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RADIAL WRIST EXTENSORS AS A DYNAMIC STABILIZERS OF SCAPHOLUNATE COMPLEX

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Wrist stabilization is ensured by the complex of stabilizers, both static (intrinsic and extrinsic ligaments) and dynamic ones (flexor and extensor sinews of the wrist). Extrinsic carpal ligaments link both carpal rows with forearm, while the intrinsic ones connect individual carpal bones. From among intrinsic ligaments, the most significant from clinical point of view is scapholunate ligament (scapholunate lig. – SL). Instability of the SL resulting from SL ligament tear is the most frequent type of carpal instability. If untreated or undiagnosed, it may lead to destabilization of the carpal rows, and in the final stage to massive degenerative changes with SLAC (scapholunate advanced collapse).

The aim of the study was to present a hypothesis of a possible influence of radial extensors of the wrist as dynamic stabilizers for SL complex, based on which it is possible to discern the partial ligament tear with accompanying damage of static stabilizers of the complex.

Material and methods. This hypothesis was based on radiological tests carried out on 5 patients, with acute partial SL ligament tear, which was confirmed during wrist arthroscopy. The outcome was presented as well, with its visualization in radiological tests.

Results. The picture of rotary subluxation of the scaphoid –signet ring sign in PA view and strengthening in stress position (clenched fist) was demonstrated in all 5 patients. In 2 patients who had wrist arthroscopy performed it was observed that the palmar and proximal part of SL ligament were injured, yet no damage of dorsal part was reported. In MRI tests of these patients, an additional injury of dorsal intercarpal ligament was revealed.

Conclusions. Correction of the scaphoid reduction in position of clenched fist may result from influence of radial extensors of the wrist (both short and long) as dynamic stabilizers of SL complex. This imagining is a completion of the radiological symptoms so far occurring in this SL instability. In case of acute, partial scapholunate ligament tear, reduction of scapholunate subluxation and its internal fixation with the lunate and capitate for a 6-week period may be an optional procedure.

Key words: scapholunate instability, scapholunate dissociation, rotatory subluxation of the scaphoid, radial wrist extensors, flexor carpi radialis, dynamic stabilizers

When speaking about the wrist, it is difficult to refer to it as one joint. In fact it should be referred to as wrist complex or even complexes of carpal joints. It is because starting from distal radioulnar joint and radiocarpal as well as ulnocarpal, via mediocarpal joint or between individual wrist bones (like scapholunate or lunate triquetrum) and finishing at metacarpal articulations, we are faced with rows of articular complexes and not with a single complex alone. Destabilization of any of these complexes may lead to painful ailments, reduction of mobility and in consequence it may cause irreversible degenerative changes. Axial load of the forearm in 80% moves onto the radiocarpal joint, and only 20% of the load via ulnocarpal joint and triangular fibrocartilage complex „TFCC", which constitues a prolongation of the joint surface for radiocarpal joint so as to create a homogenous „antebrachiocarpal" joint. Carpal rows cooperate with each other in such a way that the mainly closer row is responsible for extension, and the more distant one for wrist flex-

ion. Radial and ulnar deflection takes place mainly in radiocarpal joint.

Various theories have been formed on biomechanics of the wrist. In majority of them, however, it is the scaphoid that plays the most crucial role in stabilizing the two carpal rows. In certain theories, the scaphoid must share this role with the triquetrum. It may be compared to scales, where the lunate acts like the central slider and ligaments are the crosswise beam: scapholunate and lunate-triquetrum. The index of balance would be the capitate, also connected with this complex by means of intrinsic ligaments: scaphocapitate and capitotriquetral. Movements occurring in this complex are similar to the ones that can be observed on a balance scale, during the axial load exerted by the capitate onto the lunate, the scaphoid will show a tendency to flex, the triquetrum will extend (fig. 1). In order to sustain such forces occurring in such small joints, the wrist may not function properly without additional stabilizers, which in addition could keep balance of carpal complexes. Such stabilization is ensured by the whole system of ligaments, both extrinsic (connecting carpal rows with neighboring joints) as well as intrinsic ones (connecting individual wrist bones) (1, 2, 3).

