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Use of a modified Outerbridge-Kashiwagi procedure for the treatment of posttraumatic elbow sequelae

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Background: To review our 10-year experience treating posttraumatic sequelae of the elbow using a modified Outerbridge-Kashiwagi (O-K) procedure.
Methods: Twenty-one patients with posttraumatic sequelae of the elbow treated using the technique were evaluated clinically using the Mayo Elbow Performance Score, range of motion testing, and pain level. We noted the presence of preoperative and postoperative ulnar nerve symptoms, complications, and reoperations. Open contracture release was selected to address either removal of hardware or ulnar nerve pathology.
Results: At a mean of 39 months (range, 12-116 months), the Mayo Elbow Performance Score improved from 52 to 84 ($P < .0001$) and the mean arc of motion improved from 44° to 98° ($P < .0001$). At the final follow-up, 90% of patients reported no pain or mild pain, and 81% of patients had a satisfactory objective result. In 15 of 21 cases (71%), it was necessary to mobilize the ulnar nerve. After contracture release, 1 patient developed new onset ulnar nerve symptoms. Three patients underwent reoperation: 2 for recalcitrant contracture and 1 for new onset ulnar nerve symptoms.
Conclusions: The mini-open O-K procedure is safe and effective in restoring function in patients with retained hardware and posttraumatic contracture. Posttraumatic arthritic patients often require both removal of hardware and neurolysis of the ulnar nerve. The mini-open O-K procedure allows complete access to the elbow joint, which facilitates release for both intrinsic and extrinsic contracture.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Outerbridge-Kashiwagi; posttraumatic elbow sequelae; open elbow arthrolysis; ulnar nerve; contracture release

Painful stiffness of the elbow resulting from posttraumatic sequelae may be treated surgically when conservative measures fail. Many procedures have been described, including open or arthroscopic débridement and capsular release.[1,2,5-8,10,11,13-17,21,25-30,32,33,36,38,42,43,49-54] Vardakas et al[51] described the causes of elbow stiffness

This investigation was performed at the Florida Orthopaedic Institute and the Foundation for Orthopaedic Research and Education, Tampa, FL, USA. This study was determined to be exempt from review by the Western Institutional Review Board (WIRB).

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as being related to causative factors that are either intrinsic, extrinsic, or a combination of both. Intrinsic stiffness of the elbow often results from primary osteoarthritis (OA) and may be effectively treated using an all-arthroscopic approach. Extrinsic stiffness often results from elbow trauma, and the necessity of addressing painful hardware and ulnar nerve symptoms makes open surgery appealing. The combination of intrinsic and extrinsic stiffness may in fact be more common than both entities alone, and treatment preferences among surgeons vary widely.[18,37]

In appropriately selected posttraumatic cases, we prefer a limited open approach for the treatment of combined intrinsic and extrinsic elbow stiffness because of its simplicity, effectiveness, and ease of visualization and access. The Outerbridge-Kashiwagi (O-K) procedure was originally described in 1978 as a way to treat primary OA involving the anterior and posterior elbow through a single posterior incision with fenestration of the olecranon fossa to improve motion and allow access to the anterior joint.[19] Modern advances in surgical techniques have made it possible for this procedure to be performed using a mini-open technique. The O-K procedure has a few advantages over arthroscopic treatment particularly in patients with posttraumatic sequelae who often may require removal of hardware for alleviation of symptoms and improvement of function. In addition, with combined symptoms of ulnar neuropathy, the O-K procedure allows for safe assessment and ease of exploration in the treatment of arthritis while protecting a potentially transposed nerve that me be at risk with an arthroscopic procedure.

Favorable results have been reported in treating primary elbow OA using the O-K procedure.[2,19] In the setting of posttraumatic sequelae, there is a paucity of literature regarding results and outcomes of the O-K procedure.

We have performed a retrospective review of our results treating posttraumatic elbow sequelae using the mini-open O-K procedure. The purpose of this report is to describe our technique and report our results.

