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MR Patterns of Dialysis Arthropathy

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Abstract: Ten patients (average age 51 years) on long-term hemodialysis (average duration 13.5 years) were examined by magnetic resonance (MR) (all cases) and CT (five cases) for cystic radiolucencies of the wrist, shoulders, and hips. MR and CT revealed more lesions of smaller size than plain films and both showed a constant communication with the joint space. Synovial hypertrophy was generally absent or very mild even in the case of large osseous erosions. The MR analysis of the content of the lesions in the wrist was quite variable: low signal on T1- and T2-weighted images (12 of 24), low signal on T1- and high signal on T2-weighted images (10 of 24), and high signal on T1- and T2-weighted images (2 of 24). The patterns for transplanted (four cases) or ungrafted (six cases) patients were indistinguishable. These results suggest an articular origin of the lesions, but different from synovial processes such as rheumatoid arthritis, and confirm their probable multifactorial pathogenesis.
Index Terms: Joints, diseases—Dialysis—Kidneys, failure—Magnetic resonance imaging—Computed tomography.

Arthropathy in patients undergoing long-term (>10 years) hemodialysis (HD) has been recently described in the literature, especially in the spine, hips, knees, shoulders, and wrists (1–7). The frequency of lesions seems to be correlated with the duration of dialysis and with the age of patients (4–8).

Pathogenesis remains poorly understood. Secondary hyperparathyroidism may be responsible for lesions of the hand and fingers (9). More recently, iron metabolism abnormalities and aluminum toxicity have been suggested (10–12). Amyloid deposits were also found in synovial hypertrophy, articular effusion, and subchondral areas of large peripheral joints and carpal tunnels; synovitis due to a particular variety of amyloidosis—the β_2 microglobulin—giving lesions similar to primary amyloidosis is suspected (13–16).

Magnetic resonance (MR) has great value in differentiating intra- and extraarticular structures and especially in demonstrating osseous erosions, joint effusions, and synovial hypertrophy. The aim of this study is to describe the MR and CT patterns of the joint lesions in HD that have only been reported on standard radiographic and CT examination and to look for some common characteristics that could explain their pathogenesis.

MATERIALS AND METHODS

Ten patients with end-stage renal failure who had been treated with HD showed osseous or articular abnormalities: seven men and three women of ages ranging between 40 and 61 years (mean 51 years); the average HD duration was 13.5 years (range 10–18 years). The survey revealed hyperparathyroidism in eight patients and four of them had been operated on for parathyroidectomy. Renal transplantation was performed in four cases during the last 1–5 years, but the plain films did not reveal any modification of the lesions after the transplantation.

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Two patients complained of shoulder and one of hip pain.

Amyloidosis was found in three of the four cases of operated bilateral carpal tunnel syndrome and in the fluid of one shoulder with arthritis, but not in a percutaneous biopsy of a shoulder synovium. Aluminum overload was noted in two cases.

Plain films of the spine, pelvis, knees, shoulders, and wrists were available in all cases and showed lesions of the carpal bones (four cases), shoulder (one case), hip (one case), carpal bones and shoulder (three cases), and carpal bone and hip (one case). Magnetic resonance examinations were performed in all cases on a 0.5 T Magniscan CGR unit, using the spin echo technique with T1- [repetition time (TR) 500 ms, echo time (TE) 26 ms] and T2- (TR 2,000 ms, TE 50, 100, and 150 ms) weighted sequences, a 256 × 256 matrix, a field of view of 14 cm, and a slice thickness of 4 mm for wrists and 8 mm for shoulders or pelvis. In one case of carpal bone lesion, a STIR sequence (inversion time 150 ms, TR 1,500 ms, TE 26 ms) was added. Frontal and axial views were obtained for the wrists and frontal views for the shoulders and pelvis. In the case of bilateral lesions, only the more clinically or radiologically affected organ was imaged owing to the excessively long acquisition times and uncomfortable patient positioning. Axial CT views were obtained on a Philips Tomoscan or Siemens Somatom for three of the eight wrists and two of the four shoulders. Double contrast arthrography was performed on two shoulders.

RESULTS

Wrist (Eight Cases; Figs. 1 and 2)

Standard Radiographic Data

The abnormalities were unilateral in three cases (two left, one right) and bilateral (often asymmetric) in five cases. The lesions appeared either as marginal erosions (size, 2–6 mm) or sometimes as larger cystic radiolucencies that had an intraosseous component (size, up to 10 mm). The frequency ranged from one to seven lesions per hand. All cystic radiolucencies had regular margins and peripheral bone sclerosis. The most affected bones were the lunate, capitate, scaphoïd, radius, and triquetrum.

