

Submitted:
30.12.2020
Accepted:
23.03.2021
Published:
07.06.2021

Ultrasound evaluation of the scapholunate ligament and scapholunate joint space in patients with wrist complaints in a rheumatologic setting

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DOI: 10.15557/JoU.2021.0019

Keywords

synovitis,
power Doppler
ultrasound,
scapholunate
ligament,
synovial ganglion
cysts

Abstract

Aim: The aims of the study were to perform an ultrasound assessment of the dorsal portion of the scapholunate interosseous ligament and scapholunate joint space in patients with wrist complaints in a rheumatologic setting, to describe ultrasound abnormalities about scapholunate interosseous ligament region, and to correlate them with clinical data, presence of dorsal ganglion cysts and diagnoses of rheumatic diseases. **Material and methods:** Seventy-four consecutive patients with wrist pain and/or swelling were evaluated by routine power Doppler ultrasound. Forty normal wrists were studied to confirm the normality values of the scapholunate joint. **Results:** The mean width of the normal scapholunate joint was 2.49 mm (± 0.49 SD), with a coefficient of variation on repeated measurements of 3.662%. The best predictors of scapholunate interosseous ligament degeneration were: older age ($p < 0.0001$), male gender ($p = 0.0049$), and radiocarpal effusion ($p = 0.0156$). The presence of osteophytosis and calcifications of the scapholunate joint were higher ($p < 0.001$) in rheumatic patients. Scapholunate calcifications showed a sensitivity of 98.2% and a specificity of 61.1% for calcium pyrophosphate deposition disease. Dorsal ganglion cysts were more frequent in younger subjects ($p < 0.0012$) without rheumatic conditions ($p < 0.0001$) or midcarpal synovitis ($p < 0.0001$). Larger cysts often exhibited power Doppler signal ($p < 0.0001$). The best predictors of scapholunate dissociation were: male gender ($p = 0.0002$), presence of midcarpal synovitis ($p < 0.0137$), and higher grade of scapholunate interosseous ligament degeneration ($p < 0.0001$). Scapholunate widening was greater ($p = 0.0419$) in calcium pyrophosphate deposition disease or rheumatoid arthritis than in other rheumatic conditions. **Conclusions:** Ultrasound findings of scapholunate interosseous ligament degeneration and calcification, scapholunate space enlargement, and dorsal ganglion cysts should be considered in ultrasound reporting, since they add useful information about the diagnosis of associated rheumatic conditions.

Introduction

The scapholunate interosseous ligament (SLIL) is the primary stabilizing ligament between the scaphoid and lunate bones⁽¹⁾. SLIL is a U-shaped structure composed of three distinct parts: the dorsal, the proximal (or membranous) and the volar. The dorsal component of the SLIL is composed of short, transversely oriented collagen fibers, and it is the thickest and strongest portion, therefore playing the most crucial role in midcarpal stabilization. The proximal

or membranous part is principally composed of fibrocartilage and extends into the scapholunate joint space, resembling a meniscus. Finally, the volar portion consists of thinner collagen fascicles^(1,2).

Traumatic injuries or progressive degenerative changes of SLIL can lead to internal derangement of carpal bones^(3,4), instability of midcarpal joints (often associated to production of synovial ganglion cysts), and eventually to scapholunate advanced collapse (SLAC), which is the most common

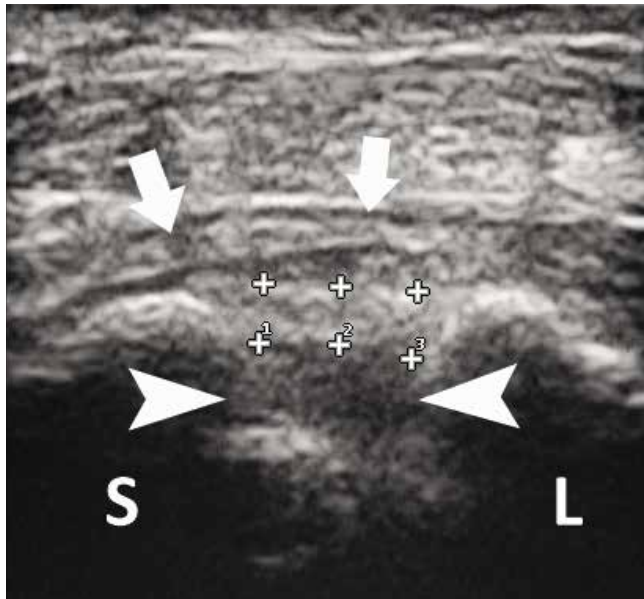


Fig. 1. Axial dorsal scan on a normal wrist (10–22 MHz transducer). The scapholunate interosseous ligament appears as an echoic band (between calipers) connecting scaphoid (S) and lunate (L) bones. The ligament shows regular and homogeneous thickness, without discontinuity. The dorsal capsule (arrows) lies over the scapholunate joint

