

Research Article

Lunate Flattening in Rheumatoid Wrists

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Abstract

Lunate flattening was studied in 36 patients (62 wrists) with rheumatoid arthritis (RA) who were age- and gender-matched to people with normal wrists.

The carpal height ratio (CHR) and lunate compression ratio (LCR; lunate height/lunate diameter×100, Ståhl index) were measured from wrist radiographs of both groups and the lunate flattening ratio (LFR) was calculated by dividing the LCR by the CHR. The LFR reflects lunate flattening compared to carpal collapse. Twenty-four wrists underwent MRI study. T1-weighted images were evaluated for bone necrosis of the lunate. Results: the normal LFR value obtained from normal wrists ranged from 79.9 to 113.5 (mean±2SD). Lunates with RA could be classified into three groups by LFR values- lunates with a LFR above 113.5 (10 wrists, 16%), lunates with a LFR within the normal range (34 wrists, 55%), and lunates with a LFR lower than 79.9 (18 wrists, 29%). Twelve (50%) of the 24 wrists that underwent MRI study showed a low signal of the lunate in T1-weighted images showing osteonecrosis. Although a satisfactory correlation was not confirmed between a LFR value and a low signal on T1-weighted images, lunate avascular necrosis was suspected to play a role in flattening of the lunate.

INTRODUCTION

Rheumatoid arthritis (RA) commonly affects the wrist in the early stage of illness. Radiographic grading and classification of RA [1-3] are useful to evaluate the stage and course of RA, even in the wrist. These evaluations based on the severity of bony erosion, joint space narrowing and carpal collapse, can be detected by measuring the carpal height ratio (CHR) [4,5] and ulnar translocation. On the other hand, studies with respect to lunate deformity in RA have been scanty, although the lunate has been considered to be the key bone of the carpus from a biomechanical viewpoint of the wrist, including kinematics and force transmission. Thus, our interest has focused on lunate flattening in rheumatoid wrists. We examined lunate flattening in RA wrists by comparing them with age- and gender-matched controls.

MATERIALS AND METHODS

Three hundred thirty-three patients with RA consulted either our rheumatology or orthopedic clinic between 2005 and 2012. Patients with wrist involvement and with wrist roentgen graphs appropriate for measurement were selected for the study. Patients with a history of wrist trauma, infection, or with advanced wrist RA that made the outline of the lunate confusing, were excluded from the study.

Thirty-six patients (62 wrists) cleared the inclusion criteria.

There were seven men and 29 women with an age range from 32 to 82 years old (average 59±7). They had been suffering from RA for an average of 7.1±6.2 years, ranging from two months to 20 years. Thirty-four of 36 (94%) patients were examined more than one year after the onset of RA. All but five patients satisfied diagnostic classification under the 2010 American College of Rheumatology / European League against Rheumatism classification criteria for rheumatoid arthritis.⁶ Because patients with comprehensive radiographs were selected for this study; the majority of the patients had slowly progressive, mild RA or well controlled RA. The remaining five patients were diagnosed as having RA by rheumatologists after differential diagnosis. Larsen classification²⁾ showed grade 0 in seven wrists, grade I in 10 wrists, grade II in eight wrists, grade III in 21 wrists, grade IV in 16 wrists, and grade V in no wrists. Patients had been treated with various kinds of disease modifying anti-rheumatic drugs (DMARDs), non-steroidal anti-inflammatory drugs (NSAIDs) and/or steroids. Sixteen patients received methotrexate, 13 patients were treated with sulfasalazine, three with bucillamin, two with tacrolimus, two with gold salts, and one with bredinin. Oral steroids were prescribed to seven patients.

For normal controls, standard radiographs [7,8].of 60 normal wrists in the same age range (32 to 82 years; average: 59±13) were selected for the study from the reference contralateral radiographs of patients with wrist fractures or extra-articular

diseases of the wrists.

Measurement of wrist radiographs; Third metacarpal length and carpal height were measured in the standard radiographs of both groups (wrists with RA and normal wrists). The carpal height ratio (CHR) [4]. was calculated by dividing the carpal height by the third metacarpal length. Lunate height and lunate diameter are also measured in the lateral views of both wrist groups. The lunate compression ratio (LCR, Ståhl index⁹) was calculated by dividing the lunate height by the lunate width and is expressed in a percentage. Then, we calculated the lunate flattening ratio (LFR), which is obtained by dividing the LCR by the CHR (Figure 1).

The decrease in the CHR reflects the degree of carpal collapse including both the proximal carpal row and the distal carpal row. The LCR decrease shows the degree of lunate flattening. Therefore, the LFR (ratio of LCR to CHR) corresponds to lunate flattening compared to carpal collapse.

