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ORIGINAL ARTICLE

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Diagnosis of distal radioulnar joint subluxation in patients with rheumatoid wrist by computed tomography

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Abstract Subluxation of the distal radioulnar joint (DRUJ) is associated with extensor tendon rupture in patients with rheumatoid arthritis (RA). However, it remains difficult to quantitatively evaluate DRUJ subluxation in RA wrist. We devised a new method for assessing DRUJ subluxation. This study investigated whether the new method, known as the RA subluxation ratio (RASR), or a conventional method was superior for detecting extensor tendon rupture in the RA wrist. Thirty-five RA wrists and 10 wrists of healthy volunteers were scanned using computed tomography. The RA wrists were divided into a tendon rupture group and a nonrupture group. The dorsal surface of the distal radius from Lister's tubercle to the ulnar aspect of the distal radius maintains a planar surface in the RA wrist. Therefore, we defined the RASR as the extent of dorsal subluxation of the ulna relative to this plane. We quantified subluxation of the DRUJ by using the RASR or the modified radioulnar line method, and compared the two methods. The RASR was 0.440 in the rupture group, 0.333 in the nonrupture group, and 0.106 in the healthy volunteers. The RASR was significantly higher than the modified radioulnar line method in the sensitivity of diagnosing tendon rupture.

Key words Computed tomography · Diagnosis · Distal radioulnar joint subluxation · Extensor tendon rupture · Rheumatoid arthritis

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Introduction

Subcutaneous rupture of the extensor tendons at the dorsum of the wrist occasionally occurs in patients with rheumatoid arthritis (RA).[1–5] Investigators have identified several factors related to tendon rupture, which are dorsal subluxation of the DRUJ, the scallop sign, and persistent swelling of the extensor tendon synovial sheaths despite aggressive treatment with anti-rheumatic drugs.

At present, subluxation of the DRUJ in RA patients is assessed clinically by inspection and palpation or is diagnosed on lateral X-ray films and computed tomography (CT) scans of the wrist. However, in patients with damage to multiple joints, as occurs in the case of RA, it is difficult to obtain a true lateral X-ray film of the wrist. Furthermore, standard X-ray films cannot detect some cases of dynamic subluxation, which can only be seen in views other than in neutral DRUJ rotation.[6] Due to sigmoid notch scalloping, ulnar head erosion, and development of a volar shelf in the rheumatoid wrist, the usual methods[7–17] for detecting subluxation of the DRUJ on CT scans are difficult to apply. To overcome these difficulties, we devised a new method for assessing subluxation of the DRUJ in the rheumatoid wrist. The purpose of this study was to compare our new method, which we termed the RA subluxation ratio (RASR), with a previously described method for detection of extensor tendon rupture in patients with rheumatoid wrist.

Materials and methods

We examined 35 wrists of 35 RA patients with severe DRUJ damage who underwent surgery between 2003 and 2005. Rheumatoid arthritis was diagnosed according to the criteria of the American College of Rheumatology. Surgery was indicated due to the rupture of one or more tendons or persistent wrist pain for more than 6 months despite adequate conservative treatment. The patients were 29 women and 6 men aged between 36 and 80 years old, with an average age of 56.3 years. The duration of RA ranged from

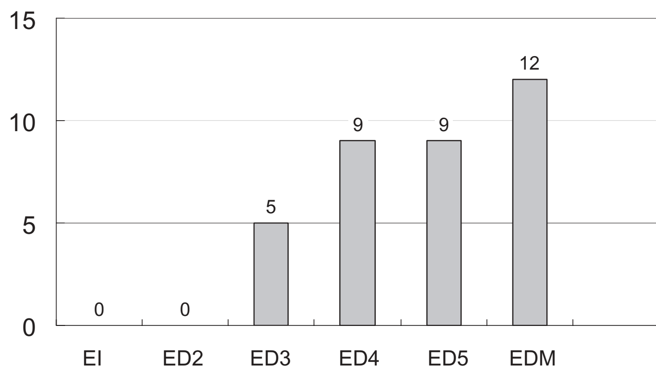

Fig. 1. Pattern of extensor tendon rupture. *EI*, extensor indicis; *ED*, extensor digitorum; *EDM*, extensor digiti minimi