cause of osteoarthritis involving the wrist⁽⁵⁾. Both calcium pyrophosphate dihydrates (CPPD) crystal deposition disease (CPDD) arthropathy and rheumatoid arthritis (RA) are rheumatologic conditions associated with wrist instability and SLAC^(6–9).

In case of nontraumatic wrist pain, and especially in the suspicion of rheumatologic diseases, the evaluation

of internal wrist derangement is often neglected, as the majority of clinical and imaging studies are focused on synovitis⁽¹⁰⁾. Moreover, even if ultrasound (US) and power Doppler US (PDUS) has been extensively used in rheumatologic settings to detect wrist synovitis, scanty US studies have assessed degenerative changes of radiocarpal and midcarpal joints⁽¹¹⁾, and recent guidelines have ruled US as a second-choice technique or not appropriate for SLIL evaluation^(12,13).

The improvement of US systems with high resolution transducers has improved the quality of evaluation of SLIL and the scapholunate space, defining its measurements in healthy subjects^(14,15). Moreover, wrist ganglia are not infrequently associated with internal derangement of the wrist, and are characteristically located close to the SLIL^(14,16,17). Dorsal synovial cysts of the wrist can sometimes exhibit vascular signals on PDUS, and they can be misinterpreted as a radiocarpal synovitis.

In this context, we aimed to describe US abnormalities of the SLIL region in patients referring for wrist pain and/or swelling in a rheumatologic secondary setting, and to correlate these findings with clinical data, presence of dorsal ganglion cysts and conclusive diagnoses of associated rheumatic conditions.

Patients and methods

Seventy-four consecutive outpatients (28 males, 46 females, mean age 59.2 years) referred in our secondary care setting for unilateral or bilateral wrist pain and/or swelling, were evaluated between December 2019 and August 2020, with routine bilateral PDUS examination by an expert rheumatologist sonographer, at the beginning of the diagnostic