The joint space was normal in six of the eight cases. In one case, a diffuse destruction was noted, giving the appearance of an erosive carpitis; in another case, the trapezoscaphoid joint was narrowed owing to degenerative changes. Synovial hypertrophy was suspected in one case owing to a thickening of the soft tissues on the radial edge of the carpus.

MR Patterns

Six left and two right wrists were examined by MR.

Osseous abnormalities. Frontal images were most efficient in lesion detection and delineation. They re-

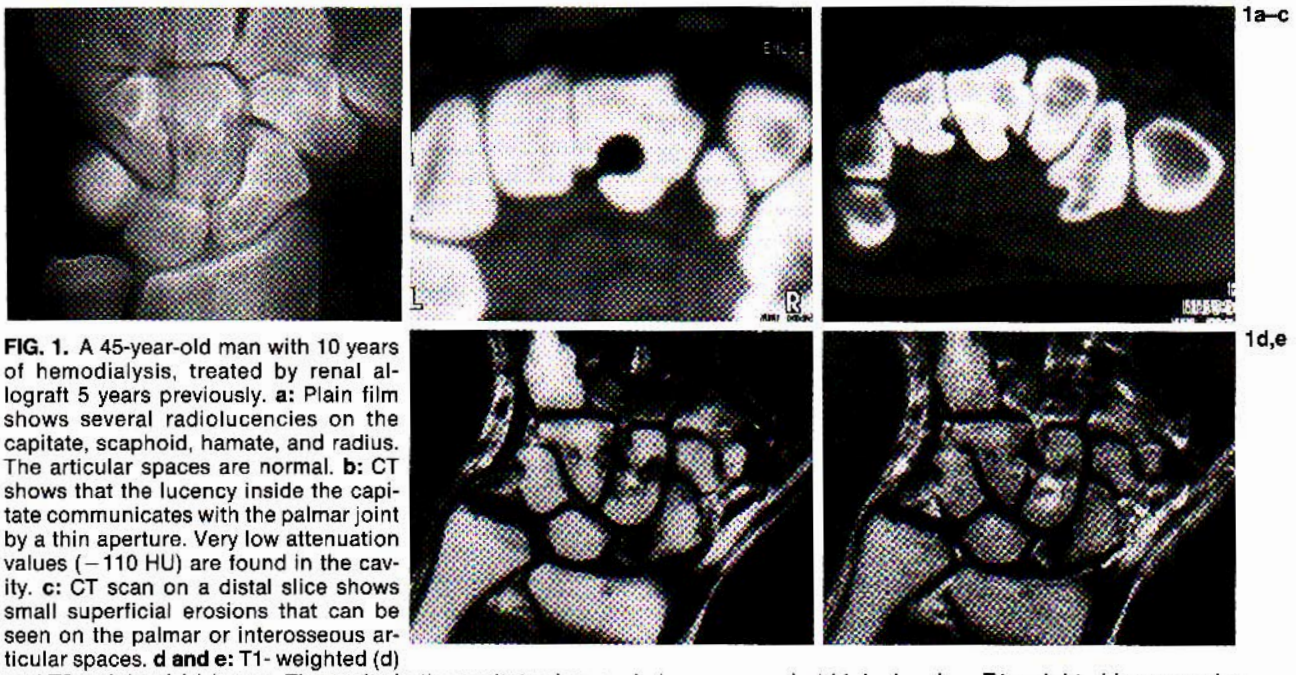

FIG. 1. A 45-year-old man with 10 years of hemodialysis, treated by renal allograft 5 years previously. **a:** Plain film shows several radiolucencies on the capitate, scaphoid, hamate, and radius. The articular spaces are normal. **b:** CT shows that the lucency inside the capitate communicates with the palmar joint by a thin aperture. Very low attenuation values (−110 HU) are found in the cavity. **c:** CT scan on a distal slice shows small superficial erosions that can be seen on the palmar or interosseous articular spaces. **d and e:** T1- weighted (d) and T2-weighted (e) image. The cavity in the capitate shows a heterogeneous but high signal on T1-weighted image and a high but slightly decreasing signal on T2-weighted image. The cavity in the scaphoid has a low signal on both sequences. No synovial proliferation can be seen.

