ABSTRACT: The evaluation and treatment of injuries of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb remain controversial. In a retrospective study that was done to assess our ability to determine whether displacement of the ligament (a Stener lesion) was present, we reviewed our accumulated experience with patients who had an injury of this ligament who were treated surgically between 1972 and 1984. Since our method of evaluation changed in 1977, we compared the preoperative and operative diagnoses in the twenty patients who were treated surgically from 1972 through 1976 with those in the twenty patients who were so treated from 1977 through 1984.

Considering all forty patients who were treated operatively, sixteen (40 per cent) had a typical Stener lesion, and in two others (5 per cent) the ulnar collateral ligament was rolled up on itself and lying beneath the adductor aponeurosis. From 1972 through 1976, stability was tested with the metacarpophalangeal joint in complete extension or in varying amounts of flexion. Of the twenty thumbs that were evaluated by this technique and were treated surgically, 20 per cent had a Stener lesion. From 1977 through 1984, stability was tested with the joint in full flexion because of the findings in anatomical studies that were completed in 1977; the incidence of a Stener lesion in the twenty thumbs that were treated by repair or reattachment of the ligament during this time was 70 per cent.

We believe that when no fracture is present, a proper physical examination of an injured thumb is sufficient to determine the degree of instability of the ulnar collateral ligament, and that a five-stage grading system of injuries that appear to involve the ulnar side of the metacarpophalangeal joint of the thumb is helpful in separating them into operative and non-operative groups.

Despite numerous recent reports on injuries of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb, controversy persists regarding management. This concerns what constitutes an appropriate evaluation of stability, the relationship between the extent of the specific anatomical injury and the resultant laxity of the joint, and the indications for surgical or non-surgical treatment of acute injuries.

There is general agreement that all patients who have a displaced fracture that involves the attachment of the ulnar collateral ligament should be treated surgically to restore the integrity of this ligament, as well as to restore the normal architecture of the joint when the articular surface is involved. The controversy about management has largely centered on injuries in which no fracture is present and the metacarpophalangeal joint is unstable during stress-testing. In 1962, Stener described the interposition of the adductor aponeurosis between the distal site of attachment of the ruptured ulnar collateral ligament and the detached ligament (Fig. 1). Since then, some authors have maintained that because of the possibility that this lesion may be present, all thumbs that have such an injury should be explored to ensure that the ligament is reattached at the proper site. Others, however, have concluded that closed treatment is satisfactory for all of these injuries, and have reported excellent results. Bowers and Hurst, on the other hand, in a review of the literature that was published in 1977, found a rate of failure of 50 per cent after treatment by closed means.

In 1977, Palmer and Louis described their findings from an anatomical study of twenty-five fresh cadaver thumbs and a clinical study of 750 normal thumbs. The two studies complemented each other, delineating the range and variability of motion in the normal human thumb and the degree to which the various supporting soft tissues are responsible for the stability of the metacarpophalangeal joint. The anatomical study demonstrated that the ulnar collateral ligament is the major stabilizing element on the ulnar side of the thumb. In full extension (zero degrees) of the metacarpophalangeal joint of the intact thumb, the average radial deviation was 4 degrees when the metacarpal of the thumb was stabilized and a radial-deviation force was applied to...
the proximal phalanx. When the thumb was similarly stressed while the metacarpophalangeal joint was in full flexion, no radial displacement could be demonstrated. It was also found that when the adductor aponeurosis, the dorsal part of the capsule, and the ulnar collateral ligament were cut, at least 35 degrees of radial deviation was possible in all specimens during stress-testing with the metacarpophalangeal joint in full flexion. However, when the same specimens were tested with the joint in full extension or 15 degrees of flexion, the joint was more stable. The greater stability under these circumstances (full extension or 15 degrees of flexion) was thought to be due to the normal tautness of the volar plate when the joint was extended as compared with its laxity during full flexion. When both the volar plate and the ulnar collateral ligament were cut, the joint could be angulated more than 90 degrees by radial stress in any position of flexion or extension.