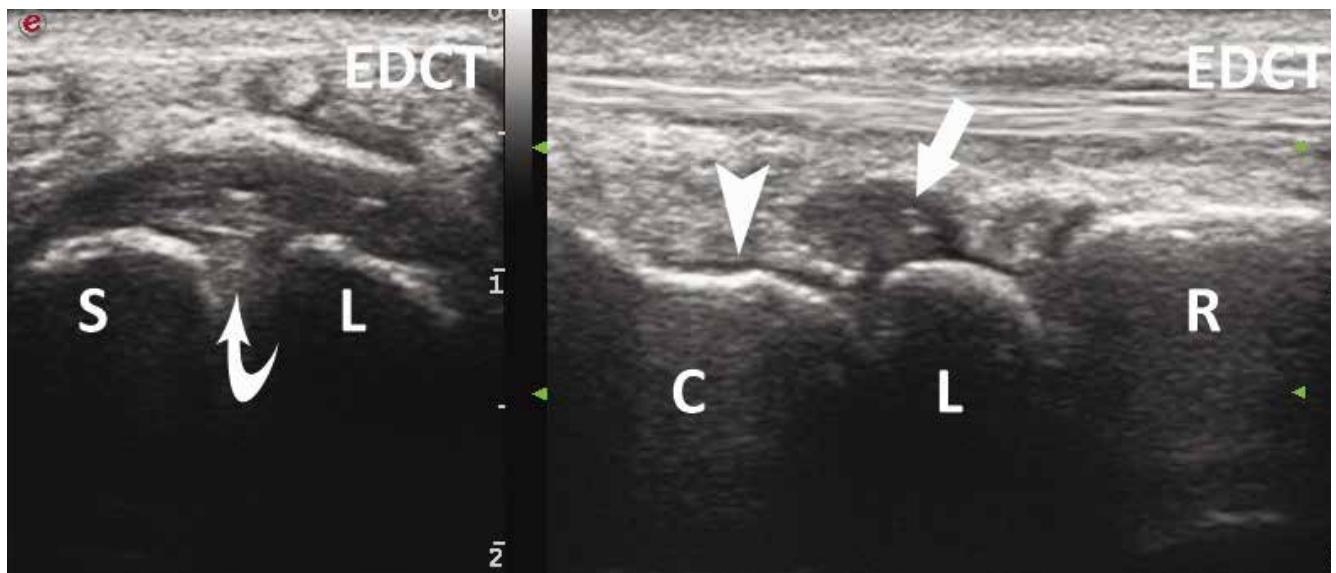


Fig. 2. Dorsal scans on a symptomatic wrist (6–18 MHz transducer). Left side: axial scan. Moderate degeneration of scapholunate interosseous ligament (curved arrow), with inhomogeneous and hypoechoic echostructure, maldefinition and convexity of superficial profile. Right side: longitudinal scan. A hypoechoic synovial ganglion cyst (straight arrow) is visible below the deep surface of extensor digitorum communis tendon (EDCT). Note the absence of fluid in the midcarpal synovial space (arrowhead)

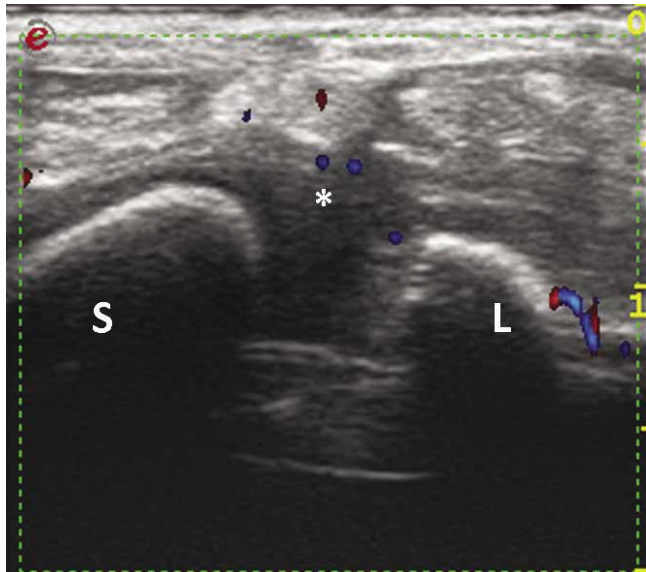


Fig. 3. Dorsal axial scan on a rheumatoid wrist (6–18 MHz transducer). Severe degeneration of scapholunate interosseous ligament (absence of definite ligamentous structure), with dissociation >3.5 mm between scaphoid (S) and lunate (L) bones, consistent with scapholunate advanced collapse (SLAC). Active synovitis (asterisk) is detectable in the synovial space, as hypoechoic undisplaceable material with power Doppler signals

3 sub-groups: 1 – no rheumatic disease or biomechanical conditions, 2 – degenerative diseases (osteoarthritis), 3 – inflammatory rheumatic diseases (rheumatoid arthritis, spondylarthritis, connective tissue diseases, crystal deposition diseases).

At the time of examination, the sonographer was blinded to the patient's definite diagnosis. Each patient underwent bilateral dynamic B-mode US and PDUS examination of both wrists with a standardized scanning method⁽¹¹⁾. PDUS was performed using an Esaote MyLab Twice (Esaote SpA, Genoa, Italy) unit equipped with broadband 6–18 MHz (LA435) and 10–22 MHz (SL3116) linear transducers and standardized B-mode and Doppler settings, which were optimized for all examinations. The Doppler parameters included pulse repetition frequency within 500–750 Hz and Doppler frequency within 6.3–11.1 MHz.

The scapholunate region was studied in longitudinal and axial dorsal scans. A dynamic scanning technique (using slight movements of the probe from side to side, and rotation) was carried out in order to allow the best visualization of the dorsal portion of SLIL and the scapholunate space (between the radial margin of the dorsal horn of the lunate and the ulnar-dorsal margin of the scaphoid, as described by Manske⁽¹⁴⁾). The width of the scapholunate joint was measured at the central interval, immediately underneath the dorsal portion of SLIL, as reported by Manske⁽¹⁴⁾. The mean value of three repeated measurements was recorded for each wrist. The examination was first completed with the 6–18 MHz transducer, while the 10–22 MHz device was eventually used to better define the smallest details of ligament structures.

Degenerative changes of SLIL were recorded and graded on a 3-point scale where: 0 = normal SLIL (linear

pathway. The exclusion criterion was a history of major trauma of the wrist or hand region.

