Palmer Midcarpal Instability: An Algorithm of Diagnosis and Surgical Management

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Abstract

Background Palmar midcarpal instability (PMCI) is an uncommon form of nondisso-ciative carpal instability. However, it is an important cause of chronic ulnar wrist pain. Diagnosis can be difficult and high index of suspicion is mandatory. Pathomechanics and optimal treatment of PMCI remain uncertain. We propose an algorithm of clinical diagnosis and evaluate the outcome of our management.

Materials and Methods Between 2000 and 2011, 16 patients, including 7 males and 9 females, of a mean age of 33.9 diagnosed with PMCI were reviewed for their clinical, radiologic, and arthroscopic features. All patients presented with ulnar wrist pain in their dominant hands except in one. Initial management included a disease-specific antecarpal supination splint. Refractory cases were evaluated by arthroscopy and treated by arthroscopic thermal shrinkage using radiofrequency appliance as an interim or definite surgical intervention. Shrinkage was targeted at the ulnocarpal ligament at the radiocarpal joint and triquetrohamate ligament at the midcarpal joint. Nonresponsive or recurrent cases were managed by a novel technique of dorsal radiocarpal ligament reconstruction procedure using a pisiform-based split flexor carpi ulnaris (FCU) tendon graft.

Results In all cases, the midcarpal clunk test was positive with pain. Other common clinical features included lax ulnar column, carpal supination, volar sagging of the wrist, increased pisostyloid distance, wrist pain aggravated by passive hand supination and not by passive forearm supination, and increased wrist pain upon resisted pronation, which could be partially alleviated by manually supporting the pisostyloid interval. Common arthroscopic findings were excessive joint space at triquetrohamate interval and reactive synovitis over the ulnar compartments. Nine patients (56.3%) responded well to splinting alone at an average follow-up of 3.3 years. Arthroscopic thermal shrinkage was performed in five patients with recurrence in two patients. Five patients received split FCU tendon graft for ligament reconstruction. All patients showed improvement in the wrist performance score (preop 21.0, postop 36.6 out of 40) and pain score (preop 10.0, postop 2.2 out of 20) at the final follow-up of average 86 months (range: 19–155 months). Grip strength improved from 66.9 to 82.0% of the contralateral side. Wrist motion slightly decreased from a flexion/extension arc of 132 to 125 degrees. Three patients were totally pain free, one had mild pain, and one

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had moderate fluctuating pain. All patients returned to their original works. X-ray showed no arthrosis.

Conclusion PMCI is an uncommon but significant cause of chronic ulnar wrist pain. We have developed a clinical algorithm for diagnosis of the condition. The natural history seems to favor a benign course. Conservative treatment with an antecarpal supination splint is recommended as the initial management. Surgical options for resistant cases include arthroscopic thermal shrinkage or soft tissue reconstruction. The reconstruction of the dorsal radiocarpal ligament using a pisiform-based split FCU tendon graft provides reliable restoration of the carpal stability with good long-term outcome and few complications. This should be considered a viable alternative to limited carpal fusion.

Symptomatic midcarpal joint instability is an uncommon clinical entity. It was included in the concept of nondislocative type of carpal instability as advocated by Dobyns et al in 1985,¹ where there is no disruption of the intrinsic ligaments connecting the carpal bones. Instead, the culprit is the abnormality of the extrinsic ligaments linking the radiocarpal joint and/or the midcarpal joint.

Midcarpal instability was first described by Mouchet and Belot in the French literature in 1934.² It remained largely neglected until the 1980s when Lichtman et al published a major series of patients with similar presentation and treatment.³ Their original series in 1981 described 10 patients with volar sagging of the midcarpal joint together with history of painful snapping triggered by ulnar deviation and pronation of the wrist,³ in which the term ulnar midcarpal instability was noted. In 1993, Lichtman et al renamed the condition as palmar midcarpal instability (PMCI) to distinguish it from other forms of midcarpal instability.⁴ In 1997, Lichtman et al further classified the midcarpal instability into four types: palmar, dorsal, combined, and extrinsic type.⁵ The PMCI is the most common. The pathomechanics of the PMCI is considered to be resulted from the laxity of both the dorsal radiocarpal ligament and the palmar ulnar arcuate ligament (triquetrohamate-capitate ligament).^{6–8} Recent studies suggest that periscaphoid ligament injury may also produce similar pattern of instability.^{9–11} Etiology can be congenital, traumatic rupture, attenuation, increased elasticity, or poor proprioception.^{11,12} The incompetent ligaments allow sagging of the head of capitate and hamate in the midcarpal joint that induces a volar intercalated segmental instability (VISI) pattern in the entire proximal carpal row. In this subluxed position, the normal joint force cannot translate normally from the proximal row to the distal row. The smooth transition of the proximal carpal row from flexion to extension during ulnar deviation of the wrist is prohibited. The VISI pattern remains unchanged until the last phase of ulnar deviation has reached, during which the force across the helical triquetrohamate joint is reengaged. This leads to a rapid catch up clunk, as the proximal row jumps back from excessive flexion into the normal physiological extension, and the head of capitate