Stabilizers of scapholunate complex

The most crucial is the complex of ligaments ensuring scapholunate stability. At the same time it is the part most frequently prone to injury. Apart from scapholunate ligament, whose dorsal part is the thickest (3 mm) and the strongest, there exist another row of ligaments, the so-called additional or secondary stabilizers for scapholunate complex. Simultaneous tear of scapholunate ligament along with secondary stabilizers leads to „prolapsing" of the scaphoid from this complex and its rotary subluxation (scaphoid radial angle in lateral view ≥ 45°) (fig. 2). We can include the following to the system of secondary stabilizers: static stabilizers (extrinsic and intrinsic ligaments) and dynamic stabilizers (sinews stabilizing the wrist).

Secondary static stabilers include:

– dorsal ligaments:
  a) radiotriquetrum ligament – dorsal radiocarpal (RTq lig.)
  b) dorsal intercarpal ligament (DIC lig.)
– palmar (volar) ligaments:
  a) radio-scapho-capitate ligament (RSC lig.)
  b) scaphocapitate ligament (SC lig.)
  c) scapho – trapezial – trapezoidal ligament (connecting the scaphoid, trapezium and trapezoid – STT lig.)
  d) short and long radio-lunate ligaments (SRL, LRL) (1, 2, 4, 5).

Part of sinews stabilizing the wrist belong to do dynamic stabilizers of scapholunate complex. Garcia Elias (6) in year 2010 described the possibility of the flexor carpi radialis (FCR) acting as dynamic stabilizer of this complex, via its direct contact with scaphoid tuberosity on the way to attachment on the palmar side of the basis of second metacarpal bone. In his

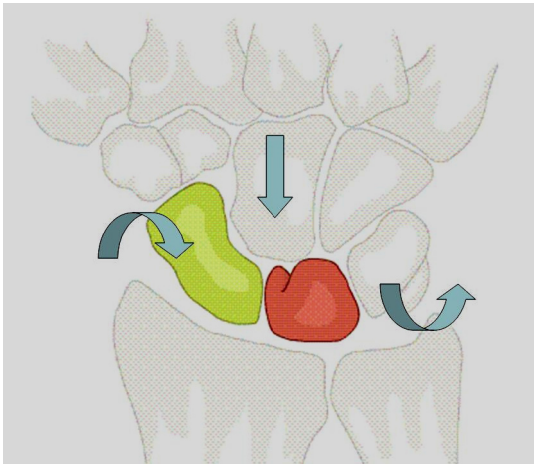

Fig. 1. As a result of axial load exerted by the capitate, the scaphoid will have the tendency to flex, triquetrum to extend

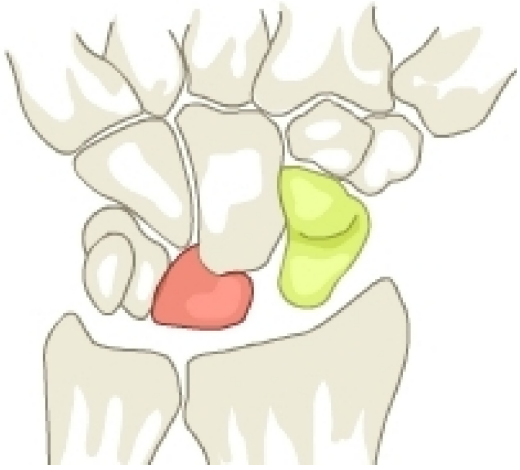

Fig. 2. Rotary subluxation of the scaphoid as a result of secondary stabilizers for scapholunate complex with DISI deformation type

opinion, also the extensor carpi radialis brevis (ECRB), due to its anatomical position, may be in turn a dynamic stabilizer for the lunate through direct influence straightening the capitate, by exerting more force onto the palmar part of the lunate-capitate joint, which in turn may protect against unfavorable tendency of the lunate to straighten up. Liaison of these two sinews is aimed at preventing from movement of flexing the scaphoid and extending the lunate, which will additionally dynamically stabilize this complex. He is of the opinion that in case of partial scapholunate ligament tear (dorsal part of the ligament preserved), the strength of tension of FCR sinew exerts impact that protects from dorsal subluxation of the pole closer to the scaphoid. However, in case when a complete ligament tear occurs, with its dorsal part included, it may lead to dislocation of the scaphoid with dorsal subluxation of the closer pole by the very force exerted by FCR sinew. The same author in 2013 excluded the hypothesis of possibility to straighten the scaphoid by means of FCR sinew. When carrying out his research, he described that the scaphoid when axially loaded will always have a tendency to flex regardless of impact of the FCR sinew. Also the trapezium applies flexing, and not straightening action on the scaphoid (7).