All patients were clinically re-evaluated at the end of the diagnostic pathway, when a definite diagnosis of rheumatic disease was available (the diagnosis was based on shared diagnostic criteria and the experience of the referring rheumatologist). The whole group was then divided into

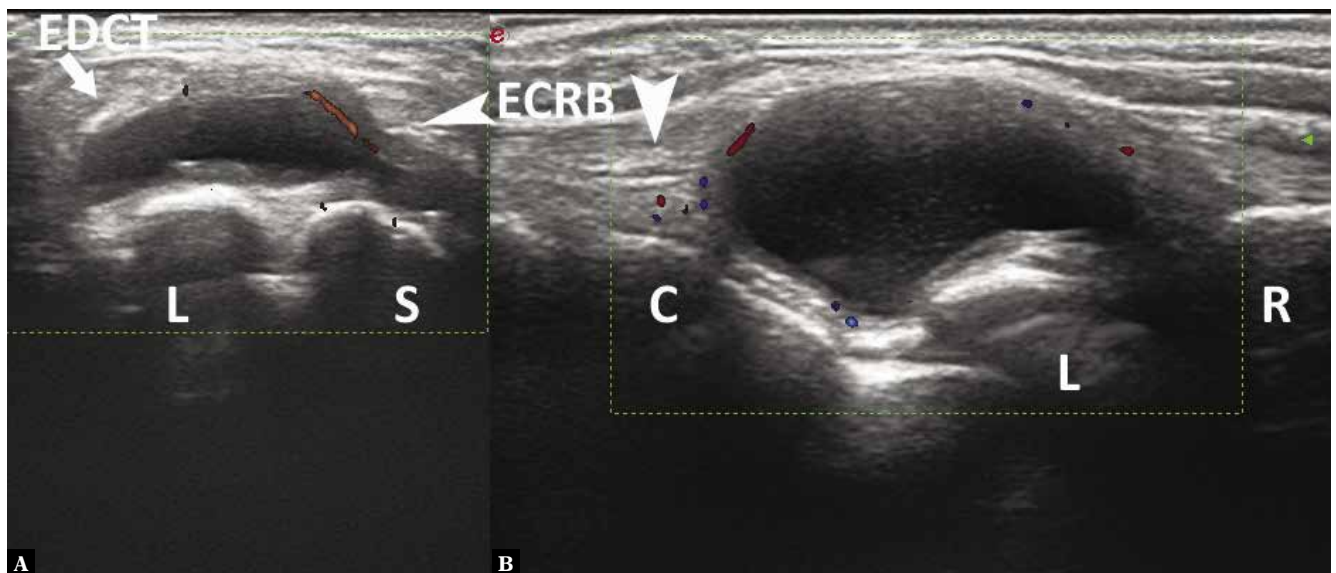


Fig. 4. Dorsal scans on a symptomatic wrist (6–18 MHz transducer), healthy subject. Left side (A): axial scan. A hypoechoic synovial ganglion cyst is visible between the extensor digitorum communis tendon (EDCT) and extensor carpi radialis brevis (ECRB) tendon. Right side (B): longitudinal scan. Power Doppler signals are detected along the wall of the voluminous synovial ganglion cyst