and hamate are relocated completely. In simple terms, the functional loss of the longitudinal midcarpal ligament constraints leads to hypermobility of the proximal carpal row relative to the radius and the distal carpal row. This results in inability to control its normal kinematics when the joint is subjected to dynamic joint reactive force.^{13,14}

Diagnosis of the PMCI is largely clinical. It is well recognized that the midcarpal shift test and the midcarpal clunk, as demonstrated clinically and videofluoroscopically are the diagnostic gold standard of the condition.¹⁵ However, it is also well known that asymptomatic laxity at the midcarpal joint is common, especially in individuals with generalized ligament laxity.¹⁶ There are also multiple causes of painful clunking in the wrist that may confuse the diagnosis. Controversy exists in the recommendation of treatment, which ranges from conservative splinting, arthroscopic thermal shrinkage, soft tissue reefing, and reconstruction to limited carpal fusion.^{17,18}

This article reviews our experience in managing this challenging condition in 16 patients, enabling us to develop a set of clinical diagnostic criteria to differentiate from other disease entities and the treatment algorithm based on the outcome.

Patient Series

Between 2000 and 2011, 16 patients were diagnosed as PMCI according to our clinical diagnostic criteria described in "Diagnosis Algorithm." There were seven male and nine female patients, with an average age of 33.9 (range, 23–53). The dominant right wrist was involved in all except one case. The average duration of symptoms before presentation was 14 months (range, 1–48 months). All except one patient presented as chronic ulnar wrist pain that interfered patient's normal work or sport activities. Ten patients had painful clicks and clunks in the affected wrists. Seven patients complained of easy fatigue or weaken handgrip, while eight patients reported a sense of wrist instability. History of trauma was noted in 10 patients (62.5%). Among them, six had definite trauma incident, while four experienced minor spraining of the wrist. Five cases were reported as injury at workplace.

Fig. 1 A patient showing carpal supination of her right wrist at rest when it is looked end on. The carpal supination can be easily reduced by using the thumb pushing pisiform bone upward.

Diagnosis Algorithm

The diagnosis was established based on a systematic wrist examination. The purpose of the examination was to elicit the typical signs of the PMCI and rule out other common causes of ulnar side wrist pain with or without association of a painful clunk. The patient was seated facing the examiner so that both wrists can be easily observed and compared. They are first examined for generalized joint laxity according to the criteria of Beighton.¹⁹ With both shoulders forwardly flexed and upper limbs held straight, the affected wrist was observed from the frontal view for carpal supination (►Fig. 1). The carpal supination could be reduced by pushing the pisiform dorsally using the examiner's thumb. From the lateral view, carpal volar sagging was observed. The amount of relative sagging could be measured from the "pisostyloid" distance, the distance between the dorsal tip of ulnar styloid and the volar margin of the pisiform (►Fig. 2). The pisostyloid distances of both wrists should be measured for comparison. If the distal radioulnar joint (DRUJ) is normal, any increase in the pisostyloid distance indicates a volar sagging and supination of the proximal carpal row.

Fig. 2 Increased distance between ulnar styloid and pisiform (pisostyloid distance) indicating volar sagging of the proximal carpal row.

Next, the wrist was palpated for major local tenderness, especially on the ulnar aspect of the wrist over the ulnocarpal joint and the midcarpal joint. Several specific provocative tests were then performed to confirm the presence of the PMCI and detect or eliminate other sources of pain in the wrist. It is important to maintain the affected wrist in a relaxed status, as any reflex muscle guarding would mask the subtle physical signs of instability.