The study of 750 normal thumbs demonstrated considerable variation in the amounts of flexion and extension of the metacarpophalangeal joint. The average total arc of motion of the metacarpophalangeal joint was 45 degrees in these thumbs. The curve of distribution for the total arc of motion was bimodal, reflecting the hypermobility of individuals with so-called double-jointed metacarpophalangeal joints in the thumb. More importantly, however, Palmer and Louis\[6,7\] demonstrated that when the metacarpophalangeal joint of these normal thumbs was stressed radially in full flexion, the average radial displacement that was possible was only 1 degree, as compared with an average of 6 degrees when the joint was in full extension and an average of 12 degrees when it was in 15 degrees of flexion. Based on these studies and on observations of patients who had an injury of the metacarpophalangeal joint of the thumb, a new classification of injuries to the ulnar side of this joint and a new method for their evaluation were developed and applied to all patients who had this injury who were seen during 1977 and thereafter.

In 1977, Palmer and Louis published a classification of these injuries in which there were four types\[6]. Louis later came to the conclusion, from his accumulated experience, that there are five distinct patterns of injury that appear to involve the ulnar side of the metacarpophalangeal joint of the thumb. In Type I, there is an undisplaced fracture on the ulnar side of the base of the proximal phalanx (Fig. 2) and in Type II, there is a displaced fracture in the same location in the proximal phalanx (Fig. 3). In Type III, there is no fracture and the joint is stable (angulates less than 35 degrees) when it is stressed radially in full flexion. In Type IV, there is no fracture but the joint angulates more than 35 degrees when it is stressed radially in full flexion, implying complete disruption of the ulnar collateral ligament, as demonstrated by the anatomical studies of Palmer and Louis\[6,7\]. Type V, which is easily confused with Types I and II and must be differentiated from them by a careful physical examination, is, in fact, an avulsion of a portion of the volar plate with an attached piece of the proximal phalanx, and not an avulsion of the ulnar collateral ligament. This lesion is identified clinically by the presence of tenderness and swelling located volarily in the area of the attachment of the volar plate to the proximal phalanx and by the position of the fragment on the volar rather than on the ulnar aspect of the phalanx, as seen on the lateral radiograph (Fig. 4). In addition, after a regional anesthetic block, the metacarpophalangeal joint of a thumb with a Type-V injury is stable when it is stressed in full flexion.

The purpose of this retrospective review of our experience was to determine the frequency of the Stener lesion in thumbs that were treated surgically for a fracture or instability after injury to the ulnar side of the metacarpophalangeal joint and to compare the frequency of this lesion in the thumbs that were operated on before 1977 with its frequency in the thumbs that were treated operatively after adoption of the new classification and new method of evaluation in 1977.

Materials and Methods

From 1972 to 1984, forty patients were treated surgically at the University of Michigan Hospitals for an acute injury to the ulnar aspect of the metacarpophalangeal joint of the thumb. We reviewed the medical records, operative notes, and pertinent radiographs of these forty patients. Sufficient data were available to fulfill the aforementioned limited objectives of this study. Assessment of the results of surgical and non-surgical management after the twelve weeks or more that these patients were followed was not possible because so many of the patients had been students who could not be located at the time of this study.

Thirteen male and seven female patients were operated on for instability of the metacarpophalangeal joint or a displaced fracture before 1977. The average age was 22.5 years (range, fourteen to twenty-nine years). The right thumb was...
Injuries of this nature, we believe, can be treated by closed means.

Fig. 3: A Type-II lesion. Note the displaced fracture at the base of the proximal phalanx. Obviously, open reduction is required to re-establish the congruity of the joint and the integrity of the ligament.

Fig. 4: A Type-V lesion, not a Type-II injury. Note the avulsion of the phalangeal attachment of the volar plate. The joint is lax in extension but stable in full flexion, a finding that differentiates a lesion of the volar plate from a tear of the ulnar collateral ligament.

injured in fourteen patients and the left, in six. The preoperative evaluation included plain radiographs to determine whether there were any fractures and clinical stress tests to demonstrate any complete tears of the ulnar collateral ligament. The radiographs showed no fracture in eight thumbs and a fracture of the base of the proximal phalanx in twelve. Of the twelve patients who had a fracture, eight had a small chip fracture that appeared to be an avulsion of the insertion of the ulnar collateral ligament with an attached piece of bone. The other four fractures involved more than one-third of the articular surface of the proximal phalanx, and all but one of these patients were less than seventeen years old. All twelve fractures were displaced, corresponding to the Type-I injury in the classification that was used in the later group.

