Carpal instability in rheumatoid arthritis and calcium pyrophosphate deposition disease

Pathogenesis and roentgen appearance

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SUMMARY The roentgen appearance and pathogenesis of carpal instability are described in an evaluation of patients and cadavers with rheumatoid arthritis and calcium pyrophosphate deposition disease. Dorsiflexion (16%) and palmar flexion (8%) instability occurs in rheumatoid arthritis, particularly in patients with moderate to advanced disease. Navicular-lunate dissociation frequently accompanies dorsiflexion instability and results from involvement of the interosseous ligament between the two bones by rheumatoid pannus. Carpal instability and navicular-lunate dissociation also accompany pyrophosphate arthropathy, resulting from calcific deposition and cystic degeneration of ligamentous structures.

Deformity and malalignment in rheumatoid arthritis may be produced by incongruity in apposing cartilaginous and bony surfaces, capsular and ligamentous laxity, and muscle and tendon imbalance. Although these deformities occur most frequently about digital articulations, they are also common in the wrist (Martel, 1964; Straub and Ranawat, 1969; Collins *et al.*, 1972; Resnick, 1976). In this latter location subluxations of the distal ulna and radiocarpal joint are well recognized: intercarpal malalignment, although not infrequent, has received little attention.

Recently Linscheid *et al.* (1972) classified malposition of the carpal bones after trauma as palmar flexion and dorsiflexion carpal instability, properly focusing attention not on a single bone, the carpal navicular, but rather on the relative position of several bones, the radius, navicular, and lunate. These same patterns of wrist instability can be recognized in patients with rheumatoid arthritis.

This report (a) re-emphasizes both the normal stable pattern of the carpal bones and patterns of carpal instability which can be recognized during radiographic evaluation of the wrist; (b) determines the incidence of such carpal instability in patients

with rheumatoid arthritis; (c) shows that such instability occurs not only in rheumatoid arthritis but additionally in calcium pyrophosphate deposition disease (CPPD); and (d) compares the pathogenesis and roentgen appearance of carpal instability in both arthritic disorders.

Material and methods

The records and radiographs of 75 patients with classical or definite rheumatoid arthritis by the criteria of the American Rheumatism Association were chosen at random from the files of the University and Veterans Administration Hospitals, San Diego. Most patients had moderate to advanced disease and considerable deformity. Many had multiple radiographic examinations over a period of several years. 24 patients were eliminated as hand and wrist radiographs were considered suboptimal for evaluation. The remaining 51 patients had adequate roentgenographic evaluation of their wrists, which included radiographs in the frontal, lateral, and oblique projections. The pattern of carpal instability (see below), the position of the remaining carpal bones, and the presence of increased intercarpal space or dissociation were recorded.

Additional examples of carpal instability were selected from 85 patients with CPPD. All had definite (31) or probable (54) disease based upon

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criteria set forth by McCarty (1972). Skeletal abnormalities in these patients have been reported previously in detail (Resnick *et al.*, 1976).

Pathological examination of the wrist in 5 rheumatoid cadavers and 5 cadavers with CPPD was used to show the pathogenesis of these deformities. This examination included whole and sectional gross pathology and radiography, and microscopical evaluation of 10 μm sections which had been double embedded with 4% celloidin in methyl benzoate and paraffin. Macerated specimens using commercial bleach were also studied.

Normal wrist alignment

In a posteroanterior radiograph of the wrist in neutral position (without ulnar or radial deviation) the radius articulates with the navicular and approximately half of the lunate (Fig. 1a). A certain degree of radial deviation at the wrist is normal. This can be determined by measuring the obtuse angle created by the intersection of two co-ordinates, one along the longitudinal axis of the second metacarpal and a second co-ordinate drawn from the tip of the radial styloid to its ulnar limit. This normal value of radial deviation is 112° (92° – 127°) (Resnick, 1976). The space between adjacent carpal bones is approximately equal throughout the wrist.

In a lateral radiograph of the wrist in neutral position (without dorsi or palmar flexion) a continuous line can be drawn along the longitudinal axes of the radius, lunate, capitate, and third metacarpal (Fig. 1b). A second line through the longitudinal axis of the navicular produces an angle (navicular-lunate angle) of 30° – 60° with the first line (Linscheid *et al.*, 1972). Navicular-lunate angles

Fig. 1(a)

Fig. 1(c)

Fig. 1 Normal and abnormal carpal alignment. (a) Posteroanterior radiograph of a normal wrist. The distal radius articulates with the navicular and a portion of the lunate. Note that the space between carpal bones is approximately equal throughout the wrist. (b) In the normal wrist (centre) the longitudinal axis of the radius (R) is continuous with that of the lunate (L) and capitate (C). The longitudinal axis of the navicular (N) creates an angle of 30° – 60° with the longitudinal axes of the other bones. Dorsiflexion carpal instability (top) is characterized by dorsiflexion of the lunate and an increased navicular-lunate angle. Palmar flexion carpal instability (bottom) relates to palmar flexion of the lunate in relation to the longitudinal axes of the radius and capitate. (c) Navicular-lunate dissociation is characterized by an increased space between navicular and lunate (arrow) and a foreshortened navicular profile related to palmar flexion of that bone.

of greater or lesser magnitude suggest carpal instability.

