (C) The assistant helps to flex and adduct the arm over the patient's chest to facilitate exposure of the posterior distal humerus.

rongeurs, clamps, and curettes was used to deliver the excised bone out of the window (Fig 6C). Once adequately decompressed anteriorly, the elbow was gently manipulated in flexion to assess the increase in range of motion. The elbow now was able to flex beyond 130° of flexion, and the hand was able to reach the patient's face (Fig 6D). Before wound closure, intraoperative fluoroscopy was used to confirm adequate decompression and to ensure no iatrogenic fractures were created.

Closure

After wound irrigation, the wound was closed in layers. The triceps tendon was closed with absorbable suture with the elbow held in 90° of flexion to prevent over tensioning of the triceps leading to extension of the elbow. The deep dermal layer was closed with buried interrupted suture, and the skin was closed with a running absorbable subcuticular suture. A sterile soft dressing was applied to allow for immediate range of motion.

Postoperative Rehabilitation

Immediate range of motion was allowed after surgery for daily activities. Formal physical therapy for range of motion exercises was begun by 2 weeks after surgery to allow for initial wound healing.

Discussion

Supracondylar humerus fractures are the most common elbow fracture in children and most often occur between 5 and 7 years of age on the nondominant elbow.[8] The most common complications of supracondylar fracture and its treatment include vascular injury, compartment syndrome, neurologic deficit, pin site infections, and cubitus varus.[9] Malunion has been identified as the cause of most angular deformities, and modern surgical techniques have vastly reduced their incidence.[10] However, malunion can still be frequently observed after conservative treatment or malreduction after closed reduction and percutaneous pinning. Whereas the most common type of deformity resulting from malreduction involves cubitus varus and hyperextension, isolated distal humeral extension-type malunions are still encountered, as in this case.[11] Although it has been shown that remodeling of sagittal plane deformities can occur, most extension type malunions result in clinically significant limitations in elbow flexion at skeletal maturity.[11] Surgical correction is therefore

