Soft Tissue Constraint Injuries in Complex Elbow Instability: Surgical Techniques and Clinical Outcomes

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**abstract**

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The surgical procedures for and outcomes of soft tissue constraint reconstruction in complex elbow instability have been rarely investigated. The purpose of this study was to analyze the clinical outcomes in a series of patients with complex elbow instability in whom the associated soft tissue constraint injuries were identified and treated based on the pathoanatomic changes found intraoperatively. Forty-five patients (23 men and 22 women; mean age, 54 years) with complex elbow instability were followed prospectively. Surgical treatment included the anatomic reduction and internal fixation of any fracture and radial head replacement in Mason type III injuries. Soft tissue constraint lesions were then repaired based on the type of lesion (eg, proximal or distal ligament avulsion, middle-zone lesion, or presence of detached bony fragments). Posterolateral capsular lesions and common extensor and flexor origin injuries were also repaired. Patients were followed clinically and radiographically after a mean of 25 months. Functional range of motion was achieved in 39 (86%) patients. Average Mayo Elbow Performance Score; Disabilities of the Arm, Shoulder and Hand score; and American Shoulder and Elbow Surgeons shoulder score were 94, 5.6, and 89, respectively. At last follow-up, 42 (93%) patients showed no evidence of elbow instability, 2 (4%) patients had mild varus instability, and 1 (2%) patient had moderate posterolateral instability. The accurate identification of pathoanatomic changes of elbow soft tissue constraint lesions associated with complex elbow instability is an essential prerequisite to planning proper surgical treatment. The results of this study show that, in patients with complex elbow instability, once the fracture has been treated and each type of soft tissue constraint lesion adequately repaired, a high percentage of satisfactory functional outcomes may be achieved.

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Figure: Three-dimensional computed tomography reconstruction showing a bone avulsion of the supinator crest (arrowhead) in a patient with a terrible triad (A). Postoperative lateral radiograph showing bone fragment fixation with 2 suture anchors (B).
The identification and treatment of elbow capsule-ligamentous and muscle-tendinous injuries are essential steps in the treatment of complex elbow instability because the presence of soft tissue constraint lesions may affect the surgical approach, type of ligament repair, and rehabilitation protocols. Although several studies have reported ligament reconstruction techniques in chronic elbow instability, little is known about the surgical techniques to be used and clinical results in patients with acute soft tissue constraint injuries. In a previous report on patients operated on for complex elbow instability, associated soft tissue constraint lesions were found in 96% of patients. The pathoanatomic features of ligament lesions were documented using the elbow soft tissue constraint injury classification, addressing the site of ligament injury (ie, proximal [type P], distal [type D], and middle-zone [type M]) and its severity (ie, whether the ligament was torn at a single site [simple lesion] or 2 or more sites [complex lesion]).

The current study reports the surgical procedures performed to manage soft tissue constraint lesions based on the soft tissue constraint injury classification and the related surgical outcomes in a large series of patients with complex elbow instability. The authors hypothesized that, when soft tissue constraint lesions are properly diagnosed and surgically addressed, high rates of satisfactory results and a reduced incidence of postoperative elbow instability may be expected.

**Materials and Methods**

According to Italian law, the authors were not required to ask for institutional review board or ethical committee approval for this type of study. However, each author certifies that his or her institution approved the human protocol for this study and that the study was conducted in conformity with ethical principles of research.

Between January 2005 and December 2008, a single surgeon (G.G.) performed surgery on 47 patients with complex elbow instability. Preoperative diagnosis included a Monteggia-like lesion in 17 patients, a transoleggena-like fracture–dislocation in 2, a comminuted radial head fracture associated with posterior elbow dislocation in 6, a terrible triad in 13, a capitulum humeri and trochlea fracture with posterior dislocation in 6, and a coronoid fracture associated with posterior dislocation in 3. Two patients with transoleggena fracture–dislocation were excluded due to no associated soft tissue constraint injuries. The patients included 23 men and 22 women with a mean age of 54 years (range, 22-75 years). The left arm was involved in 23 patients and the right in 22.

All patients underwent surgery a mean of 3 days (range, 1-7 days) after trauma. Surgical treatment consisted of open reduction and internal fixation (ORIF), with radial head replacement in Mason type III injuries. After ORIF, soft tissue lesions of the lateral compartment were repaired. A fluoroscopic assessment of elbow stability was performed. If elbow stability was not achieved, the medial collateral ligament was exposed and repaired. If elbow instability was still present at the end of surgery, a hinged elbow fixator was positioned.