To perform the stress tests from which a preoperative diagnosis of a complete tear of the ligament was made in this group, radial stress was applied to the thumb with the metacarpophalangeal joint in full extension and in varying degrees of flexion, with no attempt to control axial rotation of the metacarpal during testing. A diagnosis of a complete tear was made when the laxity of the injured joint was considered to be significantly more than the laxity of the joint in the opposite thumb, but no consistent criteria or specified amount of radial deviation was used to judge the presence or absence of a complete tear. In addition, six patients were evaluated by radiographic stress examinations with the metacarpophalangeal joint in full extension, and an abnormal radiograph was the primary indication for surgical treatment. For two of these patients stress radiographs were made despite the fact that a displaced fracture was visible on plain radiographs.

The literature at that time provided no guide to the appropriate method for clinical evaluation when rupture of the ulnar collateral ligament of the metacarpophalangeal joint of the thumb was suspected. Our aggressive surgical approach was based on our knowledge of Stener's work in 1962 and on the presumption that the displaced ulnar collateral ligament would not function effectively unless the normal anatomy was restored surgically. However, when we compared the incidence of a Stener lesion of 20 per cent in our patients who were seen from 1972 through 1976 with the incidence of 64 per cent that Stener reported, we were concerned that we were not differentiating lesions that should be treated surgically from those that should be treated non-surgically, and that we were operating on thumbs that
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might have done just as well with non-operative treatment because the ligaments were disrupted but not displaced. It was then that we changed our management of these injuries, based on the previously described findings of Palmer and Louis.\textsuperscript{16,17}

Beginning in 1977, all patients who had an acute injury to the ulnar aspect of the metacarpophalangeal joint of the thumb were treated according to the following protocol, which we continue to use. For all patients who give a history of such an injury prior to any clinical examination, plain anteroposterior and lateral radiographs are made. If there is a non-displaced fracture (Type I), the thumb is immobilized with the metacarpophalangeal joint in full extension for four weeks. If there is a displaced fracture on the ulnar aspect of the base of the proximal phalanx (Type II), operative reduction or excision of the fragment with reattachment of the ligament is performed. If there is no evidence of fracture, the median and radial nerves are anesthetized at the wrist. Then, while the metacarpal head is grasped between the thumb and index finger of the examiner's non-dominant hand, the metacarpophalangeal joint is flexed completely and passive radial deviation is attempted while the examiner holds the proximal phalanx with his or her dominant hand (Fig. 5). If resistance is felt as radial deviation of the thumb (to less than 35 degrees) is attempted, it is assumed that the patient has a so-called strain of the ligament (Type III), rather than a complete tear, and a spica cast is applied to the thumb with the metacarpophalangeal joint in extension. This is worn for three weeks to allow the ligament to heal.

If the joint angulates without resistance and to more than 35 degrees as it is stressed, a diagnosis of a complete avulsion or tear of the ulnar collateral ligament (Type IV) is established. We believe that this lesion should be treated surgically, since the presence of a Stener lesion cannot be ruled out preoperatively. In our experience, when there is no evidence of a fracture after this injury, the results of the clinical test are usually not equivocal, since the metacarpophalangeal joint either opens widely or does not open at all.