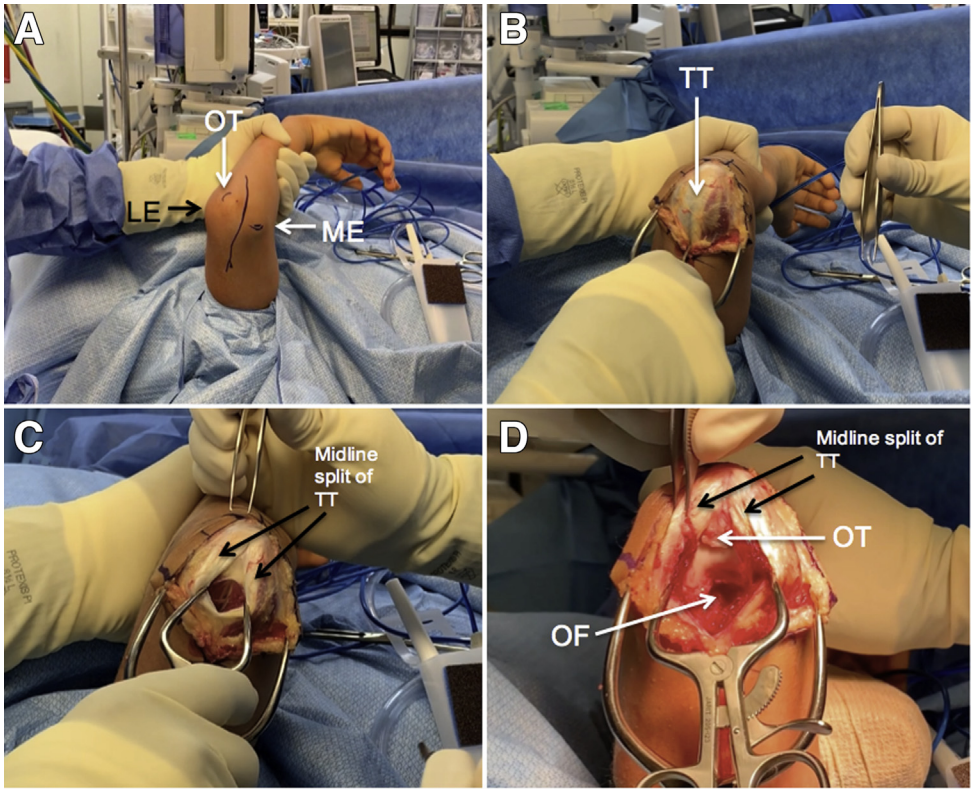

Fig 5. Patient is positioned supine with the posterior aspect of the right elbow being shown. Bony landmarks such as the olecranon, medial and lateral epicondyles, and the proposed skin incision are outlined on the skin (A). Skin incision is made, and dissection proceeds through the subcutaneous tissues as small flaps are elevated medially and laterally to expose the triceps tendon (B). The triceps tendon is incised longitudinally along its midline (C). Deeper soft tissues are elevated from the humerus medially and laterally to expose the olecranon fossa (D). Care is taken to avoid injury to the cartilage. (LE, lateral epicondyle; ME, medial epicondyle; OF, olecranon fossa; OT, olecranon tip; TT, triceps tendon.)

recommended in patients with these malunions who report functional limitations. Numerous osteotomy techniques have been described, most of which focus on realignment in the coronal and sagittal planes.[12]

Complications for traditional corrective osteotomies are reported in the literature to be as high as 50%.[13] Reported complications include ulnar-nerve palsy, hematoma, cosmetically unacceptable scarring,

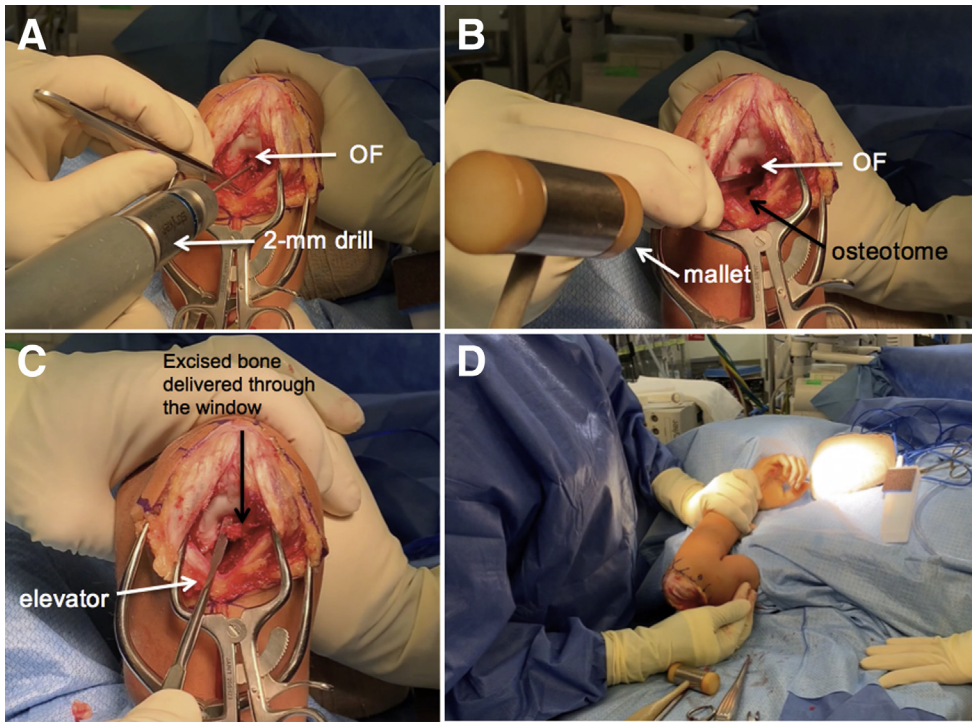

Fig 6. Patient is positioned supine with the posterior aspect of the right elbow exposed. A 2-mm drill is used to create fenestrations circumferentially around the olecranon fossa to order to create a precise, controlled, and safe osteotomy (A). An osteotome and mallet is used to complete the osteotomy (B). A mixture of rongeurs, elevators, and curettes is used to deliver the excised bone out of the window (C). Once adequately decompressed anteriorly, the elbow is gently manipulated in flexion to assess the increase in range of motion. The elbow now is able to flex beyond 130° of flexion and the hand is able to reach the patient's face (D). (OF, olecranon fossa.)

