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Traumatic Valgus Instability of the Elbow: Pathoanatomy and Results of Direct Repair

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Background: The medial collateral ligament provides valgus stability to the elbow. The purpose of the present study was to describe the pathoanatomy of acute traumatic medial collateral ligament ruptures and to report the rationale and results of direct repair.

Methods: Between 1996 and 2006, eleven athletes presented with acute rupture of the medial collateral ligament of the elbow and no history of dislocation. Three patients had received steroid injections for the treatment of medial epicondylitis, but none had a history of medial elbow insufficiency. All patients demonstrated gross valgus instability on clinical examination and medial joint space widening on valgus stress radiographs. Complete avulsion of the medial collateral ligament from its humeral origin was documented with magnetic resonance imaging in all patients. Operative findings uniformly demonstrated avulsion of the flexor-pronator muscles with distal retraction. The underlying medial collateral ligament was avulsed in a sleeve-like fashion from the denuded medial epicondyle. The ligament was directly reattached to its footprint. The avulsed flexor-pronator tendon was repaired to the residual tendon with use of interrupted figure-of-eight nonabsorbable sutures. All patients were followed for a minimum of sixteen months with serial clinical examinations, radiographs, and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.

Results: Full active range of motion was achieved in ten patients; the remaining patient had a 20° flexion contracture. Three patients had acute ulnar nerve palsies at the time of the injury, and all three recovered complete motor and sensory function by six months after the injury. Nine of the eleven patients returned to competitive college athletics between four and six months. The mean DASH score at the time of the most recent follow-up was 6.

Conclusions: Direct repair of an acute traumatic medial collateral ligament avulsion of the elbow reliably restores valgus stability, even in throwing athletes.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Numerous studies have demonstrated the contribution of the medial collateral ligament to valgus stability of the elbow. The anterior bundle of this ligament is the primary static restraint to valgus stress between 20° and 120° of elbow flexion. Callaway et al., in a cadaver model, demonstrated that disruption of the anterior bundle of the medial collateral ligament results in valgus instability at 30°, 60°, 90°, and 120°, with maximum instability at 90° of flexion. The radiocapitellar joint serves as a secondary static restraint, and the flexor-pronator mass has been shown to provide dynamic stabilization to valgus stress of the elbow.

Repetitive valgus stress places the elbow at risk for chronic overuse injuries. This is the most common pattern of medial collateral ligament injury in overhead throwing athletes. Many authors have shown that the valgus load produced during the late cocking and early acceleration phases of throwing approaches or exceeds the tensile strength of the medial collateral ligament. The repetitive nature of the forces results in microtrauma and attenuation of the ligament, with subsequent valgus insufficiency. In patients with chronic injuries, reconstruction has proven to be more successful than repair, likely because of the poor tissue quality resulting from the repetitive injury.
There have been few reports on acute medial collateral ligament rupture in the athlete. The pathophysiology of acute injuries is not well documented. We believe that the treatment of these injuries should be based on the unique pathology and should not be extrapolated from the treatment of chronic insufficiency. Norwood et al. reported the outcomes for four patients in whom acute medial collateral ligament ruptures had been treated with surgical repair; all four patients regained full range of motion without instability. Kenter et al. retrospectively reviewed the National Football League’s epidemiologic data over five seasons and reported on the treatment of nineteen acute medial collateral ligament injuries. All injuries were diagnosed by means of physical examination. There was no information regarding imaging studies, and all patients were managed without surgery. Therefore, no conclusions could be made regarding pathoanatomy.

The purpose of the present study was to describe the pathoanatomy of acute medial collateral ligament ruptures and to report the results of direct repair in this setting.

Materials and Methods
Between 1996 and 2006, ten collegiate athletes and one college pitching coach presented with acute rupture of the medial collateral ligament of the elbow and no history of dislocation. The mechanism of injury was a fall on an outstretched hand for six patients; trauma to an outstretched, fixed elbow for three; a motor vehicle collision for one; and overhead lifting for one. Three patients had received previous steroid injections for the treatment of medial epicondylitis. The mean age of the patients was twenty-three years (range, twenty to thirty-seven years). The patients included ten men and one woman. Five patients played competitive football, five patients competed in other sports (golf, swimming, wrestling, volleyball, and baseball), and one patient was a baseball pitching coach. There were three overhead throwing athletes, including one pitcher, one quarterback, and one pitching coach.

All patients presented for the evaluation of medial elbow pain and swelling. Examination consistently demonstrated a large hematoma involving the medial aspect of the elbow and the proximal aspect of the forearm. Clinical examination for valgus instability was performed with the humerus stabilized and with the elbow in 30° of flexion. The uninjured elbow was also examined for comparison. On examination, all elbows had gross valgus instability without a firm end point and a positive moving valgus stress test as described by O’Driscoll et al. The test was performed with the patient sitting upright and the shoulder abducted 90°. With the elbow maximally flexed, a valgus load was applied to the elbow until the shoulder reached its limit of external rotation. The elbow was then quickly extended to 30° while a constant valgus load was maintained. The test was considered positive when pain was maximal between 70° and 120°. No other patterns of instability were detected in any patient.