Radiological signs of scapholunate instability

In case of acute, even complete disjunction of scapholunate ligament, without the accompanying injury of the so-called secondary stabilizers, a regular wrist X-ray in PA view may show no visual changes indicating pathology or it may reveal minor changes, which for an inexperienced surgeon will be of little significance. This is why, in case of uncertainty regarding the integrity of scapholunate complex (severe wrist pain in its radial-central part) we should perform the so-called image in "stress" view, i.e. "clenched fist". In case of scapholunate ligament tear, this integrity shall be disturbed and presented on an X-ray as a gap between the scaphoid and lunate. Such picture of instability is a sign of its dynamic nature- it may only be visualized only in stress views. A limit to 2 mm was settled for suitable width of the gap between the scaphoid and the lunate. Limit from 3 to 5 mm may indicate partial scapholunate ligament tear or at its dynamic nature (fig. 3) (3), while a gap equal or greater than 5 mm indicates a complete ligament tear –Terry Thomas's sign (5, 6). Presence of this gap in turn in natural PA view for the wrist shall indicate a static nature of the instability (fig. 4). Additional radiological sign indicating scapholunate instability is the so-called rotary subluxation of the scaphoid visible on the X-ray in PA view as „signet ring sign". It is because apart from scapholunate ligament tear, we also deal with damage of secondary stabilizers of this complex, both dorsal (DIC) and palmar (SC, STT) ligaments. Illustration of the so-called ring sign is not always related to scapholunate ligament tear, just as not every scapholunate ligament tear is illustrated in radiological test as ring sign. Ring sign is deemed positive only when rotary subluxation of the scaphoid is still visible at ulnar deviation by min. 13°, it is at the same time confirmation of the static character of subluxation. Another radiological sign is the value of radioscaphoid angle in lateral view $\geq 45^{o}$, radioscaphoid system shall be depicted in shape of letter „V", where in normal conditions radioscaphoid relation is in letter „C" shape (3, 6, 8)

Other described radiological signs will be difficult to estimate by an inexperienced surgeon. These are signs occurring mainly in scapholunate static instability, visible in wrist

Fig. 3. Predynamic scapholunate instability with partial scapholunate tear – gap ≤ 3 mm

Fig. 4. Static scapholunate instability – complete scapholunate ligament injury (gap ≥ 5 mm); A – without rotary subluxation of the scaphoid, B – with palmar subluxation of the scaphoid

lateral view and indicating the already present deformation of DISI type (dorsal intercalated segment instability) and at the disturbed balance on one side between the scaphoid and lunate (scapholunate angle > 60°, lunate-capitate angle > 15°) (fig. 5), while on the other side vertically in the long axis between the capitate, lunate and radius.

MATERIAL AND METHODS

Five patients (3 women and 2 men aged 13-48) with fresh injuries of the wrist had standard radiological study of the wrist perfumed in PA and lateral view. Moreover, all patients had radiological tests in one stress view (clenched fist) carried out. Also, for comparative purposes, the same examinations were done in all projections mentioned above for the other „healthy" wrist. Two patients were subject to MRI examination of the wrist, where apart from scapholunate ligament tear, also dorsal intercarpal ligament tear was described (DIC) (fig. 6). These patients had wrist arthroscopy performed. 3 other patients did not agree to the proposed operative treatment.