2a–c 

FIG. 2. A 40-year-old man with 18 years of hemodialysis and never transplanted. Plain film **(a)** shows large erosion of the capitate, smaller on the lunate and triquetrum. No abnormalities of the joint space can be seen. T1-weighted **(b)** and T2-weighted **(c)** images show low signal on both sequences in the capitate lesion and low signal on T1- and high signal on the T2-weighted image for the triquetrum lesion. Mild effusion and synovial proliferation can be seen on the radial edge of the carpus.

vealed abnormalities in greater number and smaller size than plain films. Axial views showed their position on the palmar or interosseous articular joint surface, but never on the dorsal articular joint surface.

Twenty-four lesions, without artifact due to partial volume, could be studied on T1- and T2-weighted images and three distinct categories could be observed. Twelve showed a low signal intensity on both T1- and T2-weighted images; 10 showed a low signal intensity on T1 and on T2-weighted images, a high but slightly heterogeneous signal in 6 cases, or a hyperintense signal in 4 cases; 2 showed a high signal intensity on T1-weighted images, and high but slightly decreasing signal on T2-weighted images. These different categories were almost always associated in the same wrist. No correlation with the size of the lesion or with the location in the carpal bones could be found.

Soft tissue abnormalities. There was a mild effusion in the radiocarpal or mediocarpal joint in three cases and similarly in the trapezoscaphoid joint in the case of arthritis. Synovial hypertrophy was found in three cases. It was mild and predominant on the radial edge of the carpus in two cases or extensive and diffuse in the case of erosive carpitis; one of these three patients and another showed small synovial cysts associated with flexor or extensor tenosynovitis.

The triangular fibrocartilage was normal in three cases, heterogeneous in three cases, probably torn in one case, and could not be identified in the case of diffuse carpitis.

CT Patterns

The CT images were available for three patients. Axial views were the best for lesion detection. Computed tomography showed very small lesions, not apparent on plain films or on MR images. It confirmed that the lesions were always situated on the palmar or interosseous articular edges of bones, and that the joint space was usually preserved. The lesion aperture in the joint was often quite wide. However, in two cases, it was very narrow, with a predominant intraosseous component. The attenuation values ranged from 110 to −30 HU; they were especially low in the cases of intraosseous extension.

Synovial hypertrophy was suspected in one case, but its confirmation remained difficult owing to the poor resolution of the soft tissues.

Shoulders (Four Cases; Figs. 3 and 4)

Standard Radiographic Data

Abnormalities were found on both sides in three cases. In one case, only the left shoulder was involved but plain films obtained 3 years before showed typical calcium deposits of the supraspinatous tendon. There was a sharply defined erosion with sclerotic margins on the superior aspect of the humeral head in all cases and on the lateral aspects of the humeral head in two cases. The glenohumeral joint was always preserved. The size of the lesion was variable, often asymmetric without any correlation to the duration of HD or to the clinical complaints. In one case, a large subchondral cystic radiolucency was present in the glenoid (Fig. 4).

MR Patterns

In two cases, the frontal T1-weighted images revealed small superficial lesions of the humeral head, not clearly seen on plain films. All the humeral erosions as well as the glenoid radiolucency showed a slightly heterogeneous predominantly low intensity signal on T1- and predominantly high signal intensity on T2-weighted images.

A mild joint effusion was found in two cases, but a moderate synovial hypertrophy could be observed in only one case (Fig. 3). In one patient, both hu-