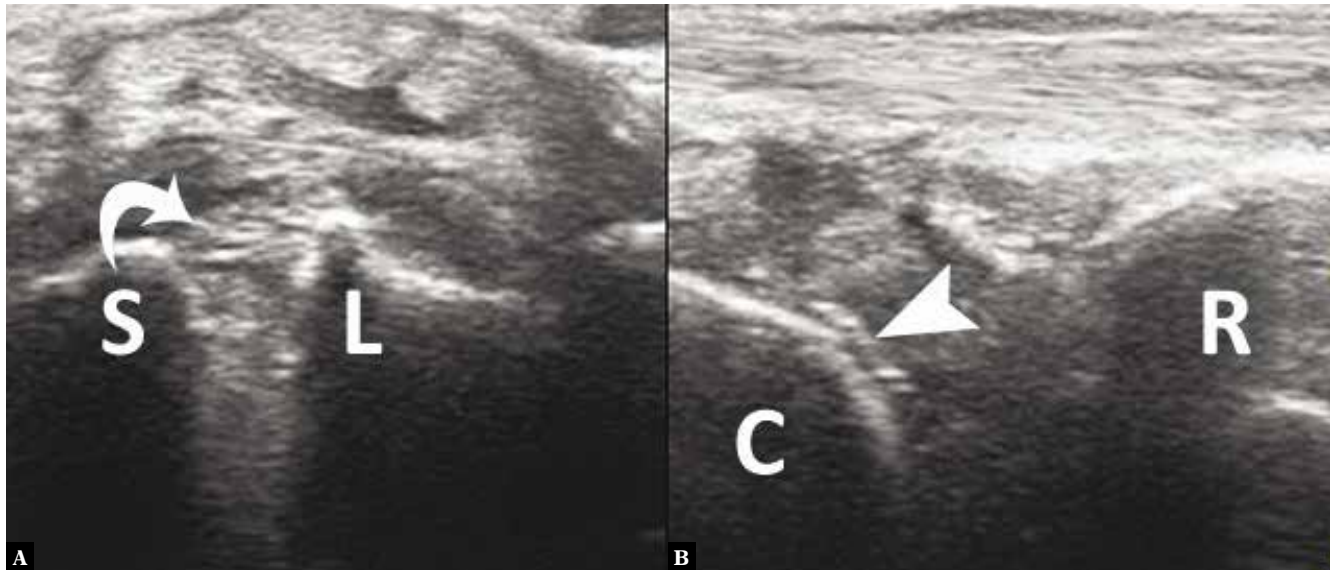


Fig. 5. Dorsal scans on a wrist (6–18 MHz transducer), patient with calcium pyrophosphate dihydrates (CPPD) crystal deposition disease (CPDD) arthropathy. Left side: axial scan. Degeneration of scapholunate interosseous ligament (curved arrow), with inhomogeneous and hyper-echoic deposits. Right side: longitudinal scan. Hyperechoic deposits (calcifications suggestive for CPPD crystals, arrowhead) lie on the cartilage of capitate bone (C) and on the scapholunate joint space

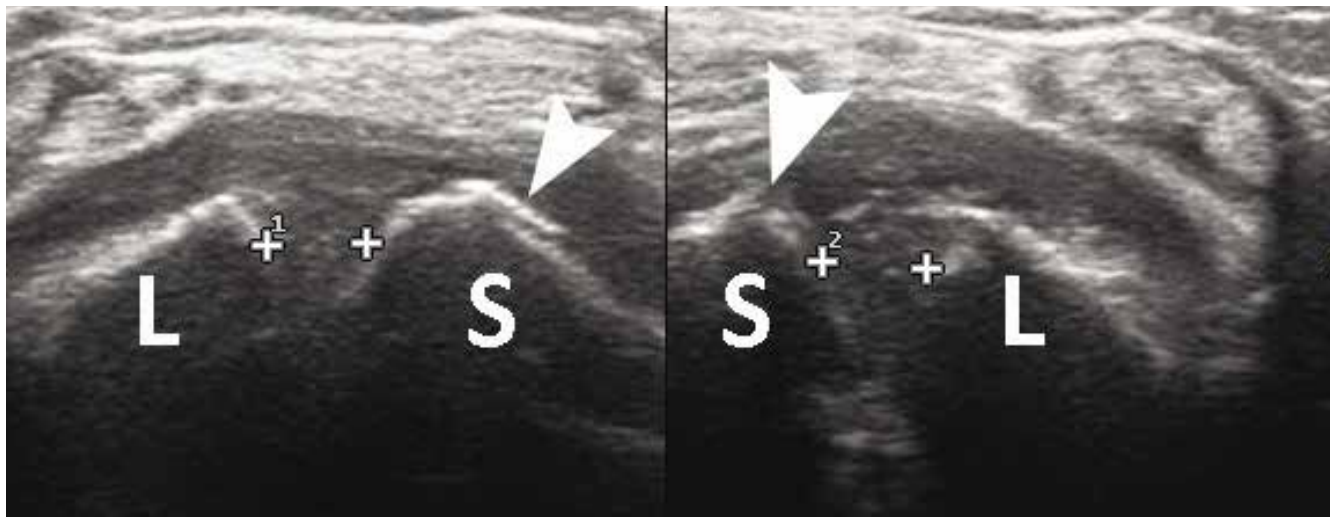


Fig. 6. Dorsal axial scans on osteoarthritic wrists (6–18 MHz transducer). Degeneration of scapholunate interosseous ligament (arrowhead), with inhomogeneous echostructure and maldefinition. Enlargement of the scapholunate joint space (between calipers) and osteophytosis over the profile of scaphoid (S) bone

appearance, regular and homogeneous thickness, without discontinuity) (Fig. 1), 1 = moderate degeneration of SLIL (inhomogeneous and hypoechoic echostructure, maldefinition and/or convexity of superficial profile) (Fig. 2), 2 = severe degeneration of SLIL (absence of definite ligamentous structure, with dissociation >3.5 mm between scaphoid and lunate) (Fig. 3) (modified from Kashiwama⁽¹⁸⁾). If necessary, in order to better define scapholunate dissociation, a dynamic scanning technique was added to the routine scanning protocol: the patient was asked to slowly move the hand in palmar flexion and ulnar deviation.