Table 1. Advantages and Disadvantages of the Outerbridge-Kashiwagi Procedure

Advantages
• The O-K procedure is less time consuming and technically less demanding than corrective osteotomies for supracondylar malunions.
• Less exposure to x-ray radiation with the O-K procedure compared with corrective osteotomies.
• No immobilization or weight bearing restrictions are required for the O-K procedure after surgery.
• The procedure has good clinical outcomes with minimal complications.
• In case the desired range motion is not achieved after decompression with the O-K procedure and adequate physical therapy, a corrective osteotomy can be still be done at another time.
Disadvantages
• May not be able to achieve desired level range of motion with the O-K procedure compared with a corrective osteotomy for a supracondylar malunion depending on malunion characteristics.
• The O-K procedure can be performed to regain range of motion when there is a bony block restricting motion and cannot be applied to all supracondylar malunions.
• Obviously the O-K procedure cannot correct deformity in any plane for supracondylar malunions.

O-K, Outerbridge-Kashiwagi.

measurable arm atrophy, and loss of correction.[13,14] The use of the O-K procedure as an alternative to a corrective flexion osteotomy may therefore be favorable due to the low incidence of reported complications and high satisfaction.[4-7] It is important to keep in mind that the O-K procedure can be successful in removing heterotopic bone that is contributing to mechanical block and loss of range of motion but will not correct a deformity. Historically, the success rates for the O-K procedure for symptomatic osteoarthritis have been 74% to 88%.[15] An early series of O-K procedures performed by Antuña et al.[7] for this indication found that 45 patients had mean improvements in the Mayo Elbow Performance Score from 55 points before surgery to 83 points ($P < .0001$) at latest follow-up in addition to an increase in the mean arc of flexion-extension from 79° to 101° ($P < .0001$) at latest follow-up. The O-K procedure has also been shown to have favorable outcomes when performed for other indications. More recently, Brewley et al.[4] reported on their series of 21 patients undergoing the O-K procedure for posttraumatic elbow sequelae and found mean improvements in the Mayo Elbow Performance Score from 52 to 84 ($P < .0001$) and an increase in mean arc of motion from 44° to 98° ($P < .0001$) at a mean of 39 months after surgery. The O-K procedure also allows for a quicker recovery time and earlier postoperative range of motion than does a formal corrective osteotomy. In conclusion, the O-K procedure may be a useful alternative in select patients for the treatment of supracondylar malunions resulting in loss of range of motion. Tables 1 and 2 depict the advantages and disadvantages, and the pearls and potential pitfalls, respectively, of the O-K procedure compared with corrective osteotomies for the treatment of supracondylar humerus fracture malunions.

Table 2. Pearls and Potential Pitfalls of the Outerbridge-Kashiwagi Procedure

Pearls
• We avoid the use of burs for creation of the osteotomy to decrease the theoretical risk of heterotopic bone formation.
• Fenestration of the olecranon fossa with a drill followed by excision bone with a mallet results in a controlled, safe, and precise osteotomy.
• If positioning the patient supine, an assistant is needed to help position the limb during the procedure. If there are no assistants available to the surgeon, consider positioning the patient in the lateral decubitus position along with the use of a padded Mayo stand.
• The triceps tendon is closed with the elbow held in 90° to avoid over tensioning of the triceps which may lead to elbow extension.
• A soft dressing is used after surgery to allow for immediate range of motion.
Potential Pitfalls
• Avoid making skin incision directly posterior and over the olecranon tip. Incision curves slightly medial to avoid the olecranon tip.
• Avoid being too medial with the skin incision and do not penetrate too deeply with the scalpel medial to the olecranon because the ulnar nerve is in close proximity.
• Avoid damage to the cartilage when elevating soft tissue off of the posterior distal humerus.
• Consider ulnar nerve transposition when treating and correcting excessive elbow contractures.

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