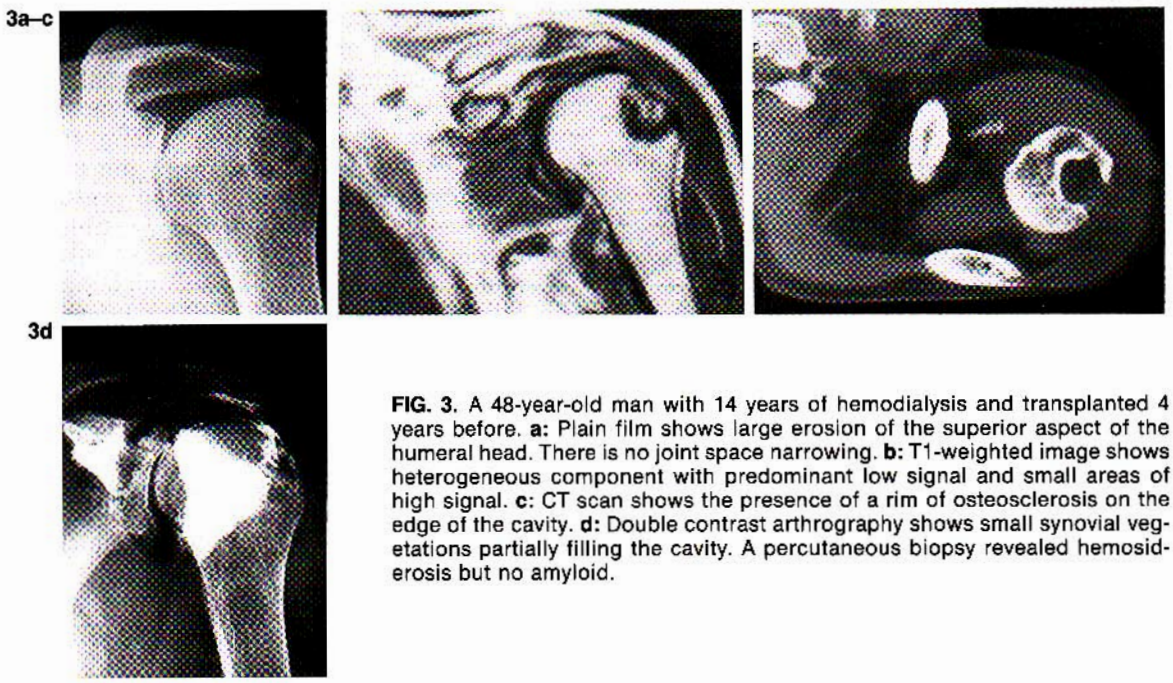

FIG. 3. A 48-year-old man with 14 years of hemodialysis and transplanted 4 years before. **a:** Plain film shows large erosion of the superior aspect of the humeral head. There is no joint space narrowing. **b:** T1-weighted image shows heterogeneous component with predominant low signal and small areas of high signal. **c:** CT scan shows the presence of a rim of osteosclerosis on the edge of the cavity. **d:** Double contrast arthrography shows small synovial vegetations partially filling the cavity. A percutaneous biopsy revealed hemosiderosis but no amyloid.