An MRI study was performed on 24 wrists with RA, and the signal intensity of the lunate on coronal T1- and T2-weighted views compared to surrounding carpal bones. Synovial proliferation around the distal radioulnar joint and the lunate was examined on axial T2-weighted and T2-weighted STIR views and the maximum thickness of the synovia was measured on the axial view. Obtained data including X-ray measurements were analyzed statistically using computed statistics soft-ware (Statcel 3, OMS Ltd., and Saitama, Japan). When two groups of measurements show a p-value of less than 0.05, value differences were judged to be statistically significant. P-values for the data with no references were calculated using Welch's t-test.

RESULTS

Patients with RA and controls had a similar average age and a similar ratio of females to males (chi-square test, $p > 0.5$, Table 1). Averaged third metacarpal length showed less than a 1-mm difference between wrists with RA and normal wrists, suggesting the average hand sizes in both wrist groups were almost equal to each other. As expected by pathology, that degradation and thinning of the joint cartilage are common features in rheumatoid wrists, averaged carpal height, CHR, lunate height and LCR were lower in wrists with RA than in normal wrists, and the differences

Table 1: Results of X-ray measurement.

gender (male/female)	7/29	12/48	>0.5
average Age	59.7±6.6	59.3±13.1	>0.5
3rd metacarpal length (mm)	59.9±3.4	59.2±4.7	>0.5
carpal height (mm)	27.9±3.4	32.5±3.2	<0.001
carpal height ratio	0.466±0.05	0.550±0.04	<0.001
lunate height (mm)	80.7±1.9	8.83±0.97	<0.01
lunate diameter (mm)	18.8±3.1	16.7±1.6	<0.001
lunate compression ratio (Ståhl, LCR) (%)	43.9±11.4	53.1±4.4	<0.001
lunate flattening ratio (LFR)	94.1±23.4	96.7±8.4	>0.5
unbiased variance of LFR	547	71	<0.001

were statistically highly significant. On the other hand, a statistically significant increase in average lunate diameter was confirmed in wrists with RA. The average LFR of wrists with RA did not significantly differ from that of the normal wrists. However, the LFR of wrists with RA showed a larger standard deviation than that of controls. Unbiased variance showed a highly significant difference between the LFR of wrists with RA and that of controls (F-test). When the normal LFR range of the controls was estimated as $\pm 2SD$, normal controls ranged from 79.9 to 113.5 (Figure.2). In RA wrists, the LFR showed a value of over 113.5 in 10 of 62 wrists (16%), while 18 wrists (29%) were under 79.9. Therefore, in 28 of 62 wrists (45%), it appeared that lunate flattening was greater or less than that of the surrounding carpus. As a consequence, lunates with RA could be classified into three types, namely, lunates with a high LFR, lunates with a normal LFR, and those with a low LFR. The incidence of low LFR was higher in grade III and IV wrists (17/37, 46%), as classified by Larsen's method, than in grade 0, I and II wrists (1/25, 4%) (Chi-square test, $p < 0.01$)

MRI RESULTS

A low signal intensity of the lunate in T1-weighted images was confirmed in 15 of 24 wrists (Figure 3), but three of 15 wrists were suspected of having a low signal in T1-weighted images because of invasive erosion due to RA (one patient) or ulnocarpal impaction (two patients). The remaining 12 patients exhibited low signal intensities in T1-weighted images with slightly low to high signal intensities in T-2-weighted images. In contrast to the MRI findings with Kienböck's disease, the area of low signal intensity in T1-weighted images was not confined to the lunate. Nine of 12 patients showed low signal intensity in T1-weighted images not only in the lunate, but also in the scaphoid, the capitate, the triquetrum, and/or the distal radius. Three of 12 patients with a low signal in T1-weighted images received oral steroids. Of the 12 wrists with a low signal in T1-weighted images, five patients had a low LFR, six patients had a LFR within the normal range, and one patient had a higher LFR. The incidence of low signal intensity in T1-weighted images was 71% (5/7) in patients with a low LFR, 46% (6/13) in patients with a normal LFR and 33% (1/3) in patients with a high LFR. However, no statistical difference was confirmed for an incidence of low intensity between wrist with a low LFR and those with a normal or high LFR, (chi-square test, $0.1 < p < 0.5$). The signal intensity of T2-weighted images of the lunate show an iso-intensity in 17 wrists,



Figure 1 Measurement of wrist roentgenography M; 3rd. metacarpal length, C; carpal height, D; lunate diameter, H; lunate height Carpal height ratio(CHR)=C/M Lunate compression ratio(LCR, Ståhl index)=H/D×100 Lunate flattening ratio(LFR)=LCR/CHR.

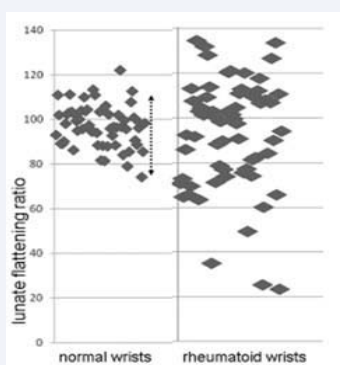


Figure 2 Showing distribution of lunate flattening ratio in normal wrists and wrists with rheumatoid arthritis. Dotted arrow indicates normal range (mean \pm 2SD).