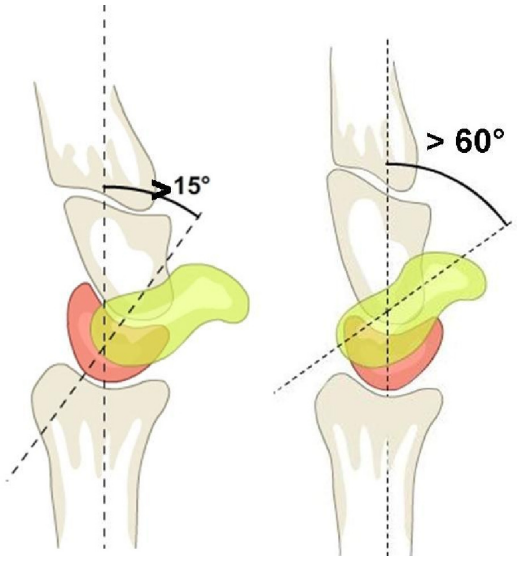

Fig. 5. In case of rotary subluxation of the scaphoid (scapholunate angle > 60°, lunate-capitate angle > 15°)

RESULTS

In PA views of injured wrists, rotary subluxation of the scaphoid (ring sign) was visualized. In all cases of stress view, extension of the scaphoid occurred in these wrists with the presence of a small gap between the scaphoid and lunate (≤ 3 mm) (fig. 7, 8). In all patients a positive Watson's maneuver was observed. Radiological test of healthy wrists showed a correct picture of scapholunate complex in all patients. In one patient the same symptom was observed at the accompanying fracture of distal radius. In patients who had wrist arthroscopy performed, during which partial scapholunate ligament tear was confirmed (visible damage from radiocarpal joint (fig. 9) without changes from midcarpal joint), an additional arthroscopic synovectomy was run, ligament tear edges were refreshed, the scaphoid was reduced and internal fixation by means of "K" wires was done (now without traction but under X-ray control) (fig. 10). „K" wires were kept for the period of 6 weeks (6,

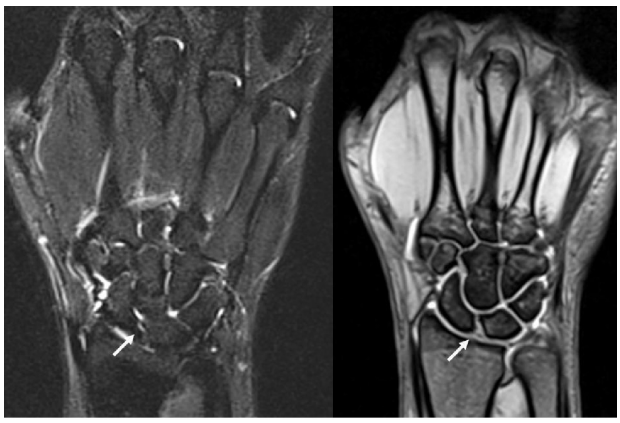

Fig. 6. MRI – partial scapholunate ligament tear

Fig. 7. Radiological test on the same female patient (31 years): A-C right hand, A – PA view in neutral position (visible rotary subluxation of the scaphoid), B – stress test (clenched fist) of the wrist shows extension of the scaphoid with no clear gap between the scaphoid and lunate, C – lateral view (scaphoid radial angle 61º), D-F left hand, D – healthy wrist in PA view in neutral position, E – healthy wrist in stress view, F – lateral view of healthy wrist (scaphoid radial angle 46º)

9). Scaphoid radial angle after this period amounted to less than 45°.

Radial wrist extensors as dynamic stabilizers of scapholunate complex

While lack of possibility of FCR sinew influence on straightening the scaphoid, the presented radiological tests of these patients may indicate a major participation of the very radial wrist extensors in dynamic instability in partial scapholunate tear with the accompanying damage of secondary stabilizers. Anatomical arrangement of these sinews was presented in fig. 11, and the possible mechanism of such action was shown in fig. 12 and 13. It seems that it is a result of influence of radial wrist extensors, during their tensioning in clenched fist position- (extensor radialis longus {ECRL} by exerting direct impact on the scaphoid, and extensor radialis brevis {ECRB} onto the capitate and lunate). Such action is possible only at partial scapholunate ligament tear and with palmar subluxation of the scaphoid.