Materials and methods

We retrospectively reviewed the medical records of all patients who had undergone open excision of bone and soft tissue around the elbow performed by the senior author (CPT code 24149) between 2004 and 2014. A total of 151 procedures were performed, which included both arthroscopic and open releases for painful elbow stiffness. Inclusion criteria were patients over the age of 18 who underwent the mini-open O-K procedure for the treatment of posttraumatic sequelae (pain, arthritis, stiffness, contracture, and ulnar neuritis) with a minimum of 12 months of follow-up. Exclusion criteria included patients under 18 years of age, those with inflammatory arthritis, OA, and patients who underwent arthroscopy as part of their index procedure. In addition, patients with severe anterior compartment pathology such as large anterior osteophytes blocking the mechanical range of motion, radiocapitellar arthrosis, and heterotopic ossification of the anterior structures as part of their index procedure. Twenty-one patients met inclusion criteria with the diagnosis of posttraumatic elbow sequelae who had undergone the O-K procedure. Patients were treated using a mini-open technique developed by the senior author as a modification of the originally described O-K technique.[19,34,41] Posterior exposure is enhanced by elevation of the triceps from the humerus, which is often scarred down in cases of distal humeral fractures.[3,44,47] The mean age of the patient population was 41 years, and the patient group included 10 males and 11 females.

The injuries leading to posttraumatic sequelae included 9 distal humerus fractures, 7 olecranon fractures, 4 radial head fractures, and 1 coronoid fracture (Table I). The mean time between injury and surgical treatment using the mini-open O-K procedure was 13 months, and all fractures had united by the time of surgery. Seventeen patients underwent prior surgery for fracture fixation, and 6 patients presented with persistent ulnar nerve symptoms. In addition, 12 of the 17 patients required hardware removal. Of the 12 patients who received removal of the hardware, only 5 required extension of the approach to facilitate mechanical impediments to débridement or range of motion of the elbow.

Patients were evaluated radiographically by the senior author before surgery using standard anteroposterior and lateral views of the elbow (Fig. 1). To comment on the severity of arthritis treated, 2 authors graded the preoperative radiographs using the systems described by Rettig et al[41] and Forster et al.[12] The system of Rettig describes the location of arthritic changes within the elbow with attention to the natural tendency for changes to appear earlier or later in characteristic areas, whereas the system of Forster assigns points based on severity of arthritis in several areas of the elbow. Both systems assign higher numbers (I-III in Rettig, and 0-9 in Forster) for more severe arthritis. However, because of the complex nature, variability, and mechanism of the original elbow trauma, it is often difficult to classify posttraumatic elbows in these radiographic classification schemes.

Operative technique

The mini-open O-K procedure is performed with the patient in the lateral position with the arm over a padded post. A sterile tourniquet is placed in all cases. A 4-cm incision of the skin is placed slightly medial to midline, allowing the surgeon access to the ulnar groove. The incision may be extended as necessary to facilitate subsequent removal of hardware. When possible, previous surgical incisions are incorporated, which is often the case in patients who have undergone internal fixation of olecranon or distal humeral fractures. The triceps tendon is then split in line with its fibers, and a periosteal elevator is used to free the triceps tendon from the posterior capsule and posterior humeral shaft (Fig. 2). This maneuver improves motion and provides adequate exposure for removal of hardware.

In patients with pre-existing ulnar neuritis and in all those with less than 90° of preoperative flexion, the nerve is routinely released. Given the difficulty of hardware removal, the ulnar nerve is often adherent to the plate that requires extensive neurolysis to mobilize the nerve. If the condition of the ulnar nerve is at all in doubt before surgery, it should be explored.

To safely expose the ulnar nerve, it is located proximal to the cubital tunnel preferably in an area outside of the scar bed. The posterior band of the medial collateral ligament (MCL) often