1. With the elbow rested on the table and the wrist held in a relaxed status, the DRUJ was balloted for instability. The forearm was then held in its proximal location and manually rotated to a fully pronated position followed by a fully supinated position. Any pain at the DRUJ during the maneuver was observed, which indicated that the source of pain probably arose from the DRUJ or peripheral part of triangular fibrocartilage complex (TFCC). The hand was then held at the metacarpal level and similarly rotated to a fully pronated position and then to a fully supinated position, while pain was being observed. Typically, a patient with PMCI alone would have no or minimal wrist pain upon forearm rotation, but the pain exacerbates during passive hand supination, which exaggerates the abnormal tendency for carpal supination.
2. Ulnocarpal stress test was performed to rule out ulnocarpal joint pathology, such as a central tear of the triangular fibrocartilage complex or ulnocarpal joint synovitis. The wrist was held in ulnar deviated position, and grinding force was applied with the wrist in varying degrees of extension and flexion.
3. The ulnar column laxity was elicited. To examine the right wrist, the surgeon placed his/her left hand on the radial and central aspect of the patient's wrist holding the radial metacarpus, carpus, and the distal radius together. The examiner then used his/her right hand to hold on the pisotriquetrohamate complex on the ulnar column of the wrist and performed ballottement of the ulnar column in a dorsovolar direction to detect excessive laxity (►Fig. 3). Both wrists were compared. To differentiate from the

Fig. 3 Laxity demonstrated on ballotting the ulnar column.

Fig. 4 Resisted pronation confrontation test. When the surgeon uses his hand to manually stabilize the ulnar column of the affected wrist, the patient feels stronger and less painful on resisted pronation action.

- lunotriquetral (LT) instability, the Reagan direct LT ballottement test was then performed.²⁰ An abnormally lax ulnar column in the presence of a normal LT joint stability indicated instability at the ulnar midcarpal joint.
4. The carpal Shuck's test was performed.²⁰ With the distal forearm manually stabilized, the whole carpus was balloted back and forth to demonstrate excessive translation of the proximal carpal row that might have been associated with pain. The midcarpal shift test as described by Lichtman was then performed.^{3,5} To increase the sensitivity of the test, the author applied a carpal supination force in addition to a radially deviated and palmary directed force on the capitate region to exaggerate the carpal sagging and subluxation between the hamate and the triquetrum. The midcarpal clunk was then demonstrated when the wrist was passively ulnar deviated, while axial loading, carpal pronation, and upward thrust were maintained to allow the sudden catch up engagement of the hamate on the triquetral articulation. The midcarpal shift test was considered positive only when the clunk was associated with significant pain alike the usual symptoms of the patient.
 5. The resisted pronation confrontation test was performed (► **Fig. 4**). The examiner held the patient's hand in a pronated position, and the patient was instructed to resist a supination force produced by the examiner. Typically, significant pain and giving way were experienced. The examiner then used his/her other hand to manually stabilize the ulnar column of the affected wrist. This can be achieved by putting the thenar eminence of the examiner's hand on the pisiform area while the other four fingers are gripping onto the dorsal surface of the distal radius but without touching the DRUJ. The gripping action helps to reduce the carpal supination, and the patient typically feels stronger and less painful on resisted pronation action. Once the examiner releases his/her grip, the midcarpal joint subluxates, the pain quickly resumes, and the patient predictably gives way instantaneously.
 6. The extensor carpi ulnaris (ECU) tendon was examined to rule out ECU tendon subluxation or tendonitis.

After a clinical diagnosis was established, standard posterior–anterior and lateral X-ray views with the forearm in neutral rotation were taken in all patients. Videofluoroscopy was not performed routinely if the clinical diagnosis was certain. In selected cases, computed tomography (CT) scan, magnetic resonance imaging, and diagnostic wrist arthroscopy were performed to evaluate the causes of the pain.

Conservative Treatment

All patients were initially treated with a course of conservative treatment for 3 to 6 months. The regime included nonsteroidal anti-inflammatory medication, modification of daily activities and work, avoidance of provoking action, proprioceptive training for extensor carpi ulnaris and hypothenar muscle, and customized splinting (► **Fig. 5**). We typically prescribed an anticarpal supination splint incorporating a self-adjustable strap wrapping around the ulnar side of the wrist obliquely from the pisiform volarly toward the radial aspect of distal radius dorsally to provide a counter support to the ulnar column of the wrist and revert the carpal supination tendency²¹ (► **Fig. 6**). We occasionally injected steroid to the midcarpal joint to alleviate pain caused by synovitis and achieved temporary pain relief.