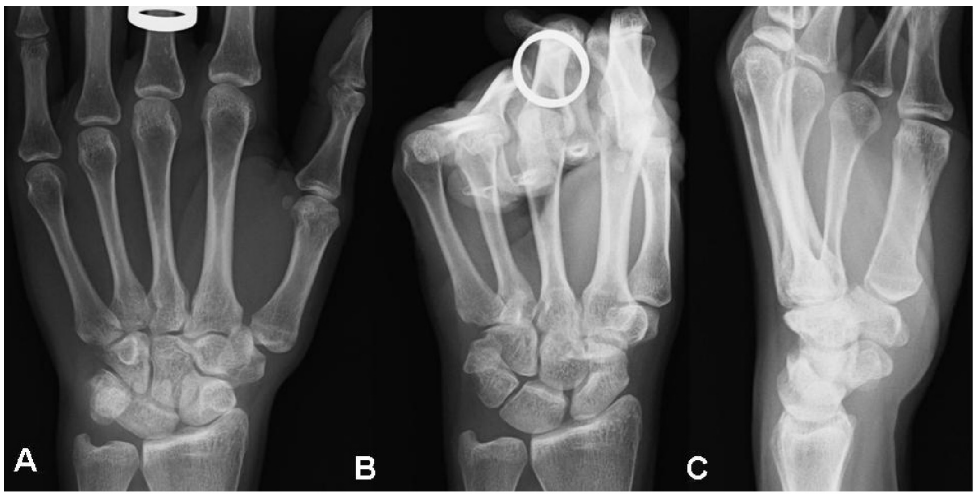

Fig. 8. Radiological test of unhealthy bone (26 years), A –PA view in neutral position (visible rotary subluxation of the scaphoid), B – stress test (clenched fist) shows extension of the scaphoid without clear gap between the scaphoid and lunate, C – lateral view (scaphoid radial angle 62º)

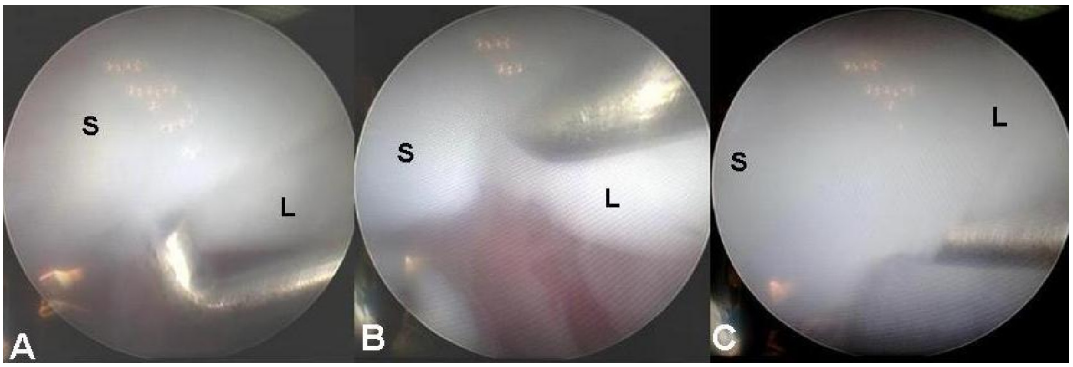

Fig. 9. Intraoperative pictures from wrist arthroscopy (3-4 portal); A – visible minor scapholunate ligament tear, B – probe migration between bones, C – detectable resistance in distal (undamaged) part of the ligament, not allowing for distal manipulation by means of the probe. S – scaphoid, L – lunate

DISCUSSION

Numerous authors believe that the breakthrough in diagnosing, classifying and treatment of wrist instability was the elaboration by Linscheid's in 1972 (10). After this time a myriad of different authors started to scrutinize anatomy and biomechanics of the wrist and to describe various operating methods of these instabilities, in particular instability of scapholunate, as well as the results of their treatment (11-23). The idea of participation of the sinew of the wrist radial flexor in strengthening of the scaphoid has already been described (6, 24); as mentioned earlier, however, the hypothesis proved incorrect (7). Salva-Coll and the afore-mentioned (25) demonstrated in their researches that the scaphoid shall be rotated in flexion and supination during FCR sinew's tensioning, at the same time the triquetrum in flexion and pronation, while the capitate in pronation. Reverse position of these bones was observed during relaxation of the dorsal part of scapholunate ligament. The same author in another work (26), investigated the participation of all sinews stabilizing the wrist (FCR, FCU, ECU, ECRL and APL). He established that while simultaneous tensioning of all these sinews, the first row on the wrist is positioned in flexion and supination. For comparative purposes, tensioning of ulnar