Table I Injury and complication data for each patient in our series

Patient	Age	Sex	Injury	Complication
1	35	F	Supracondylar humerus fracture	Elbow stiffness that required manipulation under anesthesia
2	34	F	Olecranon fracture	Ulnar neuritis
3	36	M	Distal humerus fracture	Ulnar neuritis
4	55	F	Distal humerus fracture	Ulnar neuritis
5	40	M	Coronoid fracture dislocation	Repeat debridement for pain
6	35	M	Soft-tissue injury	
7	30	F	Distal humerus fracture	
8	39	M	Olecranon and epicondyle fracture	
9	50	F	Distal humerus fracture	
10	56	F	Distal humerus fracture	
11	38	M	Distal humerus fracture	
12	21	M	Distal humerus, radial head, and proximal ulnar fracture	
13	30	F	Lateral condyle fracture	
14	38	M	Olecranon fracture	
15	51	M	Olecranon and proximal radius fracture	
16	65	F	Olecranon and radial head fracture	
17	68	F	Open olecranon fracture	
18	27	F	Radial head and ulnar fracture dislocation	
19	56	M	Olecranon fracture	
20	36	F	Soft-tissue injury	
21	26	F	Distal humerus fracture	

contributes to painful flexion contracture of the elbow and is difficult to release either open or arthroscopically if the nerve is not mobilized. We feel that releasing the posterior band of the MCL is crucial to allow for improved flexion.[45]

A posterior capsulectomy can be performed through the triceps split. We osteotomized the tip of the olecranon, as described in the original technique by Kashiwagi.[19] With the olecranon fossa exposed, all loose bodies and contracted capsule are removed. Medial and lateral soft tissue releases are then performed. The floor of the olecranon fossa is identified, and a high-speed burr is used to create an elliptical window (Fig. 3). In smaller humeri, extra care is taken to avoid over-resection of bone from the medial column, which is usually thinner than the lateral column and may be prone to fracture. Kerrison rongeurs are useful to complete the elliptical window anteriorly by removing residual osteophyte from the coronoid fossa. The coronoid process can be visualized through the elliptical window by maximally flexing the elbow. A small osteotome can be inserted through this window to remove the tip of the coronoid. The anterior capsule is stripped and released with a curved curette, and any loose bodies in the anterior compartment of the elbow may be removed through the window.

The elbow is manipulated through a short lever arm after all releases have been performed. It is only at this point that hardware is removed so as to minimize the risk of iatrogenic fracture. Instability is tested at maximum extension and supination, and valgus instability is tested at 30° of flexion and maximal pronation. The tourniquet is deflated, and hemostasis is achieved before wound closure. We prefer to wash with betadine and saline, and to introduce 1 g of vancomycin powder to the surgical site. Drains were placed before closure. The senior author experiences lower rates of postoperative effusion and hematoma with the use of both perioperative transexamic acid and placement of drains. Following the procedure, the patient is held in extension with an anteriorly based splint. The splint is removed at 7-10 days postoperatively, and early passive range of motion is encouraged, as well as night splinting on a case-by-case basis after discussion with the senior author and occupational therapist.

Patient assessment and statistical analysis

Patients were evaluated clinically using the Mayo Elbow Performance Score (MEPS) and range-of-motion testing at all postoperative visits. Pain was assessed as mild, moderate, or severe. The presence of preoperative and postoperative ulnar nerve symptoms, complications, and reoperations was also noted. Averages and standard deviations were calculated for continuous variables, and percentages were calculated for categorical variables. Nonparametric statistics were used to evaluate perioperative variables with significance set at .05.

Results

During the study period, 21 patients with posttraumatic sequelae underwent the O-K procedure performed by a single orthopedic surgeon at our institution. The mean age of patients at the time of the procedure was 41 ± 13 years (range, 21-68 years). Additional demographic data are contained within Table II. At a mean follow-up of 39 months (range, 12-116 months), significant improvements were made in range of motion, function, and pain relief after surgery performed for arthritis that was moderate to severe (Rettig class II, Forster grade 4).

The mean MEPS significantly improved from 52 to 84 points at the final follow-up ($P < .0001$). The result was excellent for 8, good for 9, fair for 2, and poor for 2,