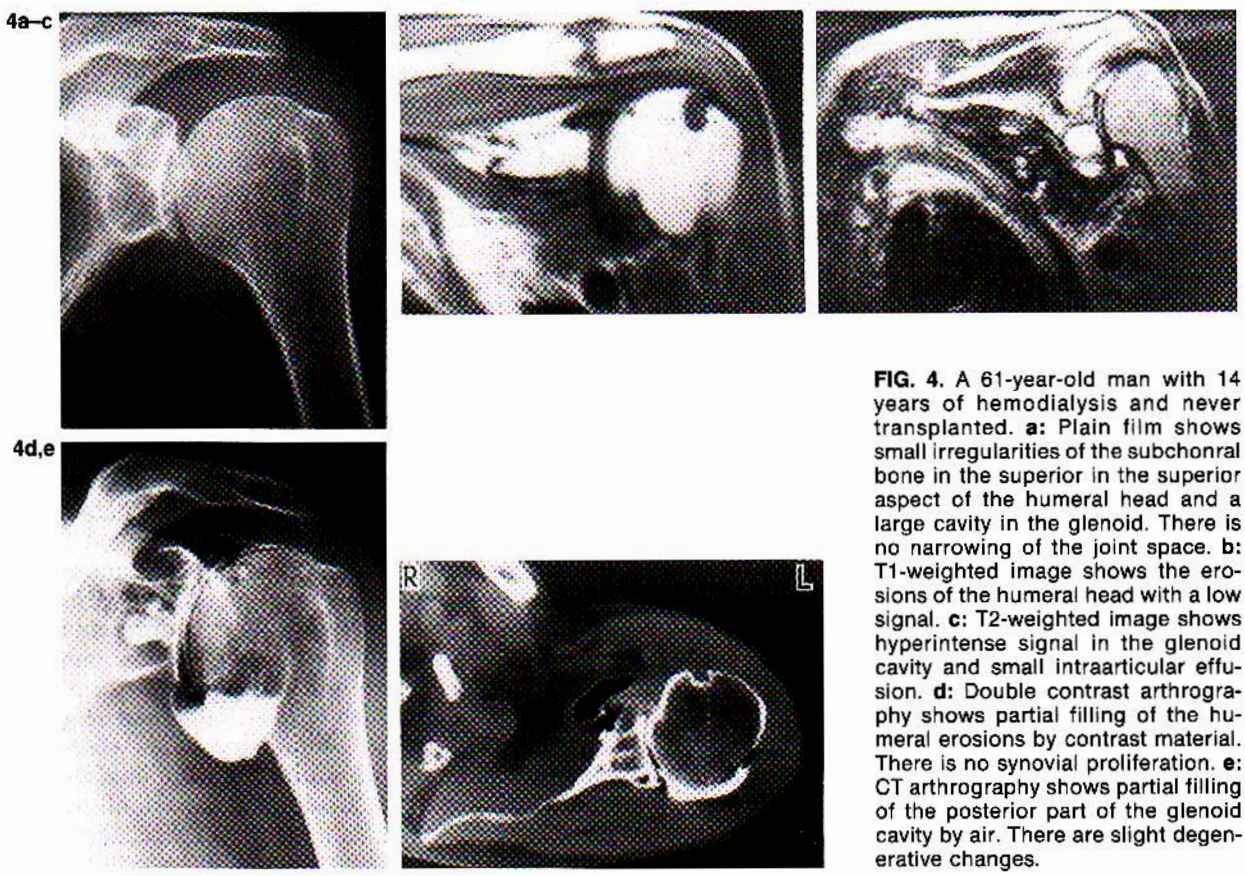

FIG. 4. A 61-year-old man with 14 years of hemodialysis and never transplanted. **a:** Plain film shows small irregularities of the subchonral bone in the superior in the superior aspect of the humeral head and a large cavity in the glenoid. There is no narrowing of the joint space. **b:** T1-weighted image shows the erosions of the humeral head with a low signal. **c:** T2-weighted image shows hyperintense signal in the glenoid cavity and small intraarticular effusion. **d:** Double contrast arthrography shows partial filling of the humeral erosions by contrast material. There is no synovial proliferation. **e:** CT arthrography shows partial filling of the posterior part of the glenoid cavity by air. There are slight degenerative changes.

meral heads showed small subchondral areas of low signal on T1- and heterogeneous signal on T2-weighted images, which was interpreted as necrosis.

Arthrography and CT

In one case, standard CT confirmed the presence of well-defined sclerotic margins around the humeral lesion. Double contrast CT arthrotomography was performed in two patients. The humeral erosions in addition to the glenoid cavity were partially filled with contrast material and air; no significant synovial hypertrophy could be seen. The articular cavity showed a normal morphology in one case and a slight thinning of the articular joint with early degenerative changes in the other case.

Hips (Two Cases)

Standard Radiographic Data and MR Patterns

Abnormalities were found on both sides. In the first case, the lesions were cystic lucencies of the acetabula with low signal-intensity on T1- and high signal intensity on T2-weighted images; slight joint space narrowing was present, suggesting osteoarthritis. In the second case, one hip showed major alterations due to an old coxalgia, and the other showed typical osteonecrosis of the femoral head, with low signal on T1- and heterogeneous signal on T2-weighted images surrounded by an intermediate zone of low signal. Neither synovial proliferation nor osseous erosions of the femur could be seen in either case.

DISCUSSION

The lesions that were seen in our cases on plain films were similar to those described in previous reports and were related to long-term HD. Both MR and CT, due to their multiple section acquisition and superior contrast resolution for both osseous and soft tissues, disclosed some common characteristics that were mainly topographic: (a) MR and especially CT revealed more lesions of smaller size than could be seen on plain films. This point was particularly true for the wrist, and, similar to the findings in rheumatoid arthritis (RA) (17), may allow an earlier diagnosis of bony erosions in HD patients. (b) Both MR and CT showed the communication of bone lesions with the joint, even in the case of predominant intraosseous involvement. This seemed to confirm the articular origin of the cystic radiolucencies. (c) CT or arthroscanography showed a constant rim of sclerosis around the bony erosions or cavities, which was also suspected on plain films and was related to the very slow development of the lesions.