Three patients had an acute ulnar nerve palsy at the time of the injury; the palsy was incomplete (with sensory deficits only) in two patients and complete in one. None of the patients...
had a history of valgus insufficiency, a history of elbow trauma, or a concomitant fracture or dislocation.

**Imaging Studies**

All elbows were evaluated with valgus stress radiographs (Figs. 1-A and 1-B). The injured elbow was compared with the uninjured elbow, and the stress radiographs were considered to be positive if there was >4 mm of difference in opening of the medial joint space. The mean gap measured 8.5 mm (range, 7 to 9 mm). Six patients were evaluated with magnetic resonance imaging arthrograms, which demonstrated complete avulsion of the medial collateral ligament from its origin in all six elbows (Fig. 2). The other five patients were evaluated with standard magnetic resonance imaging, which demonstrated an effusion and complete avulsion of the medial collateral ligament in all five elbows and marrow edema in the capitellum in four. No abnormalities of the lateral ulnar collateral ligament were noted.

**Surgical Technique**

The mean time between the injury and the repair was twenty days (range, seventeen to twenty-seven days). The operative technique utilized a 12-cm incision over the cubital tunnel and centered at the medial epicondyle. Operative findings uniformly demonstrated avulsion of the superficial layer of the flexor-pronator muscles with distal retraction. The underlying medial collateral ligament was consistently avulsed in a sleeve-like...
fashion from the denuded medial epicondyle (Fig. 3). Disrup-
tion of the flexor-pronator muscles was typically observed along
the anterior two-thirds of the muscle origin (Fig. 4). Hematoma
was observed in the cubital tunnel in six patients, and the ulnar
nerve was hemorrhagic in two of the three patients with ulnar
nerve symptoms. The ulnar nerve was transposed anteriorly in
all patients with use of a fascial sling. The reason for the trans-
position in seven patients was that repair of the ligament required
extensive mobilization of the nerve, resulting in subluxation. Of
the remaining four patients, three underwent transposition be-
cause of preoperative ulnar nerve symptoms. In the final patient,
the ulnar nerve was transposed because of concern that it would be
irritated by the suture material utilized for the ligament repair. No
intra-articular abnormalities were noted on elbow arthrotomy in
any of the patients.

In nine elbows, the medial collateral ligament was directly
repaired back to its origin with a running, locked number-2
nonabsorbable suture placed through drill-holes. An anterior
and a posterior bone tunnel were created with a 2.0-mm drill-
bit at the origin of the medial collateral ligament so that the
sutures could be secured over a bone bridge (Figs. 5-A, 5-B, and
5-C). In two elbows, suture anchors with number-2 nonab-
sorbable suture were placed into the footprint of the ligament.
The avulsed flexor-pronator tendon was repaired to the res-
dual tendon with use of interrupted figure-of-eight nonab-
sorbable sutures. Finally, the ulnar nerve was transposed anteriorly
with use of a fascial sling.

Postoperatively, all elbows were placed in a hinged or-
thesis for six weeks. The orthosis was locked at 90° for three
weeks with the forearm in neutral rotation. At three weeks, the
orthosis was unlocked and full range of motion was encouraged.
At six weeks, the brace was discontinued and progressive
strengthening was initiated with the forearm in neutral rotation.
At twelve weeks, mock throwing in the mirror was initiated for
throwing athletes, with attention to shoulder mobility and
strength. Overhead throwing athletes were permitted to throw
after they regained full elbow range of motion, performed
flexor-pronator strengthening, and demonstrated no pain with
valgus stress on clinical examination. Release to throwing oc-
curred at a mean of nineteen weeks (range, eighteen to twenty-
two weeks). The Disabilities of the Arm, Shoulder and Hand
(DASH) questionnaire, a validated outcome instrument, was
used for the evaluation of physical function and symptoms of
the injured extremity at the time of the latest follow-up.

Results
All patients were followed for a minimum of sixteen months
with serial clinical examinations, radiographs, and the com-
pletion of DASH questionnaires.

Operative findings uniformly demonstrated avulsion of the
superficial layer of the flexor-pronator muscles with distal re-
traction (Fig. 4). The entire attachment of the medial collateral
ligament, including the anterior and posterior bands of the an-
terior bundle of the ligament, was avulsed as a periosteal sleeve
from the medial epicondyle of the humerus (Fig. 3). In five
patients, the medial collateral ligament origin actually appeared
to be infolded into the ulnohumeral joint. Resolving hemar-
throsis was noted in these individuals as well. Hematoma was
noted in the floor of the cubital tunnel in six patients. In the three patients who had previously received steroid injections, the steroid residue was visualized in the flexor-pronator origin. There was no apparent difference in the injury pattern to the medial collateral ligament or flexor-pronator muscles in these patients.