Arthroscopic Thermal Shrinkage

Patients who failed in conservative management were candidates for surgical treatment. Arthroscopic thermal shrinkage was performed under portal site local anesthesia without tourniquet and sedation.²² The affected wrist was suspended in a wrist traction tower using plastic fingers traps applying to the middle three fingers under 10 to 12 lb of traction force. Fluid irrigation was maintained with a 3 L bag of saline solution under the aid of gravity. Both radiocarpal and midcarpal joints were explored using small

Fig. 5 The application of a self-adjustable anticarpal supination splint.

transverse incision. In the radiocarpal joint, a 1.9- or 2.7-mm arthroscope was inserted through the 3-4 portal, while other arthroscopic instruments were introduced from the 4-5 portal. An initial synovectomy using a 2-mm shaver was performed over the ulnocarpal ligament until the ligaments were well exposed. The ligaments were usually prominent and lax looking. The ulnocarpal ligament was then tackled with a bipolar thermal shrinkage probe systematically from the radial border near the sigmoid notch to its ulnar most aspect at the prestyloid recess. The endpoint was the loss of the surface luster of the ligament with fiber condensation, as well as shrinking of the ulnocarpal joint space. There was usually no obvious color change on the surface of the ligaments. The wrist traction force should be reduced to less than 5 lb during the process to minimize tension on the ligament.

The midcarpal joint was then explored through the midcarpal radial portal. A 2-mm shaver was then introduced through the midcarpal ulnar portal to access the triquetro-

hamate interval. The joint was typically spacious in the PMCI situation. Synovectomy was performed both in the dorsal and volar aspect of the ulnarmidcarpal joint, followed by the insertion of a thermal shrinkage probe. The target for shrinkage was the triquetrohamatecapitate ligament on ulnar palmar surface of the midcarpal joint until the joint volume reduced (→**Fig. 7**). Multiple short bursts of energy, each of them lasting for no longer than 2 seconds, were delivered to avoid an excessive rise in the local tissue temperature. Fluid drainage was maintained via an 18-G needle inserted at the triquetrohamate portal²³ to provide ventilation. The dorsal ligaments were not tackled to avoid iatrogenic injury to the extensor tendons just next to the dorsal capsular structures. During the process, the patient was constantly checked for the sensation and motion of the ulnar digits to detect for possible injury to the ulnar nerve and the extensor tendons in the vicinity by the thermal energy delivered. This was made possible using just local anesthesia at the portals and the joint capsule to conduct the surgery. The wounds were

Fig. 6 The carpal supination and volar sagging are corrected with the anticarpal supination splint.

Fig. 7 Thermal shrinkage applied to the triquetrohamate ligament.

apposed with Steri-Strips. The wrist was immobilized with a below elbow cast for 4 weeks before gradual mobilization exercise was allowed.

Dorsal Radiocarpal Ligament Reconstruction with Pisiform-Based Split Tendon Graft of Flexor Carpi Ulnaris

Since 2001, we developed a novel surgical technique of soft tissue reconstruction to restore the stability and kinematics of the midcarpal joint. The aim of our surgery was to reconstruct the dorsal radiocarpal ligament using a pisiform-based split tendon graft of flexor carpi ulnaris (FCU, ▶**Fig. 8**). The graft was delivered from the palmar side of the wrist to the dorsal side via a bone tunnel in the triquetrum. The graft was then directed toward Lister's

tubercle for fixation. The reconstructed ligament helped to reduce the volar sag of the proximal carpal row and reverse the carpal supination by imparting a pronation torque to the proximal row. The tension of the graft transferred to the pisiform on the palmar side firmly anchored to the triquetrum to suspend the ulnar palmar side of the midcarpal joint.

The operation was performed under general or regional anesthesia with the use of tourniquet. A 4-cm curvilinear incision was made radial to the pisiform and extended proximally along the radial border of the FCU tendon. The ulnar neurovascular bundle was preserved. The FCU tendon was identified at the wrist crease level and half split with knife. Another small longitudinal incision was made 6 to 8 cm proximal to the wrist crease along the FCU tendon. A thick wire suture was passed through the split tendon at the distal end. Both ends of the wire were then directed underneath the skin in the subcutaneous plane to reach the proximal wound. With the wrist positioned in maximum extension, the wire was pull proximally to allow the tendon to split continuously till reaching the proximal wound (▶**Fig. 9**). A length of split FCU tendon graft of 6 to 8 cm could be obtained, with the distal end being attached to the pisiform (▶**Fig. 10**). The tendon was then delivered subcutaneously to the distal wound at the level of pisiform. The split tendon was further dissected till the tendon attachment junction on the pisiform could be seen.