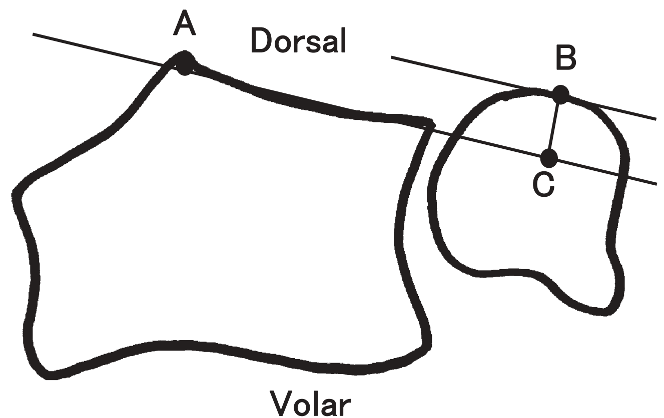

Fig. 2. The rheumatoid arthritis subluxation ratio (RASR). In a cross-sectional view that includes the sigmoid notch, the extent of dorsal subluxation of the ulna is determined by drawing a line tangential to the dorsal surface of the distal radius from Lister's tubercle (*A*) to the ulnar aspect of the distal radius. The RASR is defined as *BC*/*AC*

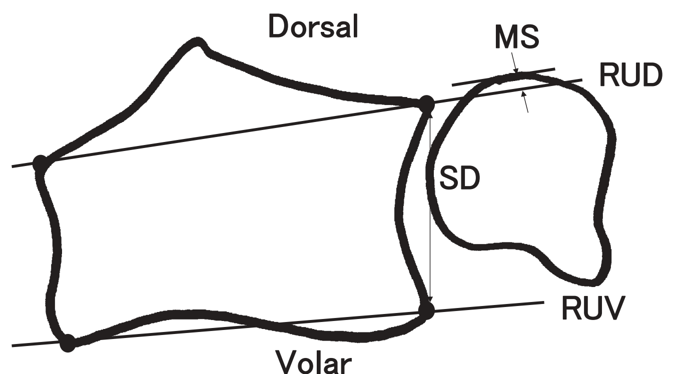

Fig. 3. The modified radioulnar line method. Subluxation is diagnosed when the maximum width of the subluxed part of the ulna (*MS*) is larger than one fourth of the sigmoid notch diameter (*SD*)

2 to 34 years (mean: 14.6 years). The patients were divided into an extensor tendon rupture group (14 wrists) and a nonrupture group (21 wrists) based on the operative findings. The extensor tendon rupture group had a total of 35 ruptured tendons: 1 tendon in 4 wrists, 2 tendons in 2 wrists, 3 tendons in 5 wrists, and 4 tendons or more in 3 wrists. Ten wrists in ten healthy volunteers (8 men and 2 women aged from 21 to 76 years, with an average age of 40.0 years) were also examined. Both X-ray films and CT scans were acquired after obtaining the consent of the patients and healthy volunteers. This study received approval from our institutional clinical research ethics committee.

The frequency of extensor tendon rupture is shown in Fig. 1. The sites of tendon rupture included the extensor digitorum (ED), extensor indicis (EI), and extensor digiti minimi (EDM). Rupture tended to occur on the ulnar side. The EDM tendon showed the highest incidence of rupture (12 tendons). The extensor pollicis longus tendon was excluded from this study because it has no relevance to dorsal DRUJ subluxation.

Images were obtained using a multidetector-row CT scanner (Light Speed Plus, General Electric Medical System, Milwaukee, WI, USA). Each subject was placed in the supine position with the involved arm above the head and the forearm in maximum pronation. Subsequently, three-dimensional volume data scans of the hand and wrist were obtained. Scanning parameters included a slice thickness of 1.25 mm, a gantry rotation speed of 0.8 s, 125 kVp, and 120–200 mA. Two-dimensional axial images of distal radius were reconstructed with a 20-cm field of view and 1.25-mm slice thickness.

Subluxation of the DRUJ was assessed on a cross-sectional view that included the sigmoid notch. First, we drew a line tangential to the dorsal surface of the distal radius that ran from Lister's tubercle (A) to the ulnar aspect of the distal radius. Next, a line was drawn parallel to this line so that it ran through point B on the dorsum of the ulna. Then a line (BC) was drawn perpendicular to the other 2 lines from B on the ulnar head. Finally, the length of the lines AC and BC was measured and the ratio of their lengths (BC/AC) was calculated, and was termed the RA subluxation ratio (RASR) (Fig. 2). Because the length of BC is increased by dorsal subluxation of the distal ulna, the value of the RASR increases. Because the length of AC is decreased by scalloping of the sigmoid notch, the RASR becomes higher. Computed tomography scans were reviewed by three authors who were blinded to other information about the subjects. Each of them measured the ratio three times, and the mean of the nine values thus obtained was used as the RASR.