Serial clinical examinations were performed at three, six, twelve, eighteen, and twenty-two weeks and at the time of the latest follow-up. Examination revealed that six patients had regained final motion at six weeks and that the remaining five patients had regained final motion between the six and twelve-week visits. No elbow had clinical instability at the time of the latest follow-up. Full active range of motion was achieved in ten of the eleven patients. The remaining patient, a baseball pitcher, had a 20° flexion contracture. At the time of surgery, that patient was noted to have calcification along the course of the medial collateral ligament. All three patients with acute ulnar nerve palsies at the time of the injury recovered complete motor and sensory function by six months. Nine of ten patients returned to competitive college athletics between four and six months. The patient who did not return to college athletics was a football player who was injured during his senior year and who did not go on to play professionally. The final patient, a college pitching coach, was able to return to throwing batting practice at a similar level as before the injury. The mean DASH score at the time of the latest follow-up was 6 (range, 2 to 12).

Discussion

The pathoanatomy and treatment of chronic medial collateral ligament insufficiency of the elbow in overhead-throwing athletes have been well studied. Repetitive valgus over-
load at the elbow results in attenuation or tears in the medial collateral ligament. The treatment of chronic medial collateral ligament insufficiency is directed at reconstruction of the ligament. The acute medial collateral ligament injury has a different etiology and therefore results in a different pathoanatomy. The humeral attachment of the medial collateral ligament is avulsed from the medial epicondyle with disruption of the overlying flexor-pronator muscle origin. The ideal treatment for such injuries must address this abnormality to restore stability and function to the elbow.

In the present series, all patients sustained an acute traumatic injury resulting in valgus instability of the elbow. Patients presented with pain, a massive forearm hematoma, and gross valgus instability on both physical examination and valgus stress radiographs. The chief indication for surgical exploration in our patient population was that a magnetic resonance imaging scan or magnetic resonance imaging arthrogram documented substantial displacement of the medial collateral ligament from its origin on the medial epicondyle. All elbows demonstrated disruption of the flexor-pronator muscles and a humeral-sided avulsion of the medial collateral ligament, which was found to be infolded into the ulnohumeral joint in five cases. These structures represent the primary static and dynamic stabilizers to valgus stress through the functional range of motion of the elbow. Direct repair of these structures resulted in the restoration of valgus stability in all elbows and resulted in a functional return to the previous level of athletic activity in nine of eleven patients.

The literature includes mixed recommendations for the treatment of this injury pattern, likely because of the paucity of information regarding the pathoanatomy of the injury. Our study had several limitations. For one, all patients were managed operatively. The series was small, and there was no comparison group of patients who had been managed nonoperatively. While we observed good results in association with the operative treatment of this injury, it is unknown whether operative treatment is superior to nonoperative treatment. Also, our results demonstrated low DASH scores at the time of the latest follow-up, but we did not obtain DASH scores preoperatively for comparison. Furthermore, the follow-up period was relatively short. While surgical repair of the medial collateral ligament and flexor-pronator muscles provided a stable elbow and a return to athletics, longer follow-up is required to assess for some complications such as degenerative joint changes. At the time of follow-up, we did not make stress radiographs or magnetic resonance imaging scans to support our clinical findings. While post-repair stress radiographs may have strengthened our conclusions, magnetic resonance imaging findings in this setting are difficult to interpret.

Future investigations should be directed at evaluating the repair techniques. We utilized both a suture anchor repair technique and a bone tunnel repair technique. While we favor securing the ligament through bone tunnels, a biomechanical analysis of the two techniques would reveal potential differences between the repair methods.

In conclusion, we were able to correlate clinical examination and imaging studies with the pathoanatomy at the time for a mean of 3.4 years. The diagnosis was made on the basis of physical examination only and revealed three grade-I sprains and two grade-III sprains. All patients were managed nonoperatively and were able to return to their positions without restrictions. No elbow demonstrated clinical instability at the time of the latest follow-up.

Our results are consistent with those reported by Norwood et al. Preoperative imaging studies and operative findings uniformly demonstrated a humeral-sided avulsion of the medial collateral ligament with disruption of the flexor-pronator muscle origin. The short-term results of both studies demonstrated the restoration of valgus stability without loss of motion and with a return to full activities. The ability to compare these results with those reported by Kenter et al. is limited by the absence of imaging studies or operative findings in that study.

Similarly, our radiographic findings in the setting of valgus instability of the elbow were comparable with those described by Eygendaal et al. Those authors defined valgus instability as a 3 to 6-mm side-to-side difference on stress radiographs when the findings for the injured elbow were compared with those for the uninjured elbow. All of their patients with humeral-sided avulsion of the medial collateral ligament met this criterion of instability. All of our patients had >4 mm of side-to-side difference on stress radiographs and had documented humeral-sided avulsion of the medial collateral ligament. Magnetic resonance imaging evaluations of medial collateral ligament injuries have yielded variable results in the literature. Magnetic resonance imaging arthrography appears to improve the sensitivity of this modality to detect tears of the medial collateral ligament.

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of surgery. Our surgical repair is anatomic and reproducible. We demonstrated effective restoration of valgus stability and functional return in nine of eleven athletes. However, we have no comparative data regarding the outcomes of nonoperative treatment of this injury.

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