The wrist was then turned to the dorsal side. A 2-cm transverse incision was made between the triquetrum and Lister's tubercle. The extensor digiti minimi tendon was retracted radially to expose the dorsal surface of the triquetrum. Under the control of an image intensifier, a 2.7-mm bone tunnel was created on the triquetrum just proximal and

Fig. 8 Schematic diagram showing the design of the pisiform-based split FCU tendon graft redirected from volar forearm to dorsal wrist through a bone tunnel at the triquetrum, to be attached to Lister's tubercle to simulate the action of the dorsal radiocarpal ligament. FCU, flexor carpi ulnaris.

Fig. 9 Splinting of the FCU tendon using metal wire through two small incisions. FCU, flexor carpi ulnaris.

radial to the pisiform from a palmar to dorsal direction using a cannulated drill (**Fig. 11**). The ulnar neurovascular bundle and the extensor tendon were carefully protected. The split FCU tendon graft was then delivered to the dorsal wound through the bone tunnel using a 2-mm small grasper

(**Fig. 12**). The tendon graft was then directed toward Lister's tubercle by passing it underneath all the extensor tendons of the digit (**Fig. 13**). Initially, we fixed the tendon with bone suture anchors at Lister's tubercle. Later on, we modified the technique by making a small 2.7-mm drill hole transversely

Fig. 10 The split FCU tendon graft is divided proximally and dissected distally till the insertion area at the pisiform. FCU, flexor carpi ulnaris.

Fig. 11 Bone tunnel is created at the triquetrum from a volar to dorsal direction under an image intensifier after the ulnar neurovascular bundle is carefully protected.

at the base of Lister's tubercle (→**Fig. 14**). The tendon graft was passed through the drill hole, being pulled tight to reduce the carpal supination to a neutral position, and then was sutured back to itself using 2-0 Ethibond suture in Pulvertaft manner (→**Fig. 15**). After fixation of the half-slip FCU tendon, the volar carpal sagging and the ulnar column laxity should be normalized. No K-wire fixation was needed. The wounds were closed with subcuticular stitches. The wrist was immobilized in a below elbow plaster in neutral position for 4 weeks. All patients with ligament reconstruction were assessed by an occupational therapist before the index procedures, during and at the final follow-up. The range of motion of the wrist, grip power, wrist functional performance score, pain score, and return to work status were charted. The wrist functional performance score developed by our hospital was modeled on the findings of Nelson.²⁴ It consisted of 10 common standardized tasks of activities of daily living (ADL) to be performed by the patient under the scrutiny of an occupational therapist.^{24,25} The performance on each task was rated by the therapist according to a 4-point scale, giving a maximum total of 40 for a normal performance of the complete test. A pain score of a 3-point scale was rated by the patient according to the pain level perceived during the performance of each ADL task.

The total score ranged from zero to a maximum pain level of 20 points.

Result

In all cases, painful midcarpal clunks could be elicited on the affected hand. However, none of the patients could make voluntary clunking on active deviation. Nonpainful clunks were also demonstrated in the opposite hand in six patients. Eight patients (50%) had signs of generalized ligament laxity. Ulnar column laxity and resisted pronation confrontation test were positive in all cases. Volar sagging, carpal supination, and increased pisostyloid distance were noted in all except two patients. Radiographic findings were normal in 10 patients. VISI pattern was noted in the other six wrists. Scapholunate and lunotriquetral intervals were normal in all wrists. One patient has received ulnar shortening osteotomy. CT scan was performed in four, MRI in four, and bone scan in one patient with no specific finding. Diagnostic wrist arthroscopy was performed either prior to the index treatment procedure or at the same therapeutic arthroscopy in eight patients. All showed copious joint space at the ulnar side of the radiocarpal and midcarpal joints and reactive synovitis. Additional findings included articular cartilage wear in two,

Fig. 12 The tendon graft is being delivered from the volar wound to the dorsal wrist using a small mosquito grasper inserted through the bone tunnel.

TFCC tear in two, and tear of lunotriquetral ligament of Geissler grade 3 in one patient.