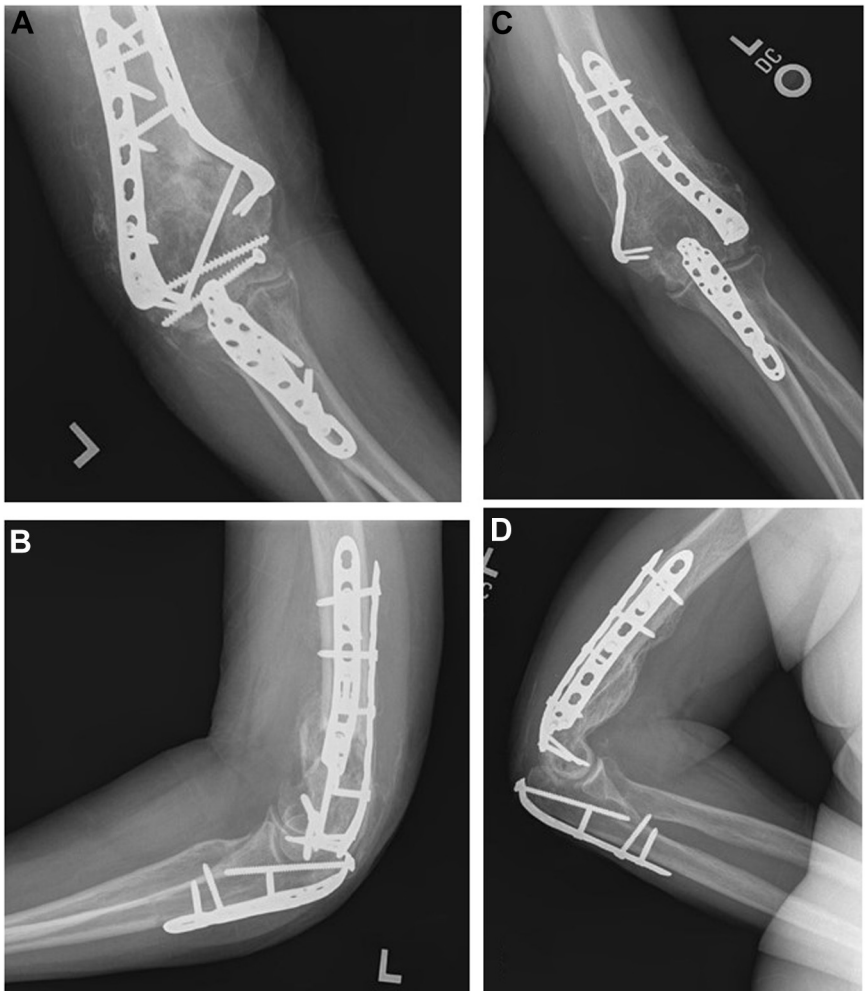

Figure 1 A 55-year-old woman with posttraumatic elbow arthritis secondary to a bicondylar distal humerus fracture. (**A**) Preoperative anterior-posterior radiograph, (**B**) lateral preoperative radiograph, (**C**) postoperative anterior-posterior radiograph, and (**D**) postoperative lateral radiograph.

making the proportion of good and excellent results 81% for our study group. The improvement in arc of motion was significant (44° to 98°; $P < .0001$). Flexion improved from 92° to 112° ($P = .002$), and extension from 49° to 14° ($P < .0001$) (Table III).

The mean gain in the total arc of motion at the final follow-up was 54° (range, −15° to 125°). The total arc of motion improved in 18 patients and decreased in 3 patients. Of the 18 patients, 11 achieved a functional arc of motion of at least 100°. At the final follow-up, 19 patients (90%) reported either no pain or mild pain of the elbow. In 6 elbows, olecranon fossa fenestration consolidated and therefore did not remain patent. In this subset of patients, the final improvements in range of motion did not differ from the remainder of the cohort.

Complications and revisions

Six patients demonstrated significant preoperative ulnar nerve irritation symptoms via physical examination. A total of 15 patients underwent decompression of the ulnar nerve, including all 6 of the patients with preoperative complaints. Of the 6 patients with preoperative symptoms, 5 experienced resolution of their symptoms by the time of the final follow-up. Two patients developed new onset ulnar neuropathy after contracture release. One patient remained satisfied with the results of the surgery and the ulnar symptoms gradually resolved. In the second case, the patient remained dissatisfied and required reoperation. In addition, 3 patients required reoperation. Patients did not achieve a functional arc of motion in 2 cases and required reoperation because of residual contracture. In a third case, the patient developed new onset ulnar neuropathy with diminished grip strength.

