Gamekeeper's Thumb—A Treatment-Oriented Magnetic Resonance Imaging Classification

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Purpose To investigate by magnetic resonance imaging the degree of ulnar collateral ligament (UCL) displacement in order to create a simple classification to aid in determining which UCL injuries require surgery.

Methods We evaluated 43 cases of UCL injury with a dedicated extremity magnetic resonance imaging and measured the degree of ligament displacement. This was correlated to clinical outcome with planned surgical intervention reserved for patients with a Stener lesion. By collating results we could generate 4 types of injury based on the appearances of the UCL.

Results Partial and minimally displaced UCL tears (type 1) and tears displaced less than 3 mm (type 2) typically healed by immobilization alone, whereas 90% of tears displaced more than 3 mm (type 3) failed immobilization and required surgery as did all of those with a Stener lesion (type 4).

Conclusions Our 4-stage, treatment-oriented classification of thumb UCL injury is based on the degree of UCL displacement in, with correlation with the likelihood of success with either immobilization or operative intervention. Tears of the UCL with more than 3 mm of displacement are likely to require operative repair even in the absence of a true Stener lesion.

Type of study/level of evidence Diagnostic IV.

Key words Classification, magnetic resonance imaging, ulnar collateral ligament.

Following Campbell's[1] description of ulnar collateral ligament (UCL) injury in 1955, there have been ongoing efforts to establish a reliable means to discriminate between injuries that require surgical intervention and those that can be managed conservatively.[2–5] Most notably, this refers to cases complicated by the presence of a Stener lesion in which the adductor aponeurosis is interposed between the distally avulsed UCL and its attachment on the base of the proximal phalanx, which prevents healing.[6] Despite their recognized limitations, clinical examination and plain/stress radiographs remain the baseline tools used to evaluate UCL injury and guide management. However, neither can provide definitive prognostically relevant information on the degree of ligament displacement or the presence of a Stener lesion.[7] As a result, many patients with UCL laxity are assumed to have either a widely displaced complete tear or a Stener lesion and subsequently undergo surgical exploration and repair regardless of the actual pathology present. In other situations, diagnostic uncertainty persists after clinical and radiographic assessment and a period of trial immobilization is instigated that can delay intervention in cases that are ultimately destined to fail conservative treatment, as defined by persistent UCL laxity with no discernible end point.

To improve diagnostic accuracy in thumb UCL injury, the value of adjunctive imaging using ultrasound or magnetic resonance imaging (MRI) has been

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extensively studied.[8–11] Magnetic resonance imaging sensitivity and specificity for UCL injury detection approaches 100%; with the latest generation of dedicated extremity coils, it offers a level of detail that can show the precise location of the torn ligament within the accuracy of a millimeter. Romano et al[12] used high-resolution MRI to characterize the detailed appearance of the thumb UCL after injury and suggested 5 distinct subclasses of ligament tear, ranging between partial tears and Stener lesions with undisplaced, minimally displaced (up to 3 mm), and moderately displaced (3 mm or more) lesions in between. This MRI classification of UCL injury offers an opportunity to study the natural history of UCL tears and identify the extent of trauma that can be tolerated and still heal without surgical intervention. Thus, this could lead the way to avoiding both unnecessary surgery and delay to surgery when there is limited chance of healing without intervention.

MATERIALS AND METHODS

Our institutional review board approved the study and we adhered to all requirements including obtaining informed consent from each patient. The study was based on the retrospective association between final outcome after UCL injury and the initial appearances of the ligament on MRI scans at presentation. The final outcome was defined as the successful establishment of stability at the ulnar side of the thumb metacarpophalangeal (MCP) joint, regardless of whether it was treated by immobilization alone or through surgical reconstruction or repair of the UCL. A total of 43 patients were included; 25 were male and 18 were female. Average age at injury was 39 years (range, 16–69 y). Duration of time from injury to presentation ranged from 1 day to 3 years. Patients with an injury to the thumb with tenderness over the UCL associated with pain or instability on clinical stress testing were included in the study. All patients underwent clinical evaluation at all stages by the senior author (S.M.T.), who also performed UCL repair when necessary. Ulnar collateral ligament laxity was assessed by stressing the thumb MCP joint in 30° flexion to isolate support from the UCL from that provided by the volar plate when held in extension.[3] Specifically, where there was an absence of a solid end point and no associated discomfort or when there was pronounced laxity compared with the contralateral thumb under the same examination, UCL integrity was deemed to be lost, requiring further treatment.