Nine patients (56.3%) responded well to splint treatment alone. They were followed up for an average of 3.3 years

(range, 0.5–7.75 years). Among them, five patients reported no pain and four patients reported reduced pain compared with pretreatment. All of them were able to resume their original duty and were satisfied with the treatment outcome.

Fig. 13 The tendon graft is delivered underneath all the extensor tendons of the hand to reach Lister's tubercle in an oblique direction.

Fig. 14 A drill hole is being made at Lister's tubercle to allow the tendon graft to be delivered through it and to be looped back onto itself before tightening.

Fig. 15 The final knotting of sutures over the tendon graft.

One patient remained asymptomatic despite very marked VISI deformity of the left wrist with capitulate angle of 46 degrees and scapholunate angle of 42 degrees. The opposite side exhibited a similar degree of VISI pattern, though the wrist had never been symptomatic.

Seven patients failed conservative treatment and received further surgical treatment. Four patients were treated with arthroscopic thermal shrinkage without any complications. Two patients did well while two other patients required revision soft tissue reconstruction surgery after 13 and 54 months, respectively, because of the persistent wrist pain. Three other patients proceeded directly to dorsal radiocarpal ligament construction with a pisiform-based split FCU tendon graft. The soft tissue reconstruction group was followed for an average of 86 months (range, 19–155 months). All patients showed an improvement in the wrist performance score (preop, 21.0 ± 9.7 ; postop, 36.6 ± 4.5 out of a 40-point scale) and pain score (preop, 10.0 ± 2.1 ; postop, 2.2 ± 3.0 out of a 20-point scale). Grip strength improved from 66.9 ± 33.6 to $82.0 \pm 20.6\%$ of the contralateral side. Wrist motion slightly decreased from a flexion/extension arc of 132.0 ± 23.0 degrees ($87.5 \pm 11.6\%$ of contralateral side) to 125.0 ± 7.1 degrees ($80.1 \pm 7.3\%$ of contralateral side). Three patients were totally pain free, one had mild residual pain, and one had moderate fluctuating pain. All patients returned to their original works. Clinical examination showed negative midcarpal shift test, shuck test, ulnar column laxity, and carpal supination in all cases (**Fig. 16**). Passive supination and resisted pronation confrontation test did not provoke pain in all except one patient at the final follow-up. Ulnar nerve function was intact in all patients, and there was no pain at the pisotriquetral joint. Radiological examination showed no arthrosis of the wrist joint. A sclerotic rim was seen over the bone tunnel at the triquetrum. Pisotriquetral joint space was normal compared with opposite hand and no arthritis was observed (**Fig. 17**).

Discussion

Among all types of nondissociative carpal instability, PMCI is perhaps the most common and most frequently reported condition. Its incidence is unclear, as many cases are misdiagnosed and/or undertreated. The natural history of PMCI is also unknown. It is an important consideration on the management in view of a high incidence of asymptomatic and probably physiological midcarpal clunking in the normal population, especially among the people with hypermobile joints. Symptomatic PMCI may or may not be preceded by injury episode. It is not uncommon for the pain and symptoms to be triggered off by a relatively minor spraining of the wrist. Whether trauma history will affect the clinical course and outcome of PMCI remains unknown.

Diagnosis of the condition is often not easily made. Conventionally, the midcarpal shift test and the midcarpal clunk, as demonstrated clinically and videofluoroscopically, are regarded as the diagnostic gold standard of the condition.¹³ In clinical practice, there are many differential diagnoses for chronic ulnar wrist pain associated with painful clunk. The clinician may find it difficult to decide whether a positive midcarpal shift test is accountable for all the symptoms in a patient. Coexisting wrist pathology may complicate the scenario. Unfortunately, the role of many currently available investigatory modalities is limited. VISI pattern is the classic radiological feature but not often observed. Tears of the extrinsic ligaments can be demonstrated with MR arthrography and probably with CT arthrography, but intact, yet redundant, ligaments are more difficult to identify. The exact role of these investigations in the diagnosis, categorization, and management of midcarpal instability has yet to be determined.²⁶ Diagnostic wrist arthroscopy generally reveals no specific abnormality, though it helps to rule out dissociative causes of carpal instability and other intra-articular pathology of the wrist. Clinical evaluation therefore

Fig. 16 Clinical outcome of a patient having 14 years of follow-up. Note that clinically carpal supination is eliminated. There is no evidence of arthrosis of the pisotriquetral joint.

remains the mainstay for diagnosis and assessment of severity. Thus, we believe there is a need to develop a more instructive diagnostic algorithm to help taking decisions on the diagnosis.