One patient with posttraumatic contracture subsequent to a fracture of the olecranon underwent the O-K procedure. His pain improved, and range of motion increased during the first year; however, over time the contracture recurred. Three years after contracture release, this patient struggled with pain and loss of a functional arc of motion

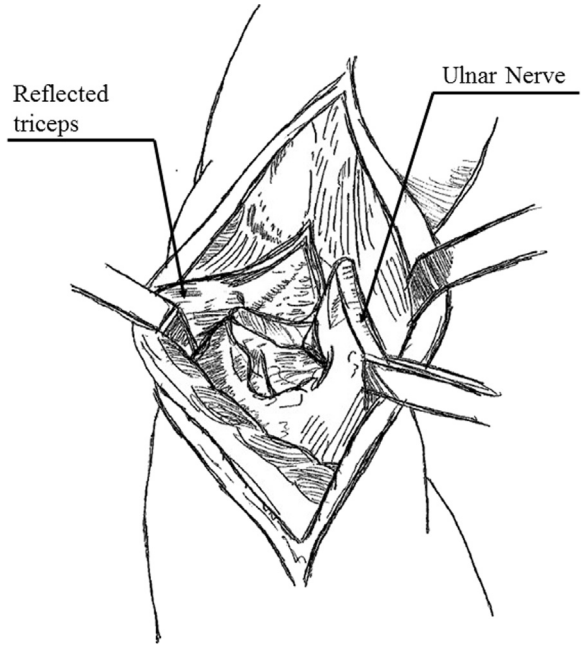

Figure 2 Line drawing of the posterior approach to the elbow for access to the olecranon fossa during the mini-open Outerbridge-Kashiwagi procedure.

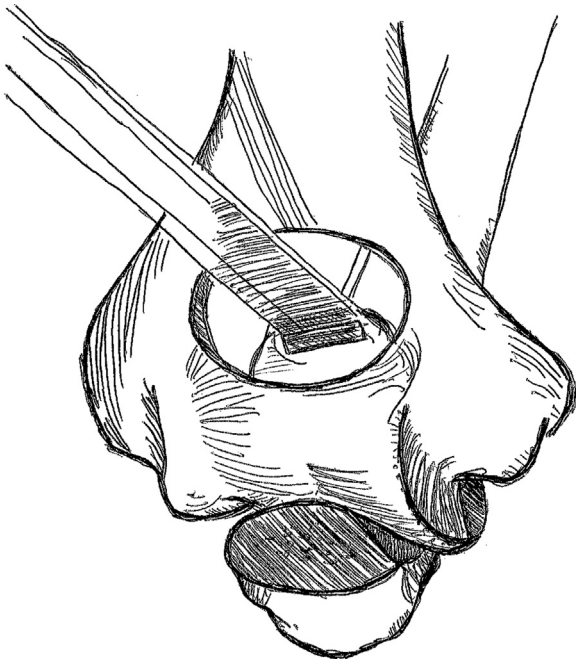

Figure 3 Line drawing of the elliptical window in the olecranon fossa for access to the anterior compartment.

and ultimately was taken back to surgery for a subsequent capsular release. Unfortunately, this operation failed to resolve his complaints.

The second patient who failed to achieve improvement after contracture release had initially sustained a fracture dislocation of his elbow. Following the O-K procedure, he saw a dramatic reduction of his pain and improved range of motion. He was content with the results of this procedure for 2 years, but then developed the insidious onset of pain and motion loss. A second contracture release was performed. At the time of the most recent follow-up, the patient remains satisfied and pain free.

A third patient underwent mobilization of the ulnar nerve to remove symptomatic hardware. Despite mild improvement, the patient remained dissatisfied with his clinical result, and nerve conduction studies revealed moderate ulnar neuropathy and decreased conduction velocity. The decision was made to return to the operating room for ulnar neurolysis. Operative findings included hypertrophic scarring with fibrosis, and the nerve was found encased in scar tissue. The nerve was released and transposed into the anterior compartment. After surgery, strength returned with only slight residual numbness in the ulnar nerve distribution, to the satisfaction of the patient.