The study was conducted as follows. Initially, we compared the RASR between healthy volunteers, the tendon rupture group, and the nonrupture group. Then we assessed the relationship between extensor tendon rupture and subluxation of the DRUJ using the RASR and the modified radioulnar line method, which is one of the conventional methods for detecting subluxation. The modified radioulnar line method is usually performed with the forearm in the neutral position, but maximum pronation was adopted in this study because dorsal subluxation of the ulnar head is greatest in maximum pronation and related to extensor tendon rupture. This method is displayed in Fig. 3. By constructing a line (RUD) through the dorsal ulnar and radial borders of the radius and a second line (RUV) through the palmar ulnar and radial borders of the radius, the ulnar

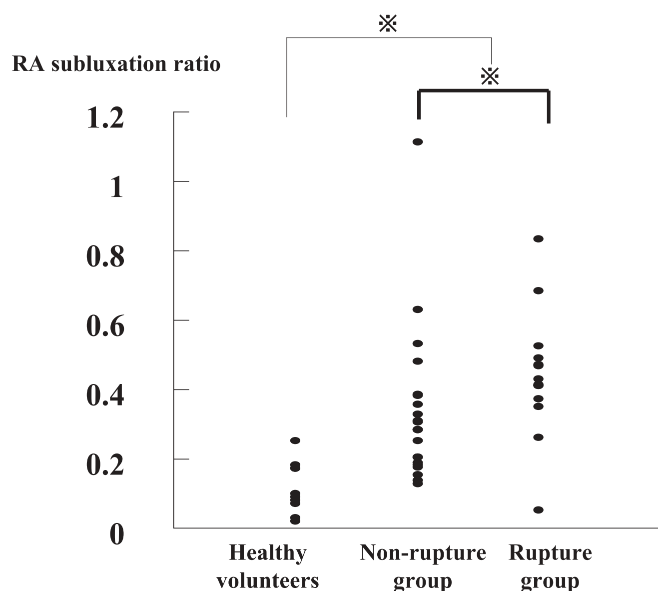

Fig. 4. The mean rheumatoid arthritis (*RA*) subluxation ratio in healthy volunteers, the nonrupture group, and the rupture group. There were significant differences among the three groups (*$P < 0.05$)

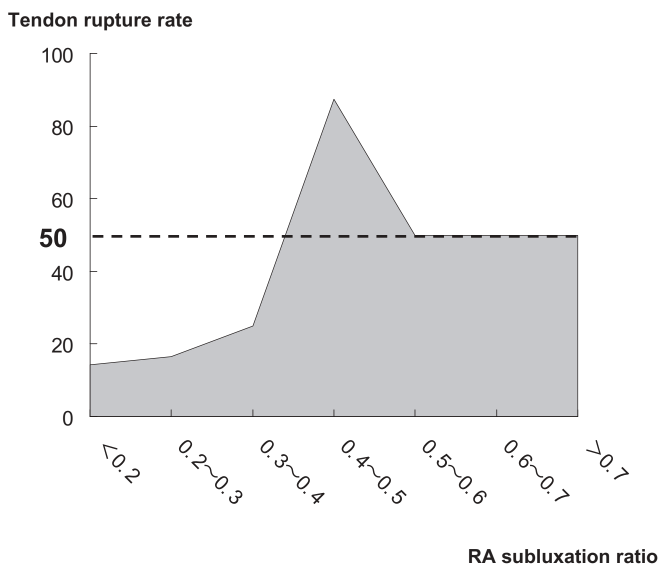

Fig. 5. Rheumatoid arthritis subluxation ratio and tendon rupture rate

head lies between two lines when the DRUJ is congruent. Subluxation is diagnosed when the maximum width of the subluxed part of the ulna (MS) is larger than one quarter of the sigmoid notch diameter (SD). The sensitivity and specificity of detecting tendon rupture by these methods were determined.

Next, the number of ruptured tendons and the RASR value were compared to detect any significant relationship. In addition, three operators reviewed all CT scans independently to determine interobserver reliability for the RASR. One operator reviewed all CT scans on three different occasions to determine intraobserver reliability.

Statistical analysis was done using the nonparametric Wilcoxon rank-sum test and significance was defined as a P value of less than 0.05.

Table 1. Rheumatoid arthritis subluxation ratio in relation to tendon rupture

RA subluxation ratio	Tendon rupture rate
>0.7	50.0% (1/2 hands)
0.6–0.7	50.0% (1/2 hands)
0.5–0.6	50.0% (1/2 hands)
0.4–0.5	87.5% (7/8 hands)
0.3–0.4	25.0% (2/8 hands)
0.2–0.3	16.6% (1/6 hands)
<0.2	14.3% (1/7 hands)

RA, rheumatoid arthritis

Table 2. Computed tomography detection of tendon rupture by different methods for diagnosing distal radioulnar joint subluxation

Diagnostic method	Sensitivity	Specificity
Modified radioulnar line method	0.14 (2/14)	0.90 (19/21)
RASR (>0.4)	0.71 (10/14)	0.81 (17/21)