Our systematic approach of inspection, palpation, and provocative testing of the affected wrist and to compare the behavior of the opposite unaffected wrist proves to be helpful in making the diagnosis. The philosophy is to target on

Fig. 17 Long-term radiological outcome of the procedure at 13 years. There is no arthrosis noted.

those common conditions, which can lead to a painful ulnar wrist with clicks and clunks. These include TFCC tear, DRUJ instability, ulnocarpal synovitis, lunotriquetral ligament injury, and ECU tendon subluxation. All patients presented with chronic ulnar wrist pain and/or painful wrist clunk over their dominant hands. In contrast to the published studies, only 62.5% (10/16) of patients experienced painful clicks and clunks in their daily lives. Trauma history is not a common feature as only six patients (37.5%) reported a definite injury episode that led to the onset of pain. Based on the findings of our patients, the salient diagnostic clinical features of the PMCI include

- (1) carpal volar sagging and supination deformity,
- (2) increased pisostyloid distance in the presence of a normal DRUJ stability on ballottement,
- (3) positive tenderness on palpation over the ulnocarpal and midcarpal joint area,
- (4) negative passive forearm pronation-supination stress test but positive hand passive supination stress test,
- (5) a lax ulnar column in the presence of a negative LT ballottement test,
- (6) positive Shuck's test,
- (7) positive midcarpal shift test with painful clunk reproduced,
- (8) positive resisted pronation confrontation test,
- (9) negative ECU tendon subluxation, and
- (10) generalized laxity of joint (50%).

Since midcarpal clunk is common among normal population and many patients have no definite history of trauma, conservative treatment at the initial management is logical. Many articles suggested this model of treatment but few commented on the effectiveness of the regime.^{6,11,12,27} Lichtman et al reported an improvement of symptoms in 6 patients out of a series of 10 patients. Wright reported a good to excellent result in 57% of treatment group.²⁷ In our series, nine patients (56.3%) responded well to conservative treatment for 3 to 6 months at an average follow-up period of 3.3 years. We are not sure whether the pain resolved spontaneously, or eliminated with the splint and muscle strengthening regime or simply due to pain adaptation or modification of life routines. Giving the relatively high response rate, we think conservative treatment should be recommended to all patients with PMCI. More aggressive surgical treatment should be offered only when the patients clearly fail conservative treatment after a reasonable period of time. Our antcarpal supination splint is similar to the design of ulnar boost splint described by Chinchalkar.²⁸ The Velcro strap provides a dorsoradially directed force to control the carpal supination based on the pisotriquetral articulation and a dorsal support to the volar sagging tendency of the ulnar carpus. In contrast to the ulnar boost splint, our splint also restricts the motion of the wrist in various directions as we consider immobilization appropriate to quiescent the frequently occurring synovitis associated with carpal instability and hypermobility, which is the immediate source of wrist pain.

Seven patients in our series failed in conservative treatment and required surgical treatment. Four of them received arthroscopic thermal shrinkage under local anesthesia. In all cases, the midcarpal joints were found to be stabilized at the end of the procedure, and the wrists were immobilized with plaster cast for 4 to 6 weeks. Two cases had recurrence of symptoms and signs at approximately 6 months after the surgery without any further trauma and eventually required open reconstruction. Mason and Hargreaves²⁹ first reported the use of arthroscopic thermal capsulorrhaphy for PMCI in 2007. They presented a prospective study in 15 wrists of 13 patients with 100% follow-up at an average of 42 (range, 14–67) months. History of injury was present in 6 out of 13 patients, and the average symptom duration was 5 years. They used a 2.4-mm diameter monopolar radiofrequency probe and applied energy to the ulnar arm of the palmar arcuate ligament (ulnocapitate, ulnotriquetral, and triquetrocipitate ligaments) as well as the radial arm (radioscaphocapitate, long and short radiolunate ligaments) and accessible part of the dorsal capsule in both the radiocarpal and midcarpal joints. Postoperative immobilization with a Futuro splint was prescribed for 6 weeks. They reported no complication. Eleven wrists showed improvement and four had complete resolution of instability. Wrist motion was reduced by a mean of 16 degrees in flexion and 10 degrees in extension. Disabilities of the Arm, Shoulder and Hand (DASH) score improved from 38 preoperatively to 17 at the final follow-up. Our result was less favorable in comparison. We used bipolar radiofrequency apparatus and did not shrink the ligaments on the radial limb of the arcuate ligament. In addition, we performed minimal shrinkage on the dorsal structures due to fear of iatrogenic damage on the extensor tendons nearby. As the result of open soft tissue reconstruction appearing more promising and predictable, we are now less inclined to offer arthroscopic thermal shrinkage to patients, unless the patients have less than significant symptoms, are reluctant for open surgery, and are willing to bear the risk of suboptimal outcomes.