The presence of dorsal synovial ganglion cysts was always assessed, and graded on a 3-point scale where: 0 = absence

of ganglion cyst, 1 = cyst with superficial margin below the deep surface of extensor digitorum communis tendon (Fig. 2), 2 = voluminous cyst extending beyond the deep surface of extensor digitorum communis tendon (Fig. 4). PD signal was evaluated in the cyst walls and recorded as present (PD score 1) or absent (PD score 0) (Fig. 4).

The presence of hyperechoic deposits (calcifications suggestive for CPPD crystals) in the scapholunate joint space or SLIL was recorded (Fig. 5), as well as the presence of osteophytosis over the profile of the two bones (Fig. 6). A dichotomous score for the presence/absence of hyperechoic deposits (at least two distinct spots) in the ligament and osteophytosis of the scapholunate joint was adopted.

Tab. 1. Demographic characteristics and ultrasound findings of patients as a whole and split up for final diagnosis. Data are expressed as means (\pm standard deviation) or percentages. The level of statistical significance was set at a *p*-level of 0.05

	Overall	Group 1 (no rheumatic or biomechanical disorders)	Group 2 (degenerative diseases)	Group 3 (inflammatory diseases)	<i>p</i> values (statistical test)
Number	74	17	18	39	
Age, in years (\pmSD) [range]	59.2 (\pm 14.2) [18–87]	43.4 (\pm 13.6) [18–60]	64.1 (\pm 6.2) [53–71]	62.7 (\pm 13.1) [30–87]	<i>p</i> <0.0001** (Kruskal-Wallis test)
Gender, males/females	28/46	4/13	5/13	19/20	
Wrists analyzed	128	26	32	70	
US grading of SLIL degeneration (mean)	1.1 (\pm 0.63)	0.8 (\pm 0.56)	1.18 (\pm 0.53)	1.15 (\pm 0.67)	<i>p</i> <0.034* (Kruskal-Wallis test)
Mean US scapholunate diastasis in mm (\pm SD) [range]	2.67 (\pm 0.66) [1.8–4.6]	2.51 (\pm 0.49) [1.8–3.6]	2.70 (\pm 0.56) [1.9–4.4]	2.69 (\pm 0.7) [1.9–4.6]	ns 0.503 (Kruskal-Wallis test)
Wrists with scapholunate joint osteophytosis	54 (42.1%)	1 (3.8%)	16 (50%)	37 (52.8%)	<i>p</i> <0.0001** (Chi-squared test)
Wrists with scapholunate space calcifications	28 (21.8%)	0	4 (12.5%)	23 (32.8%)	<i>p</i> <0.0008** (Chi-squared test)
Wrists with dorsal ganglion cysts	42 (32.8%)	24 (92.3%)	11 (34.3%)	7 (10%)	<i>p</i> <0.0001** (Chi-squared test)
Radiocarpal effusion	52 (40.6%)	0	8 (25%)	44 (62.8%)	<i>p</i> <0.0001** (Chi-squared test)
Radiocarpal PDUS synovitis score (mean)	0.31 (\pm 0.59)	0	0	0.58 (\pm 0.71)	<i>P</i> <0.0001** (Kruskal-Wallis test)
Midcarpal PDUS synovitis score (mean)	0.27 (\pm 0.55)	0	0	0.50 (\pm 0.67)	<i>p</i> <0.0001** (Kruskal-Wallis test)
ns – not significant, * <i>p</i> <0.05, ** <i>p</i> <0.01. PDUS – power Doppler ultrasound, SLIL – scapholunate interosseous ligament					

CPPD crystal deposits were assessed and defined according to the Outcome Measure in Rheumatology (OMERACT) definitions^(7,19,20).