RASR, RA subluxation ratio

Results

The mean value of the RASR (± SD) was 0.106 ± 0.072 in healthy volunteers and 0.376 ± 0.12 in the RA patients (Fig. 4), with a significant difference between the volunteers and the patients ($P = 0.00005$). This ratio was low and almost constant in the volunteers. The RA patients were divided into a tendon rupture group (14 wrists) and a nonrupture group (21 wrists). The mean value of the RASR (± SD) was 0.440 ± 0.181 in the tendon rupture group and 0.333 ± 0.222 in the nonrupture group, with a significant difference between the groups ($P = 0.02$). However, one patient in the nonrupture group had a very high RASR (1.11), while one patient in the rupture group had a very low RASR (0.05).

Using the modified radioulnar line method, 31 out of 35 wrists were classified as having no subluxation. The sensitivity was 0.14 and the specificity was of 0.90 for detection of extensor tendon rupture.

The percentage of patients who had tendon ruptures was 71.4% (10/14) with RASR >0.4 and 19% (4/21) with RASR <0.4. Using RASR >0.4 as the cutoff value, the probability of extensor tendon rupture being present was >50% (Table 1 and Fig. 5). In 14 of the 35 wrists classified as having high RASR values, the RASR showed a sensitivity of 0.71 and a specificity of 0.81 for extensor tendon rupture (Table 2).

The mean of RASR was 0.443 when one tendon was ruptured and 0.439 when two or more tendons were involved. There was no significant difference of RASR values between wrists with one tendon or two or more tendons involved ($P = 0.89$).

The RASR showed high intraobserver and interobserver reliability. The intraclass correlation coefficient for intraobserver reliability was 0.043, while that for interobserver reliability was 0.018.

Discussion

Investigation of dorsal DRUJ subluxation on CT has primarily focused on posttraumatic subluxation and the early RA wrist. The available methods include the method of Mino et al.,[9,10] the epicenter method and the congruency method,[17] the modified radioulnar line method described by Nakamura et al.,[8] and the radioulnar ratio[7] proposed by Lo et al.[7] Methods that are based on the center of the ulnar head (the epicenter method, congruency method, and radioulnar ratio) are difficult to apply in RA patients due to ulnar head erosion. We also examined the present 35 rheumatoid wrists by the modified radioulnar line method,[8] which does not employ the center of the ulnar head. Using this method, 31 out of 35 hands were classified as having no subluxation and the sensitivity of detecting extensor tendon rupture by the modified radioulnar line method was only 14%. Due to the occurrence of sigmoid notch scalloping and a volar shelf in the RA wrist, this method relies on subjective evaluation of the width of sigmoid notch (length of SD in Fig. 3). We concluded that this method was unreliable and not very useful for assessing subluxation of the DRUJ in the RA wrist.

We noticed that the plane of the dorsal surface of the distal radius from Lister's tubercle to the ulnar aspect of the distal radius was maintained in RA patients. Therefore, we assessed the extent of dorsal subluxation of the distal ulna from this plane as the RASR, thus devising a new method for the detection of DRUJ subluxation.

The RASR of the tendon rupture group was significantly higher than that of the nonrupture group. When the RASR is >0.4, the probability of extensor tendon rupture is >50%, and the method has a sensitivity of 0.71 and a specificity of 0.81 for detecting rupture. The high sensitivity and specificity of the RASR for extensor tendon rupture indicate the usefulness of this new method.

This method can assess not only dorsal subluxation but also scalloping simultaneously, which many investigators have identified as risk factors for tendon rupture. The triangular fibrocartilage complex is gradually weakened by proliferative synovitis of the DRUJ. This results in radial shift of the ulnar head caused by traction of the pronator quadratus. This deformity then undergoes progression by sigmoid notch scalloping in many rheumatoid patients. Because the length of AC is decreased by scalloping of the sigmoid notch in Fig. 2, the RASR becomes higher. However, in some cases where the ulnar head does not shift in spite of scalloping, this method seems to be unable to predict extensor tendon rupture.

There was no significant difference of RASR values between rupture of one tendon and rupture of two tendons or more, so a further increase of the ratio did not occur as more tendons were ruptured. One patient in the rupture group had a low RASR (0.05). In this patient, the cause of tendon rupture was persistent tenosynovitis. Therefore, this method seems to be unable to assess tenosynovitis, which is one of the risk factors for tendon rupture.

In conclusion, we developed a new method of assessing subluxation of the DRUJ in RA patients by using CT scans. This new method is useful for assessing dorsal subluxation of the DRUJ and scalloping simultaneously, and it can also predict extensor tendon rupture, thus determining whether surgery is necessary in patients with rheumatoid wrist.

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