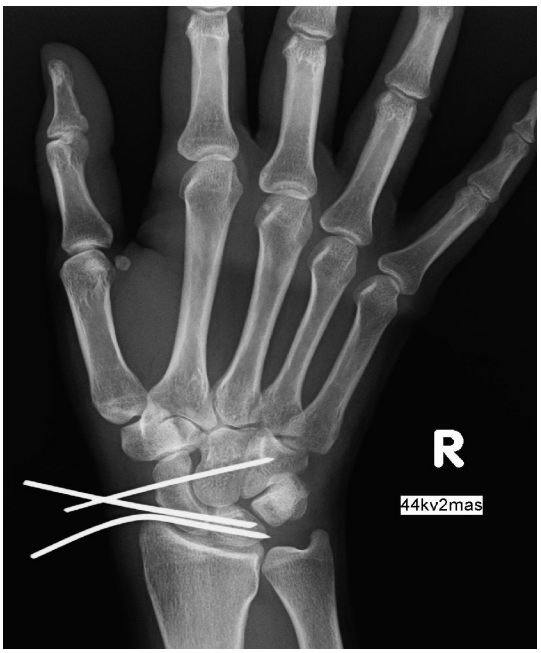

Fig. 10. The same wrist after reduction of the scaphoid and fixation by means of „K" wires two wires with the lunate, 1 wire with the capitates

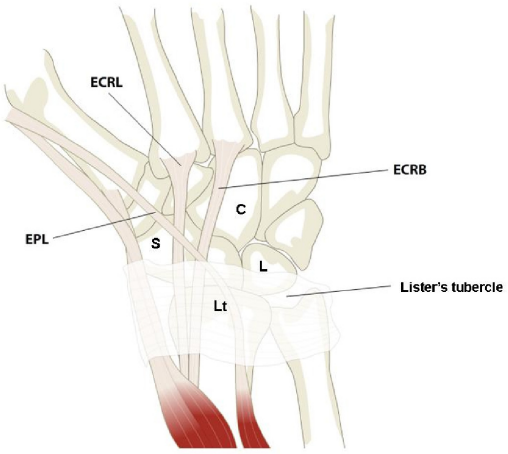

Fig. 11. Diagram demonstrating anatomical arrangement of radial wrist extensors in relation to scapholunate complex, EPL – extensor pollicis longus, ECRL – extensor carpi radialis longus, ECRB – extensor carpi radialis brevis, S – scaphoid, C – capitate, L – lunate, Lt – Lister's tubercle

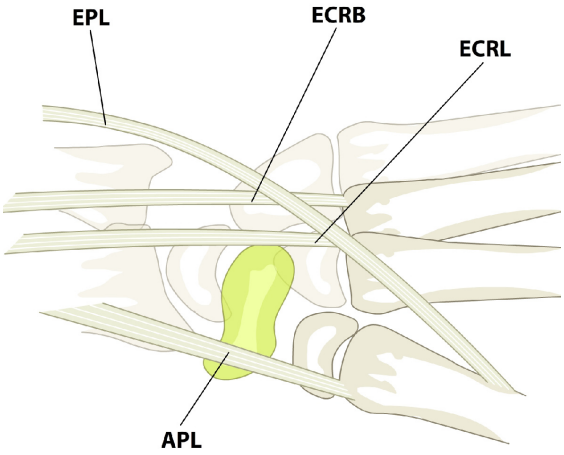

Fig. 12. Diagram presenting rotary subluxation of the scaphoid (yellow bone) in the wrist in neutral position with partial injury of SL tear and injury of ligaments that provide secondary stabilization of scapholunate complex. EPL – extensor pollicis longus, ECRB – extensor carpi radialis brevis, ECRL – extensor carpi radialis longus, APL – abductor pollicis longus