The presence of radiocarpal and midcarpal synovitis, tenosynovitis, and erosions was recorded as performed in routine practice. PDUS grading of synovitis was graded on a 3-point scale as defined in European League Against Rheumatism (EULAR)-OMERACT combined scoring system for grading synovitis⁽²¹⁾.

A preliminary observation of 40 wrists was performed in 20 normal subjects selected from hospital personnel in order to confirm the normal width of the scapholunate joint, and to calculate the coefficient of variation for this procedure. All subjects had a comparable age and sex, did not suffer from wrist pain or swelling, nor any rheumatic disease.

All patients gave their informed consent to undergo the routine diagnostic pathway. The study was carried out in compliance with the Helsinki Declaration, but ethical approval was not required in view of the retrospective nature of the study and the fact that all the procedures were performed as part of routine clinical practice.

Statistical analysis

The demographic and PDUS characteristics of patients, divided into three groups according to the final diagnosis, were compared. The data are reported as means \pm standard deviation (SD) for continuous variables, whereas

categorical and dichotomous variables are reported as frequencies and percentages. The Kruskal-Wallis test, with Dunn post-test for multiple comparisons, was used to compare the means of continuous variables between the groups. The Fisher's exact test was used to compare the percentages between the groups for categorical variables. Multivariate and univariate linear regression analysis was applied to determine the effects of variables on the outcome, and to define the correlation. The non-parametric Spearman rank test was applied for the correlation of variables. The level of statistical significance was set at a *p*-level of 0.05. Statistical analyses were performed using the InStat GraphPad (La Jolla, California) statistical package.

Results

The preliminary analysis of healthy wrists demonstrated a mean width of the scapholunate joint of 2.49 mm (SD \pm 0.49). The coefficient of variation on repeated measurements was 3.662%.

A total of 74 patients (mean age 59.2 years, SD 14,2) underwent PDUS examination for wrist pain and/or swelling (128). The whole group was divided into 3 sub-groups on the basis of their final diagnosis, as shown in Tab. 1.

The mean US grading of SLIL degeneration was significantly lower in group 1 (*p* <0.034), while no significant difference was demonstrated for mean US scapholunate joint enlargement between the groups (Tab. 1).

In a model of multivariate regression analysis, the best predictors of SLIL degeneration (r squared 0.6176) were: older age ($t = 4.147, p < 0.0001$), male gender ($t = 2.87, p = 0.0049$), and radiocarpal effusion ($t = 2.454, p = 0.0156$).

The presence of osteophytosis and calcifications of scapholunate joint was significantly higher ($p < 0.0001$ and $p < 0.0005$, respectively) in patients affected by rheumatic conditions. In particular, scapholunate calcifications suggestive for CPPD were demonstrated in 4 patients with a final diagnosis of osteoarthritis, in 1 with RA, in 2 with SpA, and, moreover, in 11 affected by CPDD: a sensitivity of 98.2% (95% CI 0.90–0.99), specificity of 61.1% (95% CI 0.35–0.82), positive predictive value (PPV) of 88.7% (95% CI 0.78–0.95), and negative predictive value (NPV) of 91.6% (95% CI 0.61–0.99) of scapholunate calcifications were determined in the diagnosis of CPDD.

The presence of radiocarpal effusion, midcarpal and radiocarpal synovitis was detected especially in inflammatory conditions ($p < 0.0001$). Conversely, the presence of dorsal ganglion cysts was significantly more frequent in subjects without rheumatic conditions ($p < 0.0001$), and it was significantly associated with younger age ($p < 0.0012$) and no radiocarpal effusion ($p < 0.0014$) or midcarpal synovitis ($p < 0.0001$).

In a model of multivariate regression analysis, the best predictors of the presence of dorsal ganglion cysts (r squared 0.5429) were: younger age ($t = 2.474, p = 0.0148$), absence of radiocarpal effusion ($t = 3.266, p < 0.0001$), and lower grade of SLIL degeneration ($t = 2.369, p = 0.0194$).

The presence of PDUS signal into the dorsal ganglion cysts was correlated to the diameter of the cysts ($p < 0.0001$).

The measure of scapholunate joint enlargement showed a significant correlation with older age ($p = 0.002$), male gender ($p = 0.0027$), and grading of SLIL degeneration ($p < 0.0001$). In a model of multivariate regression analysis the best predictors of scapholunate joint enlargement (r squared 0.5541) were: male gender ($t = 3.837, p = 0.0002$), presence of midcarpal synovitis ($t = 2.501, p < 0.0137$) and higher grade of SLIL degeneration ($t = 10.144, p < 0.0001$).