After clinical examination and standard plain radiography, all included subjects were evaluated in a 1.0-T dedicated extremity MRI machine. Our musculoskeletal radiology group evaluated all MRI scans and documented the degree of UCL injury and extent of displacement in complete tears to millimeter accuracy. The configuration of the ligament in complete tears was also noted including the typical appearance of the Stener lesion. In simplifying the classification described by Romano et al,[12] UCL injury severity was assigned 4 types, retaining their distinction of complete tears into those of up to 3 mm separation and those with separation of 3 mm or more (Table 1). Type 1 included sprains or partial tears of the UCL (Romano type 1 and 2 combined) (Fig. 1). Type 2 lesions had a complete UCL tear in which the separation between the ends of the ligament (for intra-substance tears) or the separation of the ligament from its bony point of insertion was reported to lie within 3 mm of each other beneath the adductor aponeurosis (Fig. 2). Type 3 included complete UCL injuries with 3 mm or more of separation but without interposition of the adductor aponeurosis (Fig. 3). Type 4 represented cases with a Stener lesion (Fig. 4).

TABLE 1. Classification of UCL Injury Based on Ligament Appearance on MRI

Group	UCL Appearance on MRI	Recommended Treatment Modality
1	Partial/undisplaced tear	Immobilization
2	Complete tear up to 3 mm	Immobilization
3	Complete tear $\geq$ 3 mm Buckled/quasi-Stener lesion	Surgical repair
4	Stener lesion	Surgical repair

Recommended treatment for each UCL injury group is based on the intervention necessary to achieve a successful outcome in the 42 patients studied.

All patients, including those with instability on the first examination, were initially treated conservatively by full-time immobilization in a forearm-based thumb spica orthosis unless there was MRI evidence of a Stener lesion, because this was the standard practice of the senior author at the time of data acquisition. There were no compliance problems with any conservatively managed patients included in the study. Because of the large geographical area for included study subjects, the duration of immobilization ranged from 6 to 8 weeks for logistical reasons. After immobilization was completed, we reassessed UCL stability immediately after cast removal and treated patients surgically if UCL instability persisted, defined as the lack of a discernable end point

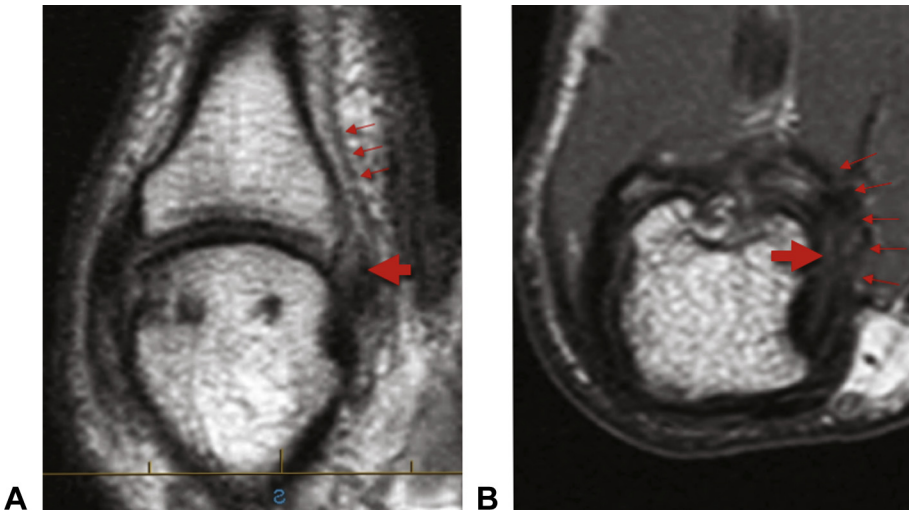

FIGURE 1: T2-weighted MRI appearance of a group 1 UCL injury demonstrating a sprain or partial tear injury of the ligament. **A** Sagittal and **B** axial views demonstrating increased signal associated with a partial tear in the UCL (large arrow) lying beneath the adductor aponeurosis (small arrows).