Table II Demographic data

Age at surgery	41.2 ± 13
Gender (female %)	52
Months of follow-up	38.6 ± 29.7

Discussion

Posttraumatic sequela with resultant loss of motion of the elbow is a difficult problem to treat. It commonly affects younger active patients during their most productive years. Despite advancements in internal fixation of elbow fractures, a high rate of complications and loss of motion lead to compromised function.[3,44,47] The etiology of posttraumatic stiffness is multifactorial to include arthritis, heterotopic ossification, nonunions, malunions, and scar tissue. Morrey[37] described a system for elbow stiffness that is based on the anatomic location of the contracture and classified as either extrinsic, intrinsic, or mixed etiologies. Intrinsic stiffness is attributed to intra-articular pathology, including loss of bony articular congruence, adhesions, impingement, articular cartilage degeneration, or a multifaceted cause. Extrinsic stiffness is largely associated with the contracture of local extra-articular soft tissue.[38] The posttraumatic elbow encompasses both intrinsic and extrinsic contracture making its treatment more complex.

In this series, we present our outcomes using a mini-open approach for elbow contracture release. This approach to the posterior elbow is extensile and allows access to both the medial and lateral gutters, as well as the tip of the coronoid and anterior capsule using a fenestration of the olecranon fossa.[20] A posterior triceps-splitting technique ensures that many of the important neurovascular structures remain out of

Table III Preoperative and postoperative outcomes

	Preop	Postop	Wilcoxon signed ranks test
Flexion	92 ± 19	112 ± 21	0.002
Extension	49 ± 27	14 ± 15	<0.0001
Arc of motion	44 ± 34	98 ± 29	<0.0001
MEPS pain	20.7 ± 10.0	35.7 ± 10.0	<0.001
MEPS motion	9.0 ± 5.4	17.1 ± 3.7	<0.0001
MEPS stability	9.8 ± 1.1	10.0 ± 0.0	0.317
MEPS function	12.4 ± 6.0	21.4 ± 5.7	<0.0001
MEPS total	51.9 ± 13.7	84.3 ± 15.0	<0.0001

MEPS, Mayo Elbow Performance Score.

the surgical field, thus making the mini-open O-K procedure appealing to surgeons. A subset of patients with posttraumatic contractures of the elbow may also present with painful symptomatic hardware or symptoms of ulnar neuritis. Using a mini-open technique has the advantage of being able to remove symptomatic hardware and perform neurolysis of the ulnar nerve. In our experience, the mobilization of the ulnar nerve facilitates release of the posterior band of the MCL that allows for a greater degree of flexion.[43] This procedure is well tolerated by patients and leads to predictable gains in elbow range of motion.

Historical outcomes of the O-K procedure for OA of the elbow generally have been very good. In 1985, Minami and Ishii[34] found that 55% of patients had little or no pain at the final follow-up. Ten years after his original paper, he published his long-term results showing only a 10% deterioration in outcomes compared with his short-term results.[35] In another outcome study, Antuña et al[2] followed 46 patients for a mean of 80 months and found that 74% had satisfactory objective results and 75% had mild pain or no pain at all. Raval et al[40] reported excellent pain relief in 85% of patients. We believe our study to be unique as to the best of our knowledge, ours is the first description of the results of the O-K procedure for patients specifically with posttraumatic sequelae of the elbow.

Our results of the O-K procedure for the treatment of posttraumatic sequelae of the elbow are consistent with the literature for patients treated with open débridement for both primary and posttraumatic sequelae. Egol et al[15] evaluated outcomes of open surgical release after posttraumatic elbow contracture in 103 patients. They used a lateral column, medial, or combined release via a posterior approach. The mean age of patients at the time of contracture release was 45.2 ± 15.6 years (range, 19-81 years). They reported an increase of 52° to the mean arc of motion. Similarly, Wang et al[54] reported an improvement in the mean arc of motion of 73°. Wada et al[53] reported on outcomes at an average of 10 years after open osteocapsular débridement in patients with primary OA. They found that the mean preoperative limitation of extension of 31° was reduced to 24°, and the mean preoperative flexion of 101° improved to 118° ($P < .001$). In addition, the mean arc of movement was found to improve by 24°. We found the mean preoperative limitation of extension to be reduced from 49° to 14° ($P < .0001$). Furthermore, our mean preoperative flexion of 92° improved to 112° ($P = .002$). The improvement in total arc of motion in our series was 54°.