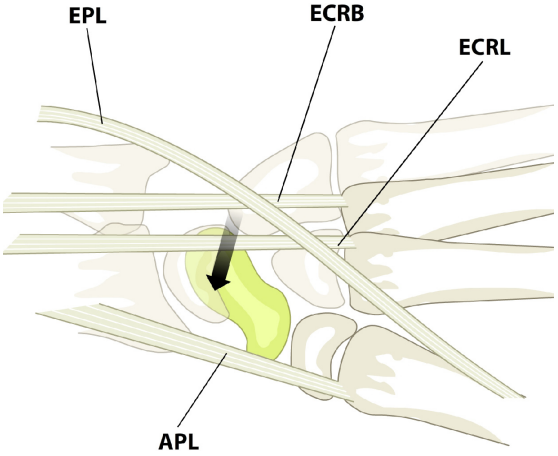

Fig. 13. Diagram demonstrating extending of the scaphoid via influence of radial wrist extensors – mainly ECRL (black arrow). EPL – extensor pollicis longus, ECRB – extensor carpi radialis brevis, ECRL – extensor carpi radialis longus, APL – abductor pollicis longus

extensor of the wrist (ECU) alone resulted in pronation of both carpal rows. He therefore divided the sinews into pronators (ECU and FCR) and supinators (FCU, ECRL and APL) of the wrist. Participation of all supinators of the wrist in extending of the scapholunate is possible provided that we are talking about scapholunate instability in partial scapholunate tear (preserved dorsal part of the ligament), yet with damage to ligaments that provide secondary stabilization of scapholunate complex (rotary subluxation of the scaphoid). In "clenched fist" position though it is the wrist radial extensors that probably have a higher degree of tension; therefore, a concept of such action may lead to image visualization of the "extended" scaphoid in an X-ray analysis of the afore-mentioned injury. Also scaphoid-radial angle, which in case of the described patients was greater than 45° in „clenched fist" position and in lateral view it will be less than 45° and close to the same angle of a healthy wrist.

CONCLUSIONS

1. Picture of rotary subluxation of the scaphoid – signet ring sign in PA view and strengthening this bone in the stressed position (clenched fist) may result from influence of radial wrist extensors as dynamic stabilizers of scapholunate complex (ECRB on lunate and ECRL on scaphoid).
2. Demonstration of these symptoms in a radiological test may indicate partial scapholunate ligament tear (preserved dorsal part of the ligament) and failure of static stabilizers of this complex.
3. This type of injury may be depicted in acute injuries (up to 3 weeks) and/or subacute (up to 6 weeks) tears of scapholunate ligament.
4. In case of acute, partial scapholunate ligament tear, reduction of scapholunate subluxation and its internal fixation with lunate and capitate for a 6-week period may be an optional procedure.
5. In case of subacute, partial scapholunate ligament tear, such a procedure should be preceded by wrist arthroscopy with evaluation of the ligament quality and the possible refreshment of its edges, in order to create possibilities for its primary healing.
6. Detailed knowledge oh biomechanics of stabilizers both static (extrinsic and intrinsic ligaments) and dynamic ones (sinews stabilizing the wrist) of scapholunate complex is necessary in order to properly diagnose and treat these injuries and to confirm or reject this hypothesis.