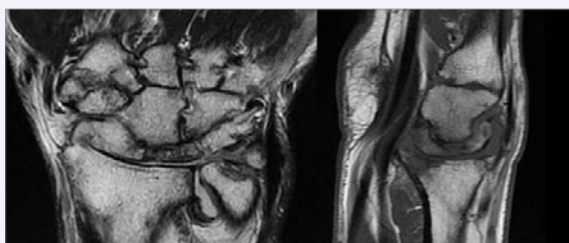


Figure 3 T1-weighted magnetic resonance images in a wrist with rheumatoid arthritis showing a low signal of the flattened lunate with a LFR of 74. The capitate head and proximal edge of the hamate also show a low signal.

an iso intensity with a partially low signal in four wrists, and an iso intensity with a high signal in three wrists. T2-weighted and T2-weighted STIR images confirmed synovial proliferation around the distal radioulnar joint in all wrists with a maximum thickness from 1.8 to 8.5 mm. Synovial proliferation around the lunate was also observed in all wrists with a maximum thickness from 1 to 6.3 mm.

DISCUSSION

In wrists with RA, carpal collapse is frequently observed and has been studied by several authors [10-12]. However, studies about lunate deformity are scanty, although the lunate is considered to be the key stone bone of the carpus. We examined the the LFR in RA wrists by comparing with age- and gender- matched controls. The results showed the average lunate flattening ratio did not differ significantly between wrists with RA and controls. But the LFR value in wrists with RA had a significantly wider variance than in control wrists (Table 1, Figure 2). Therefore, the lunates in wrists with RA could be classified into three types; those with a high LFR, those with a normal LFR, and those with a low LFR. If RA destroys or erodes the lunate and surrounding carpal bones equally, there should be no difference in the LFR value between wrists with RA and controls. Our results show that flattening of the lunate in RA is variable compared to flattening of the surrounding carpal bones, that is, lunates with a high LFR are more preserved than the surrounding carpal bones, and lunates with a low LFR develop

more flattening than surrounding bones.

The cause of variation in the LFR values of wrists with RA cannot be explained by a simple mechanism. Bony erosion, osteomalacia [1,3], osteitis (bone marrow edema [14,15] and oral steroids may lead to the development of lunate flattening, but we could not find more severe cases of bony erosion and osteoporosis in lunates with a low LFR. Steroid induced osteonecrosis is a well-known event and three of 11 patients with a low signal intensity in T1- weighted images received oral steroids. But a study on steroid-induced osteonecrosis regarding treatment of severe acute respiratory syndrome (SARS) revealed a lower incidence in the lunate and scaphoid (11 of 539 patients, 2%) than in hips (130 of 539, 24%) [16]. Thus, we believe that the possibility of steroid-induced osteonecrosis of the lunate is slight compared to that of hip necrosis. Our results confirmed that a lunate with a low LFR shows not only flattening but also increased diameter from a lateral view.

These changes are similar to the findings of idiopathic osteonecrosis of the lunate (Kienböck's disease). Furthermore, MRI studies confirmed the low signal intensity of T1-weighted images in the lunate in most patients with a low LFR. Therefore, we suspect that osteonecrosis of the lunate plays a role in lunate flattening.

Rheumatoid synovial proliferation may cause bony erosion and eventually destroy vascular channels into the lunate. Even in patients with a normal LFR, six of 13 patients showed a low signal. However, we expected a more satisfactory correlation between a low signal in T1-weghted images and a low LFR. The site of synovial proliferation, the axial load of the wrists in daily use, and the recovery potential from poor blood circulation may cause the difference in intensity of T1-weighted images. Kienböck's disease associated with RA is extremely rare in the literature and we can find only one case report by [17]. His patient showed a low signal intensity not only in the lunate but also in the proximal portion of the scaphoid. The difference in MRI findings between Kienböck's disease and lunate flattening by RA is that the low signal in T1-weighted images is confined to within the lunate in Kienböck's disease but in wrists with RA, not only the lunate but also the surrounding part of the scaphoid, capitate and/or triquetrum show a low signal intensity. The process from vascular insufficiency to osteonecrosis in RA wrists may be occasional but reasonable, considering that synovial proliferation develops in not only the ulnar wrist but also around the lunate.

Pathologic synovia is suspected to impair the vessels on the carpal ligaments and impair the perforating vessels to the lunate. Another characteristic feature is that an extensively low signal intensity of the lunate in T2-weighted images was not observed in wrists with RA but was occasionally detected in wrisst with Kienböck's diseas [18]. Radiographs frequently show fragmentation of the lunate in Kienböck's disease but no fragmentation in RA.

In clinical situations, when surgeons are considering radiolunate arthrodesis as an elective surgery, patients with a high LFR are believed to be technically easier to operate on than patients with a low LFR, because of the higher quantity and quality of lunate bone.

This study is limited to data from patients with relatively slowly progressive RA, thus, we cannot comment on rapidly advanced RA at this time.

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