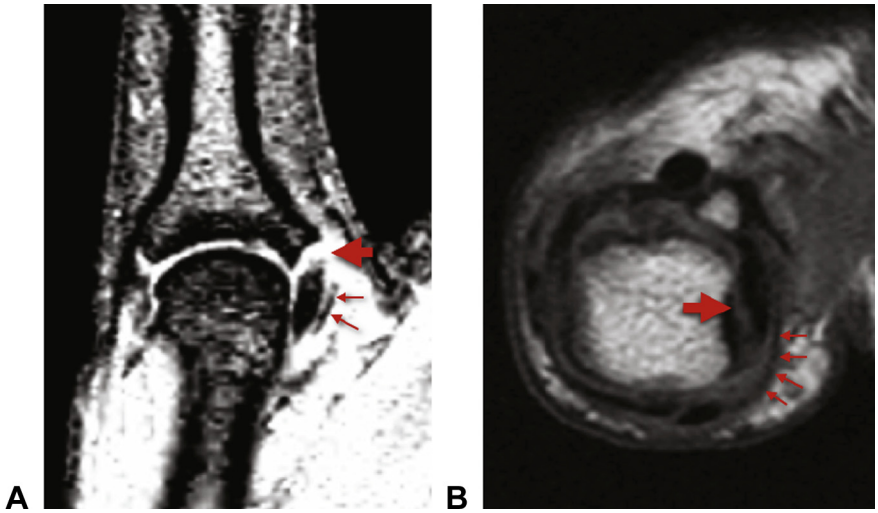

FIGURE 2: T2-weighted MRI appearance of a group 2 complete UCL tear less than 3 mm. **A** Sagittal and **B** axial views demonstrating the complete tear (large arrow) with the proximally attached end remaining beneath the adductor aponeurosis (small arrows).

on clinical reevaluation. Although full maturation of the scarring process in conservatively managed UCL injuries remains at an early stage 6 to 8 weeks after injury, our definition of a successful outcome was defined as stability at the ulnar side of the thumb MCP joint to applied stress. All patients with Stener lesions were treated operatively.

RESULTS

Plain radiography revealed an avulsion fracture of less than 20% of the total articular surface area as part of the UCL injury in 6 of 43 patients. Patients assessed for study inclusion were rejected if the bone fragment occupied more than 20% of the articular surface; these injuries were treated as a fracture rather than a UCL injury. The presence of a small bony UCL avulsion fragment did not alter management compared with pure ligamentous injuries. There was one case of a combined displaced UCL avulsion fracture and a separate undisplaced fracture at the insertion point of the UCL at the base of the proximal phalanx.[13] Of 43 patients, 14 (33%) had a type 1 injury, 5 had a type 2 injury (12%), 10 had a type 3 injury (24%), and 14 cases had a type 4 injury (33%).

All type 1 injuries were treated conservatively with full-time immobilization for 6 to 8 weeks and healed uneventfully. Four of 5 patients who initially

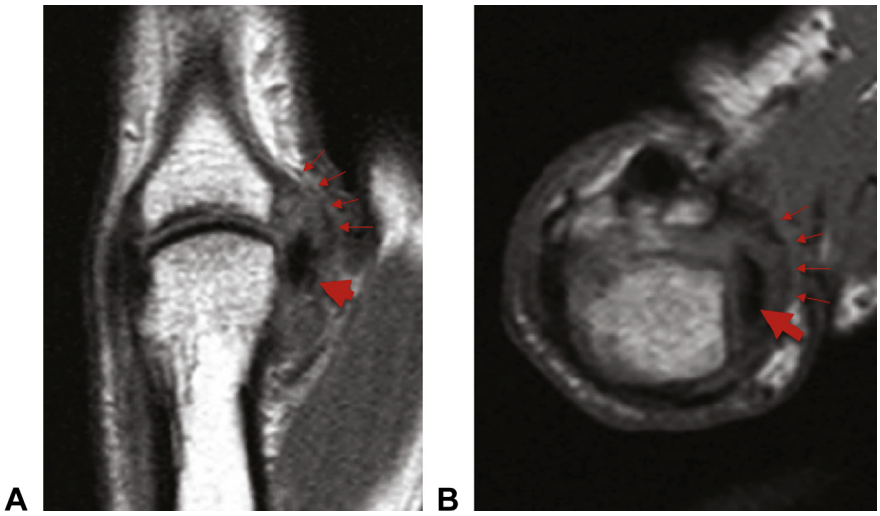

FIGURE 3: **A** Sagittal and **B** axial T2-weighted MRI images of a group 3 complete tear in the UCL with more than 3 mm separation. In this example, the free end of the ligament has become reflected proximally (large arrow, sagittal image) while remaining beneath the adductor aponeurosis (small arrows) as a quasi-Stener lesion.