With our technique, we are able to access the medial and lateral columns as well as the anterior structures of the elbow. In our experience, functional gains are similar to those obtained by authors who employ other open techniques.[2,35,40,45,46]

We feel that the modified O-K procedure can be a very useful tool to decrease pain and improve range of motion in patients who have failed conservative management of posttraumatic sequelae. However, there are instances in which other surgical treatments may be preferred instead. During the study period between 2004 and 2014, the senior author performed more arthroscopic elbow débridements than open elbow débridement surgeries, including the mini-open O-K procedure. Circumstances in which an arthroscopic débridement would be favored over an open approach could include etiologies that are intrinsic by nature, such as capsular and intra-articular fibrosis, adhesions, and small loose bodies.

Arthroscopy of the elbow has been shown to be a safe and appropriate procedure for contracture release.[4,39,48] However, there are circumstances when an arthroscopic approach to elbow contracture release is either contraindicated or has disadvantages compared with an open technique. Ankylosis of the elbow, which makes entry into and subsequent distention of the joint very difficult, active infection of any of planned portal sites, and previous history of transposition of the ulnar nerve, placing it at high risks for injury during portal placement, are several examples of cases where arthroscopy would not be feasible for contracture release.[4]

Although results of open and arthroscopic osteocapsular débridement have been described with primary OA,[2,21,28,49,53] there is a paucity of outcome studies evaluating open techniques in patients with posttraumatic sequelae.[10,32] Cohen et al[9] compared the OK procedure with an arthroscopic débridement and olecranon fossa fenestration. They found that both open and arthroscopic

débridement are effective in treatment of primary OA and posttraumatic sequelae. No difference was found between the procedures in terms of patient-perceived overall effectiveness of the surgery. However, patients treated by arthroscopic débridement achieved better pain relief ($P < .10$), whereas patients who underwent the O-K procedure achieved significantly greater improvement in range of flexion ($P < .05$). DeGreef et al[27] found comparable results between the arthroscopic and open procedure. The O-K procedure can be a useful technique in carefully selected cases of combined intrinsic and extrinsic elbow arthritis that cannot be adequately treated with arthroscopy. Our series showed statistically significant improvements in both objective clinical outcome measure (MEPS, 32 points $<.0001$) and total arc of motion (55°, −15° to 125° $<.0001$) similar to those reported in patients with primary and posttraumatic elbow sequelae treated surgically.[22-24,31]

The limitations of the current study include its retrospective nature, and lack of direct comparison with another technique. However, we feel that the comprehensive patient database at our institution provides an excellent resource to study a technique we have used to treat a relatively uncommon problem that significantly diminishes the function of a young and active group of patients. Despite the variability of pathology and severity in posttraumatic cases, it is evident that the O-K procedure can reliably improve function and range of motion. The senior author's modifications of the O-K procedure, which include a smaller incision, the release of the posterior band of the MCL, a more physiologic elliptical fenestration, and improved instrumentation, have made it less invasive and more appealing to patients and surgeons. These changes have not impacted the significant pain relief and improvement in motion described by earlier reports. The procedure is safe and straightforward, and tourniquet time is usually less than 1 hour. It provides a solution for surgeons who prefer an open approach, rather than arthroscopy, especially in posttraumatic cases when open surgery must be undertaken for hardware removal or ulnar nerve decompression. The modified O-K procedure allows access to the olecranon fossa, anterior capsule, medial, and lateral gutters in a relatively safe manner.

Conclusion

The modified O-K procedure is a safe and effective surgical procedure for addressing both intrinsic and extrinsic causes of elbow stiffness in patients with posttraumatic sequelae. Clinical results gained in this population have been comparable with those achieved in the literature via arthroscopic methods. In addition to capsular releases for gains in range of motion and functional improvement, hardware and neurolysis can be performed concomitantly pain and neuropathic symptomatology. The versatility of this procedure to address multiple pathological processes in the posttraumatic elbow makes it a useful technique in a surgeon's armamentarium and should be considered for the right patient.

Disclaimer

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