**Fracture Treatment**

Thirty patients had a radial head fracture. Of these, 12 Mason type III fractures were treated with radial head replacement; 15 of 17 Mason type II fractures were fixed with headless screws and 2 were fixed with a precontoured plate. In 1 patient, a fragment of the radial head too small to be fixed was excised. Seventeen patients had a Monteggia-like lesion; 14 of 17 ulnar fractures were treated with a dorsal precontoured plate and 3 with tension band wiring. Twenty-one patients had a coronoid fracture; 9 were treated with 2 or 3 threaded wires, 2 with a precontoured plate, and 2 with both. In 5 patients, the coronoid fracture was treated with transosseous sutures placed through drill holes in the ulna and grasping the anterior capsular attachment to the coronoid fragment, and in the final 3 patients, who had a fracture of the tip of the coronoid, the fragment too small to be fixed was excised. Six fractures of the capitellum and trochlea were repaired with 2 or more headless screws.

**Soft Tissue Treatment**

The soft tissue constraint lesions were classified according to the system previously reported.

**Lateral Collateral Ligament Lesions.** Lateral collateral ligament lesions were classified as simple in 16 cases and complex in 27. Simple lesions included 7 type P, 2 type P-BF (proximal plus associated bone fragment), 6 type M, and 1 type D-BF (distal plus associated bone fragment). Type P and D ligament lesions were treated using a double-wire suture anchor positioned perpendicular to the tubercle of lateral epicondyle or to the supinator crest, with 2 modified Mason-Allen stitches (Figure 1). When a bone fragment was associated with proximal or distal avulsion (types P-BF and D-BF), the lesion was fixed with a suture anchor placed at the fracture site, with the suture wires passing through or around the bone fragment depending on its dimension and shape (Figures 2, 3). Type M lesions were repaired with side-to-side cross sutures (Figure 4).

Complex lesions included 22 type PM (type P+type M), 3 type DM (type D+type M), and 2 type PDM (type P+type M+type D). In type PM lesions, side-to-side cross sutures were used to address the middle-zone tear; thereafter, a suture anchor and modified Mason-Allen stitch was used to treat the proximal ligament avulsion (Figures 5, 6). Type DM lesions were treated the same as were type PM. However, in 2 of 3 patients with DM lesions, an adequate ligamentous reconstruction was not achieved intraoperatively and a hinged external fixator was positioned. Type PMD lesions, in which the lateral collateral ligament was entirely torn and unable to be repaired, were also treated with a hinged external fixator.
**Posterolateral Capsule Lesions.** Twenty-three small (less than 1 cm) and 8 large (more than 1 cm) capsular tears were found. Small tears were repaired after lateral collateral ligament reconstruction using the posterior wire of the suture anchor used for lateral collateral ligament reinsertion. Large tears were always associated with an anconeus detachment and were repaired with an anchor placed perpendicular to the nonarticular posterolateral surface of capitulum humeri (Figures 6, 7). In 1 case, a posterolateral capsule lesion was associated with a large bone fragment (type PLC-large BF) of the posterolateral aspect of capitellum, the so-called Osborne-Cotterill lesion,15,16 which was fixed using 2 threaded wires (Figure 8). Posterolateral capsule lesions were always associated with proximal lateral collateral ligament avulsion.

**Common Extensor Origin Lesions.** Ten patients had an injury associated with proximal lateral collateral ligament avulsion. In 6 cases, common extensor origin lesions were repaired using cross sutures because a partial injury was present; in the other 4 cases, the entire tendon was completely dethatched from its origin and was reinserted with an anchor and 2 modified Mason-Allen stitches. The muscular damage associated with common extensor origin lesions was repaired with side-to-side cross sutures in all cases.

**Medial Collateral Ligament Lesions.** Intraoperative valgus–pronation testing performed under fluoroscopy showed evidence of medial collateral ligament injury (ie, a medial joint space greater than 2 mm) in 21 patients. After ORIF and lateral compartment reconstruction, 6 of 21 patients showed persistent elbow instability. They underwent medial compartment exploration and reconstruction. The surgical treatment was similar to that performed for the reconstruction of the lateral compartment. In 2 cases with type PM and DM tears, a flexor–pronator injury was associated; because an adequate...
reconstruction of the medial compartment was not achieved and instability of elbow joint persisted, a hinged elbow fixator was applied for 7 weeks.