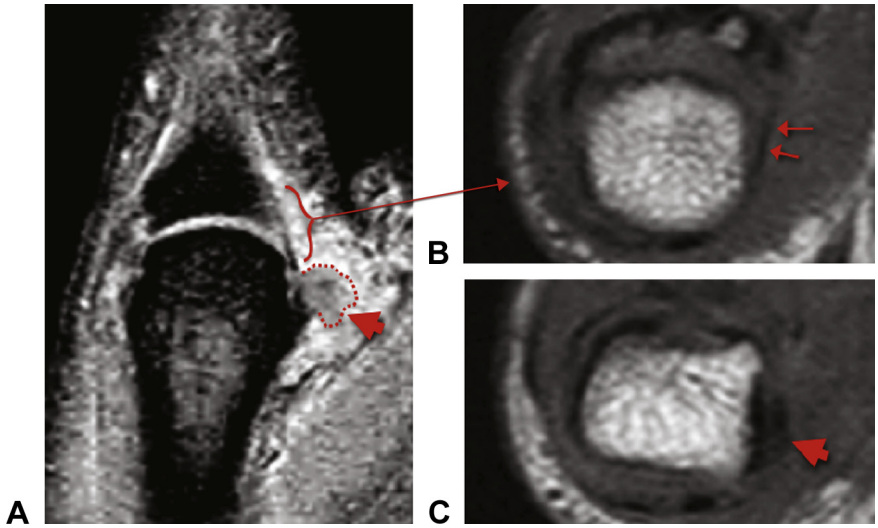

FIGURE 4: **A** Sagittal and **B** twin-level axial T2-weighted MRI images of a group 4 thumb UCL Stener lesion. Image B demonstrates the direct approximation of the adductor aponeurosis against the joint capsule (small arrows), whereas **C** gives a more proximal axial view of the joint where the rolled-up free end of the UCL (outlined in red in **A**, large arrows) lies proximal to the free edge of the adductor aponeurosis.

presented with a type 2 injury healed with immobilization but one required subsequent UCL reconstruction; that case was noteworthy in that there was a 5-month delay to presentation from the time of injury. All 10 patients with a type 3 injury were initially treated with immobilization, but 9 subsequently failed to regain MCP joint stability on clinical examination and required surgical repair. One patient with a type 3 injury demonstrated a UCL tear with more than 3 mm separation, with the proximal end of the ligament rolled onto itself but remaining beneath the adductor aponeurosis. Romano et al[12] described a similar lesion. We did not expect this quasi-Stener lesion (Fig. 3) to heal spontaneously. All patients with a type 4 injury underwent surgery and had uneventful, successful outcomes.

DISCUSSION

Accurate identification of the position of the UCL ligament after injury is clinically important because it helps guide appropriate treatment, either immobilization or repair. Early reports of clinical examination in thumb UCL injury were inconclusive and led

Palmer and Louis[3] to attempt to clarify UCL laxity in a standardized manner, taking into account numerous other stabilizing structures that resist radial stress at the MCP joint of the thumb. They concluded that laxity of 35° or more indicated that the UCL was torn when examined in full flexion. Unfortunately, the accuracy of assessment of joint stability remains fraught with practical difficulty including stiffness from local edema, poor patient compliance owing to pain, and the unknown degree of pre-injury UCL laxity against which to compare it. Furthermore, UCL laxity compared with the contralateral uninjured thumb is also potentially misleading, because research demonstrated frequent differences in collateral ligament laxity between the right and left thumbs of healthy volunteers.[14] X-ray quantification of laxity to radial stress is similarly problematic because it is technically difficult to perform as a result of patient positioning and interference from the examiner's radiopaque gloves.[15] Moreover, seemingly innocuous UCL avulsion fractures seen on plain films may represent avulsion fractures of the adductor insertion or other structures damaged at the time of injury. These cases are often associated with a concomitant Stener lesion that may or may not have a second avulsion fracture that can be difficult to spot on standard orthogonal x-ray views, with obvious risk to a successful outcome if missed.[13,16,17]

Although ultrasound has considerable value in evaluating UCL injury, its sensitivity and specificity are inferior to MRI and it is highly operator dependent for both data acquisition and interpretation.[5] Current-generation MRI technology has demonstrated high rates of sensitivity and specificity in diagnosing UCL injury through the use of high-strength magnets and strong gradient fields to generate images with a high signal to noise ratio within the required small field of view of 4 to 6 cm.[11]