Carpal alignment normally changes during radial and ulnar deviation of the wrist. In radial deviation palmar flexion of the proximal carpal row occurs and the distal navicular rotates into the palm; during ulnar deviation the space between the navicular and lunate increases slightly and the navicular is exposed in full profile (Arkless, 1966).

Pattern of carpal instability

The pattern of carpal instability may be classified as in Fig. 1b. (1) Dorsiflexion instability (DFI) in which the lunate is dorsiflexed and displaced in a volar direction with an associated vertical displacement of the navicular. This results in an increased navicular-lunate angle and usually indicates a dissociation between the two bones (Fig. 1c),

Fig. 2(a)

Fig. 2(b)

Fig. 2 Carpal instability in rheumatoid arthritis. (a, b) Note progressive widening of the space between navicular and lunate (arrow) and proximal migration of the capitate (arrow heads) in a 6-month period. Other rheumatoid abnormalities include soft tissue swelling, joint space narrowing, bony erosions, and increasing space between distal radius and ulna. (c) On the lateral radiograph, dorsiflexion of the lunate (L) and an increased navicular-lunate (N, L) angle are apparent.

Fig. 2(c)

termed navicular-lunate dissociation (NLD). (2) Palmar flexion instability (PFI) in which the lunate is palmar flexed in relation to the longitudinal axes of the radius and capitate. NLD is absent.

Results

Ninety-six wrists in 51 patients (37 men, 14 women) with rheumatoid arthritis were evaluated. The mean age was 55 years, range 25–83 years. The duration of disease varied from 6 months to 37 years. DFI was noted in 15 wrists (16%) and PFI in 8 wrists (8%). Increased intercarpal space between the navicular and lunate (NLD) unrelated to apposing erosive abnormalities was noted in 25 wrists (26%); DFI was present in 10 of these wrists (40%) and PFI in 1 (4%) (Fig. 2).

In the 25 wrists with NLD, 23 had associated medial displacement and 11 associated volar displacement of the radiocarpal joint. DFI was evident in all cases of severe dissociation. One patient developed NLD after resection of the distal ulna associated with severe medial and moderate volar displacement at the radiocarpal joint. Many patients had 'pseudo' NLD created by adjacent erosions of the two bones. In these patients, if one reconstructed the osseous outlines, the navicular and lunate appeared in normal position. Carpal collapse with severe disorganization was noted in 8 wrists. Additional deformities in these rheumatoid wrists appear in Table 1 (Resnick, 1976).

Discussion

Intercarpal instability is a recognized complication after wrist trauma. Although similar instability occurs in rheumatoid arthritis, most reports of the latter disease stress malalignment of the distal ulna and radiocarpal joint. The normal concavity of the

radiocarpal joint is disrupted by destruction of the triangular fibrocartilage and dorsal subluxation of the distal ulna. This results in medial and volar displacement of the proximal carpal row. Exaggerated radial deviation at the radiocarpal joint becomes apparent and may be associated with ulnar deviation at the metacarpophalangeal joints producing the 'zig-zag' deformity of the rheumatoid hand (Stack and Vaughan-Jackson, 1971; Resnick, 1976). Abnormal motion at the radiocarpal joint may produce sclerosis and osseous debris (Arkless, 1966, 1967; Resnick and Gmelich, 1975).

Intercarpal instability in rheumatoid arthritis consists of both PFI and DFI. In our series the latter was more frequent. PFI apparently results as the proximal carpal row migrates in an ulnar and volar direction along the inclined articular surface of the distal radius. Palmar flexion of both navicular and lunate occurs and the navicular appears foreshortened on frontal radiographs (Linscheid, 1969; Linscheid *et al.*, 1972; Pekin and Zvaifler, 1963). The exact aetiology of DFI is unknown but may be related to disruption of the navicular-lunate

(a)

Fig. 3 Cadaver with rheumatoid arthritis. (a) Radiograph of a coronal section of the wrist shows navicular-lunate dissociation (arrow). Note joint space narrowing and erosive abnormalities. (b) Photograph of the corresponding specimen, the increased space between navicular and lunate (black arrow) can be seen. Pannus is covering the navicular-lunate interosseous ligament and producing fibrous ankylosis of the joint (white arrows). (c) Photomicrograph ($\times 4$) of a coronal section of the wrist, extensive synovial inflammation has resulted in pannus-covered ligaments and cartilage at the radial aspect of the radiocarpal joint (arrows). Note the medial displacement of the navicular (N) and lunate (L) in relation to the distal radius (R).