At the end of surgery, the forearm fascia was closed with side-to-side cross sutures; deep cross sutures, including ligament, tendon, and fascial layer, were performed near the ligament’s humeral insertion (Figure 6).

Figure 5: Illustration showing a type PM (proximal plus middle-zone) lesion (left) and the surgical technique (right). The complex lesion is first reduced into a simple lesion using side-to-side cross sutures to repair the midsubstance tear. A suture anchor (arrow) was then positioned perpendicular to the tubercle of the lateral epicondyle to reinsert the ligament with 2 modified Mason-Allen stitches.

Figure 6: Intraoperative photographs taken from the lateral compartment of the elbow showing the surgical steps to repairing lateral collateral ligament type PM (proximal plus middle-zone) lesion and posterolateral capsule large lesion in a patient with a terrible triad. A suture anchor was placed on lateral epicondyle (A) and on the nonarticular posterolateral surface of the capitulum humeri (B). The posterolateral capsule and anconeus lesions were then repaired (C). The lateral collateral ligament midsubstance tear was repaired with side-to-side cross sutures (D). A modified Mason-Allen stitch was used to repair the lateral collateral ligament proximal avulsion (E). The fascial layer was closed with side-to-side cross sutures (F).

Postoperative Protocol
All patients underwent the same postoperative protocol, including articular drains with a plaster splint in extension for 48 hours, cryotherapy, and analgesic drugs. Two days postoperatively, patients started active and passive motion exercises with a hinged elbow brace. Indomethacin (100 mg daily) was administered for 5 weeks to prevent heterotopic ossification. During extension exercises, the forearm was positioned in pronation or supination, respectively, in cases of lateral collateral ligament or medial collateral ligament deficiency due to weak reconstruction or irreparable lesion. When both ligaments were repaired, the forearm was positioned in neutral rotation. Complete forearm rotation was immediately allowed at 90° of flexion. In patients with anterior coronoid fractures repaired with transosseous sutures, extension was limited to 30° until 25 days postoperatively. Patients were discharged an average of 3 days (range, 2-5 days) postoperatively. The operated elbow was protected for 45 days with a hinged elbow brace. Strength exercises were allowed after fracture healing.

Clinical Evaluation
Patients were followed clinically and radiographically for a mean of 25 months (range, 12-61 months) postoperatively. Clinical evaluations were performed every 3 weeks for the first 3 months, every 6 weeks for the following 3 months, every 3 months thereafter, and then annually after the first year. At 6-month follow-up, elbow stability was evaluated with varus and valgus stress tests, pivot shift test, and drawer test. The tests were performed by 2 orthopedic surgeons (S.G., G. C.); in cases of disagreement between them, the joint was reassessed until a consensus was reached. In patients with positive or uncertain tests or with clinical symptoms of instability, a fluoroscopic evaluation was conducted to assess whether a joint opening occurred in valgus–varus stress tests and to evaluate any possible loss of concentric reduction of the joint during flexion–extension and forearm rotation. Clinical evaluation included the Mayo Elbow Performance Score (MEPS), modified American Shoulder and Elbow Surgeons (m-ASES) shoulder score, and Disabilities of the Arm, Shoulder and Hand (DASH) score. Anteroposterior and lateral radiographs of the involved
elbow were taken, and the presence of degenerative changes were recorded using the classification system of Broberg and Morrey. Heterotopic ossification was rated using the functional classification of Hastings and Graham.

RESULTS

Average extension and flexion was 10° (range, 0°-50°) and 139° (range, 90°-145°), respectively. Forearm rotation averaged 82° (range, 5°-90°) in pronation and 80° (range, 0°-90°) in supination. The functional range of motion (range, 30°-130° in extension–flexion and 50°-50° in pronation–supination) was achieved in 39 of 45 patients.

Average MEPS was 94 (range, 70-100); according to the Mayo Elbow Performance Index, 34 results were excellent, 9 were good, and 2 were fair. Average DASH and m-ASES scores were 5.6 (range, 0-38.8) and 89 (range, 64-100), respectively. Forty-two (93%) patients had no signs or symptoms of elbow instability at most recent follow-up. A moderate instability, with a positive pivot shift test and varus stress test, persisted in 1 patient with an excellent result. This patient sustained a terrible triad; he was treated with a radial head prosthesis and lateral collateral ligament proximal reinsertion with a suture anchor. The patient developed a postoperative infection that likely caused the ligament reconstruction failure. Infection was resolved after 2 months with oral antibiotics. Despite the persistent instability, the patient was pain free and refused ligament reconstruction. Two other patients showed a mild laxity of the lateral collateral ligament associated with a varus stress test that did not limit their activity. Elbow stiffness was present in 6 patients: 3 with isolated limited forearm rotation, 1 with limitation of motion in the flexion–extension arc, and 2 with limitations in both planes.