Controversy exists on the optimal surgical treatment for PMCI. This is likely due to the lack of consensus and understanding on the pathomechanism and the ligament lesions, which account for the instability. It has been shown in laboratory studies that sectioning of the ulnar limb of the palmar arcuate (triquetrohamatecapitate) ligament and/or the dorsal radiotriquetral ligament could produce a VISI deformity and wrist pathomechanics of PMCI.^{7,8} Lichtman et al also demonstrated in vivo that tightening of the dorsal radiotriquetral ligament alone could stabilize the proximal row and eliminate the clunk of PMCI.³⁰ It remains unclear of which ligament lesion starts first in the pathogenesis and the relative contribution of each ligament lesion to the instability. The secondary constraint to the instability was also not studied, but this can have significant contribution in chronic instability.

Early soft tissue reconstruction combined some reefing procedures, including distal advancement of the palmar arcuate ligament, dorsal radiocarpal capsulodesis, and imbrication of the palmar radioscaphocapitate ligament and

the palmar radiolunotriquetral ligament to close the space of Poirer. Outcome had been suboptimal and was only recommended for milder cases. Lichtman et al compared the results of their midcarpal fusions with soft tissue reconstruction in 13 patients who had 15 surgical procedures in 1993 and confirmed the advantage of midcarpal arthrodesis.⁵ Goldfarb reported similar results of four-corner fusion with satisfactory outcome in seven of eight patients with PMCI.³¹ The mean follow-up of this study was short (35 months), and there was significant loss of motion with a combined extension–flexion arc dropping from 145 degrees preoperatively to 75 degrees at follow-up. Rao and Culver noted less successful result with triquetrohamate fusion in 11 patients.³² They still preferred midcarpal fusion to ligamentous reconstruction for more reliable pain relief and elimination of the midcarpal clunk. Other soft tissue reconstruction design involved tissue augmentation using tendon graft. Garcia-Elias had suggested weaving a strip of extensor carpi radialis brevis dorsal to volar through the capitate, then volar to dorsal through the triquetrum, attaching the free end to the radiotriquetral ligament dorsally.¹⁰ The design theoretically restored the palmar and dorsal support to the proximal carpal row simultaneously. No clinical data had been published on the outcome. It also appeared technically demanding to work around tight spaces in the wrist with potential neurological and tendon complications. Chaudhry described a new procedure using the palmaris longus tendon graft fixed with bone anchor to reconstruct the dorsal triquetrohamate ligament to stabilize the hamate and triquetrum.³³ At a relatively short follow-up of 28 (range, 17–37) months, four out of six patients had mild or no pain. Flexion and extension were reduced to 71 and 81% of the opposite side, respectively. Grip strength increased from 15 to 21 kg.

Our surgical design on the soft tissue reconstruction focused on restoring the dorsal radiocarpal ligament using a tendon graft to control the carpal sagging and supination as the primary goal while to boost the support on the palmar side taking advantage of the pisiform from which the tendon graft takes the base. The surgical dissection on the palmar side was confined to Guyon's canal region and was considered less complicated than the Garcia-Elias approach. The pisiform provided a strong anchor for the split FCU tendon graft to transfer appropriate tension to the triquetrum and hence to correct the proximal carpal row when it was being redirected to Lister's tubercle for fixation. The endpoint of correction was easy to judge as long as the carpal supination was fully corrected. The oblique placement of the graft following the anatomical alignment of the dorsal radiocarpal ligament also reduced the amount of motion loss after the surgery, especially on the flexion range. Our satisfactory outcome on a long-term follow-up of an average of 86 months confirmed the durability of this surgical reconstruction. Range of motion was well preserved in most patients. The concern on the potential rise in the pisotriquetral joint pressure and arthrosis risk was lessened when we observed no radiological or clinical abnormality in this region at the latest follow-up of the patients.

Conflict of Interest
None.

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