Table 1 Rheumatoid attitudes and deformities

Attitude or deformity	No. of hands or wrists
Radiocarpal	
Radial deviation	95
Ulnar deviation	1
Medial displacement	59
Volar displacement	27
Intercarpal	
Dorsiflexion carpal instability	15
Palmar flexion carpal instability	8
Inferior radioulnar	
Diastasis	27
Dorsal ulnar subluxation	51
Metacarpophalangeal	
Ulnar deviation	45
Radial deviation	1
Volar subluxation	29

Fig. 3(b)

Fig. 3(c)

ligament and the distal attachment of the palmar radiocarpal ligament. These alterations result in an increased angle between the longitudinal axes of the navicular and lunate, and NLD. Our pathological studies confirm the presence of synovial inflammation with pannus covering these ligaments, resulting in weakening and disruption (Fig. 3).

The incidence of NLD in our rheumatoid wrists was 26%. Arkless (1966, 1967) used cineradiography to evaluate wrist motion and noted that the lunate failed to return to its supraradial position in ulnar

deviation in 58 of 110 rheumatoid wrists. Separation between navicular and lunate was apparent in 50% of these wrists. Other series report a slightly lower incidence of NLD and note additional sites of intercarpal dissociation (Collins *et al.*, 1972).

DFI and NLD occur in other arthritides. They frequently appear in the wrist arthropathy of CPPD associated with radiocarpal joint space narrowing, sclerosis, osteophytosis, and subchondral cysts, preferring the navicular, lunate, and capitate (Resnick *et al.*, 1976) (Fig. 4). Chondrocalcinosis

Fig. 4(a)

Fig. 4(b)

Fig. 4 Carpal instability in calcium pyrophosphate deposition disease (CPPD). (a) An increased space between navicular and lunate has resulted from proximal migration of the navicular with narrowing of the radiocarpal joint (arrow) and distal migration of the lunate with narrowing of the midcarpal joint (arrowhead). Calcification within the wrist is present but poorly identified. (b) More severe changes have resulted in separation of navicular (arrow) and lunate (arrowhead). Sclerosis, osteophytosis, subchondral cyst formation, and calcification are apparent. (c) Photograph of a macerated wrist specimen from a cadaver with CPPD, note the disruption of the interosseous ligament between navicular and lunate (arrow) producing a gap between the two bones. Calcification of cartilage and synovia (arrowhead) can be seen. (d) The corresponding photomicrograph ($\times 4$) shows the navicular-lunate (N-L) dissociation related to disruption of the interosseous ligament (arrows). The radius (R) is indicated.

Fig. 4(c)

Fig. 4 (d)

may or may not be apparent (Resnick and Utsinger, 1974). The abnormal separation between the navicular and lunate in this condition is often distinctive. As the radiocarpal joint space narrows, the navicular moves proximally becoming impacted in the articular surface of the distal radius; as the midcarpal joint space narrows, the lunate moves distally becoming intimate with the capitate. A 'step-off' between navicular and lunate becomes apparent. This pattern of NLD, although not invariably present, differs from that occurring in the rheumatoid wrist.

Examination of the pathological alterations accompanying NLD in CPPD also indicates changes distinct from those in the rheumatoid wrist (Table 2). Cystic degeneration and calcific deposition are apparent within the interosseous ligament between navicular and lunate. Ligament laxity and disruption become apparent. Cartilage fibrillation and erosion, and subchondral sclerosis and cyst formation are associated findings.

Table 2

Location	Pathological abnormalities in rheumatoid arthritis	Pathological abnormalities in CPPD
Cartilage	Pannus destruction, replacement with granulation tissue	Fibrillation, erosion, denudation, calcific deposition
Subchondral bone	Pannus extension with cysts, erosions	Bony eburnation, cysts, osteophytosis
Synovium	Inflammation, hypertrophy, cellular infiltration	Cartilaginous and osseous debris with local inflammatory change, calcific deposition
Intra-articular ligaments	Pannus invasion and destruction	Calcific deposition and cystic degeneration

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