The mean scapholunate joint enlargement failed to demonstrate significant differences between the three groups. However, when considering patients affected with CPDD and RA taken together, their mean values of scapholunate joint enlargement were significantly higher ($2.92 \text{ mm} \pm \text{SD } 0.71$) than those observed in other rheumatic conditions as a whole ($2.6 \text{ mm} \pm \text{SD } 0.63$) ($p = 0.0419$).

Discussion

The use of US for the evaluation of the dorsal component of SLIL has been well described, with some reports demonstrating excellent accuracy for the visualization of this carpal structure using high-frequency US^(11,14,15,18). However, US was considered a second-choice technique or not appropriate for SLIL evaluation in recent US guidelines^(12,13), and

US evaluation of SLIL is often neglected in common rheumatological clinical practice^(22,23).

Our preliminary data about scapholunate joint width measurements in healthy volunteers seem to be comparable with previous reports⁽¹⁴⁾. The measurement of the scapholunate joint space, immediately underneath the dorsal portion of SLIL, appears to be a fast and repeatable procedure. Nevertheless, as previously reported by Manske *et al.*⁽¹⁴⁾, scapholunate gap measured using US seems wider than assessed with plain radiography and magnetic resonance imaging (MRI)^(3,24), presumably due to the more dorsal site of measurement with US.

The results of our study demonstrate a frequent involvement of SLIL in patients undergoing US examination for wrist pain and/or swelling and suspected rheumatic diseases.

The main factors associated to SLIL degeneration seem to be inflammatory rheumatic diseases, especially in older male patients. The most severe cases of SLIL involvement, with scapholunate dissociation, were observed in CPDD and RA patients, as reported in previous works^(6,8,9,25), and in these cases the presence of active midcarpal synovitis seems to be a causative factor. The data suggest that older patients with CPDD or RA and midcarpal synovitis should be considered at high risk of secondary wrist arthropathy, and specific pharmacological and orthotic therapies should be suggested to prevent secondary wrist instability.

Our study confirms that US examination of SLIL may add useful information in cases of suspected CPDD. Even if our data cannot confirm that CPPD crystals could be directly associated to SLIL degeneration, the US detection of hyperechoic foci suggestive for CPPD crystals confirms its high diagnostic accuracy in the diagnosis of CPDD^(7,26).

Systematic US examinations for dorsal ganglion cysts and their description can add useful information in the differential diagnosis of early arthritis. Larger cysts may often exhibit Doppler signals and they could be misinterpreted as radiocarpal synovitis. When a dorsal ganglion cyst is identified in a young subject, the absence of US-detected midcarpal swelling is a useful indicator of a noninflammatory nature of this finding. Even if SLIL degeneration grading was lower in these subjects, we suppose that dorsal ganglion cysts could be one of the first imaging signs of midcarpal instability due to structural abnormalities of SLIL, in the same manner as meniscal cysts of the knee are associated to meniscal tears⁽²⁷⁾. As arthrographic studies demonstrated that wrist compartments are often well separated, so the finding of dorsal ganglion cyst immediately over a slightly degenerated SLIL should alert the clinician to possible wrist instability due to SLIL pathology^(4,28).

The study has some limitations. Firstly, it is not designed to prove that wrists with wider scapholunate joint space develop carpal instability and osteoarthritis with advancing age: only a longitudinal study is able to reliably assess the progression from an early stage of SLIL degeneration to scapholunate dissociation and subsequent secondary wrist arthropathy.

Secondly, no comparison of US measurements and findings with the imaging gold standards such as radiography or MRI was made, since the study was carried out in a scenario of real clinical practice, where only a minority of patients need to undergo other imaging techniques. However, all US measurements were standardized and repeatable on the basis of previous studies^(7,14,19,20). Thirdly, the small number of subjects and nonhomogeneity of the cohort in terms of age and disease duration do not allow to draw definitive conclusions about the causative factors of SLIL degeneration. Also, further longitudinal studies are needed to define the weight of various factors (such as synovitis, disease duration, chondrocalcinosis, age) on SLIL degeneration and scapholunate joint enlargement.

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Conclusions

US findings of SLIL degeneration and calcification, scapholunate space enlargement, and presence of dorsal ganglion cysts should be systematically reported during wrist US evaluation, as they can add useful information about the causes of wrist pain or swelling in rheumatological settings.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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