From 1977 through 1984, twenty patients were treated surgically according to the aforementioned protocol. There were thirteen men and seven women, and the average age was 32.5 years (range, twenty-one to fifty-eight years). The right thumb was injured in nine patients and the left, in eleven. There were seven Type-II, one Type-III, and twelve Type-IV injuries, as determined by our preoperative evaluation. The one Type-III injury that was treated surgically occurred in the dominant thumb of a surgical resident who requested surgical treatment even though only 25 degrees of radial deviation was possible when the metacarpophalangeal joint was stressed in full flexion. In none of the Type-II injuries did the fracture involve more than one-third of the surface of the proximal phalanx. No stress radiographs were made for these twenty patients, but a positive arthrogram of the metacarpophalangeal joint of one patient with a Type-IV injury supported the findings by clinical stress-testing. Five other patients (who were not treated surgically and not included in the series) were evaluated under regional anesthesia.

![Fig. 5](image-url)

The proper method to test for instability of the ulnar collateral ligament of the thumb. With the carpometacarpal joint initially in a position of extension, the metacarpal is stabilized by grasping it just proximal to the condyles of the metacarpal head. The proximal phalanx is then grasped as shown, and the stability of the metacarpophalangeal joint is tested first with the joint in full flexion. In this position, if the collateral ligament is intact, the joint will not open. However, if the joint is held in a position of less than the maximum obtainable passive flexion, there may be some laxity normally. In the fully extended position, there is normally some laxity of the ulnar collateral ligament, the average excursion being 6 degrees. If the fully extended joint is tested for laxity, and there is only an injury of the volar plate, there will be marked laxity of as much as 30 degrees. However, when the same joint is tested in flexion, it will be stable, since the ulnar collateral ligament is intact. (Reproduced with permission from Palmer, A. K., and Louis, D. S.: Assessing Ulnar Instability of the Metacarpophalangeal Joint of the Thumb. J. Hand Surg., 3: 545, 1978.)
anesthesia in the operating room and examined by one of us (D. S. L.). They were found to have a Type-III injury and were therefore not treated surgically. Unfortunately, no additional data are available regarding the remaining patients who were seen between 1977 and 1984 and who were considered to have a Type-I, III, or V injury. All of the patients in the later group who were treated non-operatively had a stable thumb when they were last seen.

Results

Of the twenty patients who had an injury of the ulnar collateral ligament that was treated surgically between 1972 and 1976, eight did not have an associated fracture. Two of these had a rupture of the distal part of the ulnar collateral ligament with a classic Stener lesion, while the other six had complete disruption of the ulnar collateral ligament but no displacement. Of the six ligaments that did not show a Stener lesion, four were torn from the attachment to the proximal phalanx and two were a mid-substance rupture.

Of the twelve patients who had a fracture that was treated surgically before 1977, eight had a chip-type avulsion fragment that was displaced from its original position, and four had a fragment that involved more than one-third of the joint surface. Of the eight chip-type fragments, one was associated with a Stener lesion. In the other seven thumbs, the ulnar collateral ligament was detached from its attachment to the proximal phalanx in all seven, the fragment of bone remained attached to the ulnar collateral ligament in six, and the fragment was attached only to synovial tissue in one. Of the four patients who were treated surgically and had a significant articular fragment, one had associated displacement of the ligament as described by Stener and in three the fragment was displaced sufficiently to distort the normal architecture of the joint, but none of the ligaments was rolled back on itself.

The eight patients who did not have an associated fracture and the eight patients who had a small avulsion fracture were treated by primary repair or reattachment of the ligament to the proximal phalanx, depending on the location of the injury. The other four patients, all of whom had a major articular fragment, were treated with open reduction and internal fixation using Kirschner wires. This restored the integrity of the ulnar collateral ligament, which was attached to the fragment of the fracture. All twenty thumbs were immobilized in a spica cast with the metacarpophalangeal joint held in extension for four to six weeks.

Postoperatively, one patient in this group had persistent anesthesia in the operating room and examined by one of us (D. S. L.). They were found to have a Type-III injury and were therefore not treated surgically. Unfortunately, no additional data are available regarding the remaining patients who were seen between 1977 and 1984 and who were considered to have a Type-I, III, or V injury. All of the patients in the later group who were treated non-operatively had a stable thumb when they were last seen.