The analysis of the signal intensities of the lesions by MR revealed a great variability. Two predominant patterns could be seen: (a) Low signal on both T1- and T2-weighted images, with intermediate attenuation values on CT (-10, $+30$ HU). Because of the lack of histologic correlations, we can only speculate about their nature; but the presence of tissues of low water concentration (e.g., fibrous tissue) is the most probable explanation. (b) Low signal on T1-weighted images and high signal on T2-weighted images, which was either intense, suggesting fluid contents, or moderate and slightly heterogeneous, indicating the presence of several components (i.e., association of soft tissues and fluid). On CT, the attenuation values were also intermediate.

In two cases, the lesions showed a high signal intensity on T1-weighted images and a high but slightly decreasing signal in T2-weighted images; the low attenuation values (-60 to 110 HU) on CT could be explained by beam hardening artifact from the surrounding bones, but the presence of a fat component also has to be considered since the signal on the STIR sequence was very low. These two lesions were situated in the lunate and capitate bones, respectively, and their patterns were similar to those we found in the primary cysts of the lunate. No simple explanation could be given for the diversity of MR patterns of the contents of the cavities. It is especially surprising to find, on the same wrist, different MR patterns for lesions that have the same appearance on plain films.

In our study, synovial hypertrophy appears to play only a minor role. In the hip, the lesions observed were due either to necrosis or to degenerative changes, without the appearance of synovial proliferation. In the shoulder, the bony erosions were located on articular margins and were similar to those seen in patients with synovial diseases such as RA, pigmented nodular synovitis, hemophilia, and primary amyloidosis (1). The communication between the lesion and the joint space was very large, and the cavities were partially filled by contrast material and air on arthrography, but no significant synovial hypertrophy or cartilage erosion could be found by MR or arthroscanography. In the wrist, the erosions were always situated on palmar or intraosseous surfaces of bones, which has to be correlated with the predominant flexor tendon synovitis in such patients. Nevertheless, the distribution of lesions in the carpus is slightly different from that reported in RA (17), since the predominant location in the hamate and bases of the third and fourth metacarpals, which was described in early stages in RA, was not found in our cases where the lunate, capitate, and scaphoid were mainly affected. On the other hand, even though all the lesions communicated with the joint space, the articular space was usually preserved, even in two cases

of large lesions where a moderate synovial proliferation was found on the radial edge. The only exception was the case of diffuse carpitis where no amyloid deposits were found in biopsy of the carpal tunnel synovium.

Magnetic resonance did not reveal a common pattern of the different lesions. If their location suggested an articular origin, their content appeared very different and no constant synovial hypertrophy could be shown.

No correlation could be found with the clinical complaints, hyperparathyroidism, or abnormalities of aluminum or iron metabolism. Similar findings were noted both in previously transplanted and untransplanted patients.

Nevertheless, several pathogenic factors have to be discussed: Degenerative changes have first to be proposed owing to their higher incidence in elderly patients. Subchondral cysts, giving a low signal on T1- and high signal on T2-weighted images, are frequent and easily recognized because of the narrowing of the joint space and their location in high pressure areas. We encountered such patterns in one trapezoscaphoid joint and in two hips.

Hyperparathyroidism is known to induce the formation of cystic lucencies, the "brown tumors," which are situated mainly in the metacarpals and phalanges of the fingers and toes. However, our lesions were located predominantly in the carpus and no regression of the osseous abnormalities was noted after parathyroidectomy, in contrast to the periosteal resorptive changes on phalanges, which disappeared. In other studies, previous hyperparathyroidism was inconsistent and this factor alone could not explain the abnormalities (4,15).

Aluminum can accumulate in articular structures and induce inflammatory changes of synovium (10,12). Aluminum overload was present in only two of our cases. Iron can also have an important adjuvant role (11). In one of our shoulder erosions, percutaneous biopsy showed hemosiderin deposits among moderate inflammatory changes of the synovium.

Deposition of a special type of amyloid, β_2-microglobulin, has been reported in the carpal tunnel, the hypertropic synovium, and synovial fluid of hips or shoulders and the vertebral disks (5,7). This suggested that β_2-microglobulin could be responsible for a destructive arthropathy with radiological patterns similar to primary amyloidosis or synovial processes (13). Our findings are slightly different: Amyloid was found in three cases after carpal tunnel biopsy and in the fluid of a synovial arthritis of a shoulder, but no synovial proliferation could be demonstrated by MR or arthroscanography. No amyloid deposit could be found in two other patients, especially in the case with a major synovial proliferation and a diffuse carpitis.