In the current study, we evaluated patients presenting with clinical signs of UCL injury by clinical examination and plain radiography in conjunction with dedicated extremity MRI used to measure the degree of ligament separation in complete tears in a manner similar to the work of Romano et al.[12] Clinical examination of the thumb UCL has great value when the joint is stable to the application of stress, with a clear end point, and with the stability necessary for normal hand function. We therefore used clinical evaluation through stress testing as a tool to assess outcome of treatment in which stability was demonstrable and persistent instability led to further intervention. In their MRI study, Romano et al proposed 5 classes of UCL injury (Stener lesion; moderate displacement of 3 mm or more; minimal displacement of up to 3 mm; nondisplaced; and partial tears). However, on the basis of the treatment outcomes in the current study (clinical stability of the UCL), we grouped undisplaced and partial tears or sprains into the same type. When comparing the more extreme injuries between our findings and those of Romano et al (classification groups 2 to 4), we noted a similar number of type 3 lesions, secondary to Stener lesions and undisplaced tears in this series.

We propose an MRI-based classification of 4 types of UCL injury (Table 1), which had a direct bearing on our management and prognosis. All but one of our patients with type 1 or 2 injuries healed by immobilization alone. One chronic injury with less than 3 mm separation (5-mo delay to presentation) failed to heal by immobilization and required surgery. Although the length of time to presentation may be a confounding factor affecting the healing potential for UCL injury with up to 3 mm separation, it does not appear to have a negative impact on gaps of 3 mm or more in that all of these cases required operative repair irrespective of the duration of the injury. In addition, because all patients in group 3 were initially immobilized, these injuries could already be considered chronic after at least 6 weeks of immobilization before reassessment and subsequent surgery.

Surgery may be essential for the treatment of Stener lesions (type 4), but our study revealed a high proportion of patients presenting with type 3 lesions, 90% of whom failed conservative management after 6 to 8 weeks of immobilization. This suggests a high probability of failure of conservative treatment if there is 3 mm or more of separation between the ends of the torn ligament.

This apparent poor intrinsic healing potential for tears displaced 3 mm or more also raises the question as to whether clinical testing for instability of the UCL can potentially worsen prognosis. For example, if a difference exists between successful conservative management and the need for surgery at 3 mm or more of tear displacement, could stress testing potentially increase this separation further during forcible radial deviation in an attempt to evaluate stability of the UCL? Although no evidence supports this, is it possible that such a maneuver could potentially displace the ends of a ligament further and ostensibly worsen prognosis? In this regard, a type 2 lesion that would otherwise heal by immobilization could become converted to a type 3 or 4 lesion by overzealous stress examination. This raises the concept that a patient who presents with pain on the ulnar side of the thumb MCP joint could undergo

evaluation by MRI without subjecting the joint to a stress test, to accurately identify patients treatable by immobilization alone and avoid theoretical iatrogenic worsening of the injury. Although this hypothesis is interesting from a purely theoretical viewpoint, it may be impractical. For the current study, we examined all patients with an in-house dedicated extremity MRI machine, and the cost for performing an examination of the thumb UCL at our institution was $700 when paid directly by the patient. The cost for such an examination is likely to include a large number of variables and may vary significantly from one facility to another. Despite the resultant onerous cost burden, if routine MRI evaluation were to be performed for every potential UCL injury, its reliability in diagnosing the condition is beyond doubt.[7] Furthermore, the impact of the cost for an MCP joint MRI could potentially be offset through savings in patients with a type 1 or 2 injury (as was the case in 45% of our patients) who are subsequently treated with an orthosis instead of surgery although they had a potentially unstable joint.

Despite our findings of a clear demarcation in healing potential for UCL injury based on tear displacement, we acknowledge that our data were drawn from a small number of patients and include a relatively broad spectrum of delay to presentation. Furthermore, there was minor variation in duration of immobilization, and the qualitative outcome measure of stress applied to the ulnar side of the thumb offered few quantitative data (such as pinch strength, range of motion, or residual discomfort) for further analysis but was selected for its ability to represent functional joint stability.

With time and increasing reliance on high-quality MRI in all areas of medicine, its use as a diagnostic tool in UCL injury may become an increasingly viable option aided by better ease of access and reduced costs and waiting times.

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