Discussion

When a patient who has an acute injury to the ulnar aspect of the metacarpophalangeal joint of the thumb is first seen, the surgeon must decide if the joint is unstable and whether surgical repair is required to restore stability. When the ulnar collateral ligament is torn and displaced, with interposition of the adductor aponeurosis as described by Stener, stability can be restored only by surgical repair. Stener described this lesion in twenty-five of thirty-nine patients, or 64 per cent of the patients whom he operated on. In some, but not all, of these patients there was an associated avulsion fracture. He concluded that displacement of the ruptured ligament cannot be ruled out before operation, and this key point is supported by the evidence in our study. Stener did not specify the indications for surgical treatment, and no additional details concerning the injuries in his patients are available. Several authors have subsequently reported incidences of surgically proved Stener lesions that have ranged from 15 to 52 per cent, and they used a variety of indications for surgical treatment.

In our patients, in whom the status of the ulnar collateral ligament was treated surgically between 1972 and 1976, eight did not have an associated fracture. Two of these had a rupture of the distal part of the ulnar collateral ligament with a classic Stener lesion, while the other six had complete disruption of the ulnar collateral ligament but no displacement. Of the six ligaments that did not show a Stener lesion, four were torn from the attachment to the proximal phalanx and two were a mid-substance rupture.

Of the twelve patients who had a fracture that was treated surgically before 1977, eight had a chip-type avulsion fragment that was displaced from its original position, and four had a fragment that involved more than one-third of the joint surface. Of the eight chip-type fragments, one was associated with a Stener lesion. In the other seven thumbs, the ulnar collateral ligament was detached from its attachment to the proximal phalanx in all seven, the fragment of bone remained attached to the ulnar collateral ligament in six, and the fragment was attached only to synovial tissue in one. Of the four patients who were treated surgically and had a significant articular fragment, one had associated displacement of the ligament as described by Stener and in three the fragment was displaced sufficiently to distort the normal architecture of the joint, but none of the ligaments was rolled back on itself.

The eight patients who did not have an associated fracture and the eight patients who had a small avulsion fracture were treated by primary repair or reattachment of the ligament, followed by immobilization. The other eighteen patients were treated by repair or reattachment of the ligament, followed by immobilization in a thumb-spica cast with the metacarpophalangeal joint held in extension for four to six weeks.

Postoperatively, one patient in this group had persistent anesthesia on the ulnar aspect of the thumb, presumably due to accidental injury of the ulnar digital nerve at the time of operation. When these twenty patients were last seen, three to twelve months after repair, none had any evidence of instability of the metacarpophalangeal joint and all were free of symptoms. Two patients had mild stiffness of the thumb.
ligament was proved by operative exposure, we attempted
to determine whether an appropriate physical examination
and radiographs provide an accurate and reliable way of
determining whether surgical treatment is indicated.

Based on the anatomical studies of Palmer and
Louis and on our clinical experience, presented here, we
believe that acute injuries of the ulnar collateral ligament
can be divided into four types that can be identified by
clinical and radiographic examination, and that the appro-
appropriate treatment can be selected according to the type. A
fifth type of injury is included because avulsion of the volar
plane with an attached piece of bone may easily be mistaken
for a Type-II injury on the basis of radiographs. This is not,
however, an injury of the ulnar collateral ligament, and the
implications for treatment are different. Table I lists the five
types of injury and the treatment that we prefer for each
type at the time of writing.

As shown by the findings in this study, our ability to
diagnose the Stener lesion improved by 50 per cent after
1977, when we began to follow the protocol that we have
described. Two questions remain, however. First, since all
patients who did not have a fracture and were treated sur-
gically from 1972 through 1976 had complete disruptions
of the ulnar collateral ligament, and presumably would have
been classified as having a Type-IV injury if they had been
examined according to our present protocol, why was their
incidence of a Stener lesion only 25 per cent (two of eight),
whereas in the later group the incidence was 70 per cent?
One possible explanation is that these joints were so unstable
that displacement of a previously disrupted but undisplaced
ligament occurred during the type of stability testing that
was performed in the later group. Second, why did the
incidence of a Stener lesion in thumbs that had a displaced
chip-type avulsion fracture increase from 13 per cent (one
of eight) to 86 per cent (six of seven) between the earlier
and later groups? There is no obvious explanation for this.