REFERENCES

1. Anatomy and Biomechanics Committee of the IFSSH. Position Statement: Definition of Carpal Instability. *J Hand Surg* 1999; 24A: 866-67.
2. *Short WH, Werner FW, Green JK, Masaoka S:* Biomechanical evaluation of the ligamentous stabilizers of the scaphoid and lunate: Part II. *J Hand Surg* 2005; 30A: 24-34.
3. *Trail IA, Stanley JK, Hayton MJ:* Twenty Questions on carpal instability. *J Hand Surg Eur* 2007; 32: 240.
4. *Żyluk A, Piotuch B:* The management of scapholunate wrist instability: A review. *Polish Orthopedics and Traumatology* 2012; 77: 83-89.
5. *Żyluk A., Piotuch B., Mazur A:* Niestabilność łódeczkowo-księżycowata nadgarstka – przegląd piśmiennictwa. *Chir Narządów Ruchu i Ortop Pol* 2011; 76(3): 175-81.
6. *Garcia-Elias M:* Carpal instability w: Green's Operative Hand Surgery. VI wyd. Philadelphia: Elsevier 2010; 481-94.
7. *Garcia-Elias M:* Understanding wrist mechanics: a long and winding road. *J Wrist Surg* 2013; 2: 5-12.
8. *Ozçelik A, Günal I, Köse N:* Stress views in the radiography of scapholunate instability. *Eur J Radiol* 2005; 56(3): 358-61. Epub 2005 Jul 19.
9. *Darlis NA, Kaufmann RA, Giannoulis F* et al.: Arthroscopic debridement and closed pinning for chronic dynamic scapholunate instability. *J Hand Surg* 2006; 31A: 418-24.
10. *Linsceid RL, Dobyns JH, Beabout JW* et al.: Traumatic instability of the wrist. Diagnosis, classification and pathomechanics. *J Bone Joint Surg Am* 1972; 54(8): 1612-32.
11. *Talesinik J:* The ligaments of the wrist. *J Hand Surg Am* 1976; 1(2): 110-18.
12. *Mayfield JK, Johnson RP, Kilcoyne RK:* Carpal dislocations: pathomechanics and progressive perilunate instability. *J Hand Surg Am* 180; 5(3): 226-41.
13. *Berger RA, Blair WF, Crowninshield RD* et al.: The scapholunate ligament. *J Hand Surg Am* 1982; 7(1): 87-91
14. *Blatt G:* Capsulodesis in reconstructive hand surgery. Dorsla capsulodesis for the unstable scaphoid and volar capsulodesis following excision of the distal ulna. *Hand Clin* 1987; 3(1): 81-102.
15. *Cooney WP, Garcia-Elias M, Dobyns JH* et al.: Anatomy and mechanics of carpal instability. *Surg Rounds Orthoped* 1989; 10: 15-24.
16. *Horii E, Garcia-Elias M, An KN* et al.: A kinematic study of lunotriquetral dissociations. *J Hand Surg Am* 1991; 16(2): 355-62.
17. *Cooney WP, Linsceid RL, Dobyns JH:* Carpal instability: treatment of ligament injuries of the wrist. *Instr Course Lect* 1992; 41: 33-44.
18. *Brunelli GA, Brunelli GR:* A new technique to correct carpal instability with scaphoid rotary subluxation: a preliminary report. *J Hand Surg Am* 1995; 20(3 Pt 2): S82-85.
19. *Van Den Abbeele KL, Loh YC, Stanley JK* et al.: Early results of a modified Brunelli procedure for scapholunate instability. *J Hand Surg Br* 1998; 23(2): 258-61.
20. *Garcia-Elias M:* Treatment of scapho-lunate instability. *Ortop Traumatol Rehabil* 2006 28; 8(2): 160-68.
21. *Garcia-Elias M, Lluch AL, Stanley JK:* Three-ligament tenodesis for the treatment of scapholunate dissociation: indications and surgical technique. *J Hand Surg Am* 2006; 31(1): 125-34.
22. *Harvey EJ, Berger RA, Osterman AL* et al.: Bone-tissue-bone repairs for scapholunate dissociation. *J Hand Surg* 2007; 32A: 256-64.
23. *Szabo RM, Slater RR, Palumbo CF, Gerlach T:* Dorsal intercarpal ligament capsulodesis for chronic, static scapholunate dissociation: clinical results. *J Hand Surg* 2002; 27: 978-84.
24. *Janeta CL, An KN, Linsceid RL* et al.: The role of the scapho-trapezial-trapezoidal ligament complex on scaphoid kinematics. W edycji: Schuind F, An KN, Cooney WP III i wsp. Advances in the Biomechanics of the Hand and Wrist. New York, NY: Plenum Pres; 1994: 345-61.
25. *Salva-Coll G, Garcia-Elias M, Llusa-Perez M* et al.: A The role of flexor carpi radialis muscle in scapholunate instability. *J Hand Surg Am* 2011; 36(1): 31-36.
26. *Salva-Coll G, Garcia-Elias M, Leon-Lopez MT* et al.: Effect of forarm muscles on carpal stability. *J Hand Surg Eur Vol* 2011; 36(7): 553-59.

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