Radiographic evaluation revealed the presence of heterotopic ossification in 14 (30%) patients, rated as class I in 8, IIA in 1, IIC in 2, and IIIB in 3. Five of these patients discontinued indomethacin prophylaxis.

In 28 (62%) patients, degenerative changes of the joint were present, rated as grade 1 in 13 elbows, grade 2 in 8, and
In the most frequent soft tissue constraint injuries—type P or D—suture anchors were used with modified Mason-Allen stitches to grasp the torn ligament. This suture stitch, originally used in hand surgery and subsequently in rotator cuff repair, combines a mattress and a single suture stitch. Its mechanical properties have been shown to be superior to a single and mattress stitch singly used, with reduced risk of causing ischemic changes or necrosis of the ligament. In the presence of lesions involving the intermediate portion of the ligament (type M), side-to-side cross sutures were used because the authors feel this type of suture distributes the tensile forces in a larger area of the ligamentous structure compared with single stitches. In complex lesions, the middle-zone tear was first repaired with cross sutures, and the ligament avulsion was then reattached to the bone with a suture anchor. However, in particularly severe lesions, such as type PMD, a dynamic external fixator was used when adequate joint stability was not obtained after ligament reconstruction.

The surgical technique may differ when the ligament avulsion is associated with a bone fragment. In these cases, the size of the bony fragment influences the type of reinsertion. In particular, when the bony fragment is between 0.5 and 1 cm, 1 or 2 suture anchors were used, with the suture wire passing through or around the bone fragment. This type of fixation led to an adequate ligament tension in all cases of small bone fragments encountered in the study. A bone fragment greater than 1 cm, which was observed in 1 patient, was fixed with 2 threaded wires because threaded wires or mini-screws allow better stability of a large fragment than suture anchors.

In the current series, injuries of secondary elbow stabilizers (posterolateral capsule or common extensor and flexor-pronator origin muscles) were treated because evidence shows that they contribute to elbow biomechanics. The current results show that small posterolateral capsule lesions are adequately repaired, along with lateral collateral ligament proximal reinsertion, using the most posterior wire of the suture anchor and performing a Mason-Allen stitch. Conversely, large posterolateral capsule lesions extending more than 1 cm from the epicondyle should be treated differently because they are often associated with an anconeous detachment. Because the anconeous and the posterolateral capsule prevent the external rotation of the ulna and posterior translation of the radial head, they should be accurately repaired, particularly when the ulnar band of the lateral collateral ligament is severely damaged, which was frequently observed in complex lesions. The authors’ treatment of large posterolateral capsule lesions associated with anconeous detachment consisted of the positioning of suture anchors on the posterior aspect of the capitellum to repair both the capsular and anconeous lesions.

At short-term follow-up, surgical outcomes confirmed that when bone and soft tissue constraint lesions are adequately treated, high rates of satisfactory results may be achieved in complex elbow instability. A functional range of motion was reached in 87% of patients, an excellent or good MEPS was obtained in 96% of patients, and mean DASH and m-ASES scores were satisfactory. Only 1 patient with postoperative infection, which may have affected the ligament reconstruction healing process, developed a posterolateral instability. Two other patients showed a mild lateral collateral ligament laxity at follow-up, which did not influence their physical activities. Six patients exhibited elbow stiffness: 3 involving forearm pronation, 1 involving flexion-extension, and 2 involving both.

Despite the high rate of satisfactory clinical results, degenerative changes of the elbow joint were observed on plain radiographs in 62% of cases. This result may be explained by the severe damage of the cartilaginous tissue, which is often
found in complex elbow instability, but it may also be the consequence of persistent microinstability, which may be difficult to diagnose clinically. In both cases, such degenerative changes may affect long-term results by reducing the high percentage of excellent and good outcomes observed at short-term follow-up.

**Conclusion**

The results of the current study suggest that identifying the type and severity of soft tissue constraint lesions occurring in complex elbow instability may lead to appropriate treatment aimed at restoring the original function of primary and secondary soft tissue stabilizers of the elbow joint. Such a surgical strategy may be helpful to reduce the rate of postoperative instabilities and improve the surgical outcomes in this patient population.

**References**