We cannot yet establish the validity of our present
management protocol because we do not have documented
data on the results in the thumbs of all patients who were
treated according to the protocol for each type of injury,
and then were followed for long enough to establish the
result. However, the incidence of a Stener lesion among
Type-II lesions of 86 per cent (six of seven) and the inci-
dence among Type-IV lesions of 66 per cent (eight of
twelve) suggest strongly that all patients who have this type
of injury should undergo repair of the ligament. We antic-
icate that appropriate treatment for all injuries to the ulnar
aspect of the metacarpophalangeal joint of the thumb can
be determined by using this simple protocol and the clas-
sification that we have described. In order to establish the
validity of this suggestion, we are now beginning both a
prospective and a retrospective study of patients who were
treated according to this protocol.

References

Adolescent Idiopathic Scoliosis Treated by Harrington-Rod Distraction and Fusion*

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ABSTRACT: One hundred and thirty-three patients who had adolescent idiopathic scoliosis were treated by insertion of a single Harrington distraction rod and spinal fusion. Postoperative immobilization consisted of six months in a below-the-shoulder cast. The mean preoperative curve was 50 degrees, with a range of 30 to 110 degrees. The mean final curve was 35 degrees, with a range of 19 to 63 degrees. There were no neurological injuries and no deep wound infections. Twelve patients required further surgery for complications, all of which were treated successfully. The duration of follow-up ranged from twenty-four to seventy-two months. At final follow-up, all patients had resumed their normal preoperative activities without limitations.

For more than twenty years, posterior spinal fusion with Harrington-rod instrumentation has been the surgical treatment of choice for adolescent idiopathic scoliosis in many centers. Since Harrington reported the early results, the popularity of this procedure has increased11,12. Its advantages compared with other methods are low rates of morbidity and mortality13,10,12 and few long-term complications. However, in patients who have had a fusion that extended to the lower part of the lumbar spine or the pelvis, there have been problems such as iatrogenic flat back and low-back pain3,8.

Since 1976, more complex procedures, such as segmental spinal instrumentation with sublaminar wiring, have become increasingly popular in the treatment of certain patients who have scoliosis, including those who have adolescent idiopathic scoliosis. We therefore reviewed our recent experience with spinal fusion using Harrington-rod instrumentation in patients who were treated at Newington Children's Hospital for idiopathic scoliosis. The purpose of the study was to compare our results with this technique with those reported in the literature for the more complicated procedures that are used to treat adolescent idiopathic scoliosis (excluding severe curves).

Materials and Methods

In a retrospective study, the cases of patients who had adolescent idiopathic scoliosis and were treated by instrumentation with a single Harrington distraction rod and autogenous bone-grafting at Newington Children's Hospital from October 1, 1978, to December 31, 1982, were reviewed. The chart and radiographs of each patient were studied. Only patients who had a minimum follow-up of two years were included. A total of 179 patients who had adolescent idiopathic scoliosis were treated by surgery during this period of time. One hundred and sixty-eight patients were treated with Harrington-rod instrumentation and eleven, with Luque-rod instrumentation that was attached to the spine by sublaminar wiring.

Thirty-five patients, all with Harrington-rod instrumentation, were lost to follow-up: Sixty-five patients were followed for less than three years, fifty-five were followed for three to five years, and thirteen were followed for more than five years. The mean length of follow-up was forty-four months (range, twenty-four to seventy-two months). The operations were performed by six different surgeons.

Of the 133 patients who were treated by Harrington instrumentation, in 130 the indication for surgery was progressive idiopathic scoliosis of more than 40 degrees and an age of at least ten years. The other three patients had a rapidly progressing curve that had not yet reached 40 degrees. In the eleven patients who were treated with Luque-rod instrumentation and sublaminar wiring, this stronger system16 was thought to be preferable to the Harrington instrumentation for several reasons. Seven patients had profound or morbid obesity, and therefore a system with greater strength of internal fixation was indicated; three patients had severe psychiatric problems, and it was believed that they