Consequently, the role of β_2-microglobulin as an etiologic agent in the synovial proliferation is doubtful. If amyloid deposits are frequent in HD patients, they may be only a secondary phenomenon that occurs in the synovium of joints already damaged by other processes. Such conclusions are in agreement with a recent study based on clinical, biological, and histological data (15).

A chronic intraarticular hypertension due to fluid movement during the HD could also be responsible since the intensity of shoulder pain observed in two of our cases was related to the rhythm of HD and because a large glenoid lesion, as observed in one case (Fig. 4), has been described in a case of chronic repetitive trauma (18).

In conclusion, MR and CT allow for the early detection of destructive arthropathy in long-term HD patients. The great diversity of MR characteristics of the erosions and the inconstant presence of synovial hypertrophy support the supposed multifactorial pathogenesis of these lesions (15). The follow-up of such patients by MR could be helpful toward a better understanding of the observed patterns.

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REFERENCES

1. Bonavita JA, Dalinka MK. Shoulder erosions in renal osteodystrophy. *Skeletal Radiol* 1980;5:105–8.
2. Sundaram M, Wolverson MK, Heiberg E, Grider RD. Erosive azotemic osteodystrophy. *AJR* 1981;136:363–7.
3. Rubin LA, Fam AD, Rubenstein J, Campbell J, Saiphoo C. Erosive azotemic osteoarthropathy. *Arthritis Rheum* 1984; 27;1086–94.
4. Goldstein S, Winston E, Chung TJ, Copra S, Pariser K. Chronic arthropathy in long-term hemodialysis. *Am J Med* 1985;78:82–6.
5. Kaplan P, Resnick D, Murphy M, et al. Destructive noninfectious spondyloarthropathy in hemodialysis patients: a report of four cases. *Radiology* 1987;162:241–4.
6. Naidich JB, Karmel MI, Mossey RT, Bluestone PA, Stein HL. Osteoarthropathy of the hand and wrist in patients undergoing long-term hemodialysis. *Radiology* 1987;164: 205–9.
7. Rafto SE, Dalinka MK, Schiebler ML, Burk DL, Jr., Kricun ME. Spondyloarthropathy of the cervical spine in long-term hemodialysis. *Radiology* 1988;166:201–4.
8. Gaucher A, Kessler M, Netter P, Azoulay E, Pere P, Mur JM. Dialysis arthropathy: the effect of age. *J Rheumatol* 1988;15:1880–1.
9. Resnick DL. Erosive arthritis of the hand and wrist in hyperparathyroidism. *Radiology* 1974;110:263–9.
10. Netter P, Kessler M, Burnel D, et al. Aluminum in the joint tissues of chronic renal failure patients treated with regular hemodialysis and aluminum compounds. *J Rheumatol* 1984; 11:66–70.

11. Cary NRB, Sethi D, Brown EA, Erhardt CC, Woodrow DF, Gower PE. Dialysis arthropathy: amyloid or iron? *Br Med J* 1986;293:1392–4.
12. Kriegshauser JS, Swee RG, McCarthy JT, Hauser MF. Aluminum toxicity in patients undergoing dialysis: radiographic findings and prediction of bone biopsy results. *Radiology* 1987;164:399–403.
13. Bardin T, Kuntz D, Zingraff J, Voisin MC, Zelmar A, Lansaman J. Synovial amyloidosis in patients undergoing long-term hemodialysis. *Arthritis Rheum* 1985;28:1052–8.
14. Huaux JP, Noel H, Bastien P, et al. Amylose articulaire, fracture du col fémoral et hémodialyse périodique chronique. *Rev Rhum Mal Osteoartic* 1985;52:179–82.
15. Hurst NP, Van Den Berg R, Disney A, et al. Dialysis related arthropathy: a survey of 95 patients receiving chronic hæmodialysis with special reference to β_2 microglobulin related amyloidosis. *Ann Rheum Dis* 1989;48:409–20.
16. Laurent G, Charra B, Calemard E, et al. Mesure échographique de l'épaississement synovial de la hanche. Intérêt dans l'évaluation de l'arthropathie des dialysés. *Presse Med* 1989;18:939.
17. Gilkeson G, Polisson R, Sinclair H, et al. Early detection of carpal erosions in patients with rheumatoid arthritis: a pilot study of magnetic resonance imaging. *J Rheumatol* 1988; 15:1361–6.
18. Hellmann DB, Helms CA, Genant HK. Chronic repetitive trauma: a cause of atypical degenerative joint disease. *Skeletal Radiol* 1983;10:236–42.