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Metaphyseal sclerosis in patients with chronic renal failure

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Abstract. We reviewed radiographs of the hands and wrists of 33 patients with immature skeletons and chronic renal disease. Various radiographic manifestations of renal osteodystrophy were seen, including osteopenia in 23 patients (70%), subperiosteal resorption in 20 (61%), distal tuft resorption in 14 (42%), sclerosis of vertebral bodies in 2 (6%), and soft-tissue calcification in 1 (3%). We also noted that 13 patients (39%) exhibited metaphyseal sclerosis adjacent to the growth plates. Five of these 13 showed persistent sclerosis years after the growth plates had fused. None of the patients showed other radiographic changes of rickets, and there was no correlation between the serum calcium, phosphorus, or aluminum levels and the presence of metaphyseal sclerosis. Neither was there any association with the underlying cause of renal failure, method of treatment, presence of a transplant, or type of dialysis. We view this finding as another manifestation of renal osteodystrophy. The importance of distinguishing it from other sclerotic lesions is discussed.

Key words: Metaphyseal sclerosis – Renal osteodystrophy – Dialysis – Hyperparathyroidism – Radiology

During recent decades, the improved results of long-term dialysis treatment and transplantation for renal failure have led to a rapidly growing number of patients undergoing routine radiographic examinations. Renal osteodystrophy consists of a well-known constellation of skeletal abnormalities. Some of the features are associated with the loss of bone density, whereas others reflect bone sclerosis. Although generalized sclerosis and sclerosis of the metaphyses have been described in renal osteodystrophy, band-like sclerosis limited to the metaphyses has not, to our knowledge, been noted. This study was undertaken to assess the prevalence of this finding in the hands and wrists and to characterize its appearance and evolution.

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Materials and methods

We reviewed the medical records and radiographs of 33 long-term nephrology patients (23 males and 10 females) who were either receiving dialysis (22) or were living with successfully transplanted kidneys after initial treatment. The patients were seen at the University of Michigan; they are under 21 years of age and have undergone radiographic examination. The primary diseases of these patients were as follows: dysplastic kidneys (6), chronic glomerulonephritis (6), hereditary juvenile nephronophthisis (4), interstitial nephritis (3), obstructive uropathy (3), immunoglobulin G nephropathy (2), Alport's syndrome (2), polycystic kidney disease (2), diabetic nephropathy (1), cystinosis (1), hemolytic uremic syndrome (1), focal glomerulosclerosis (1), and Bartter's syndrome (1).

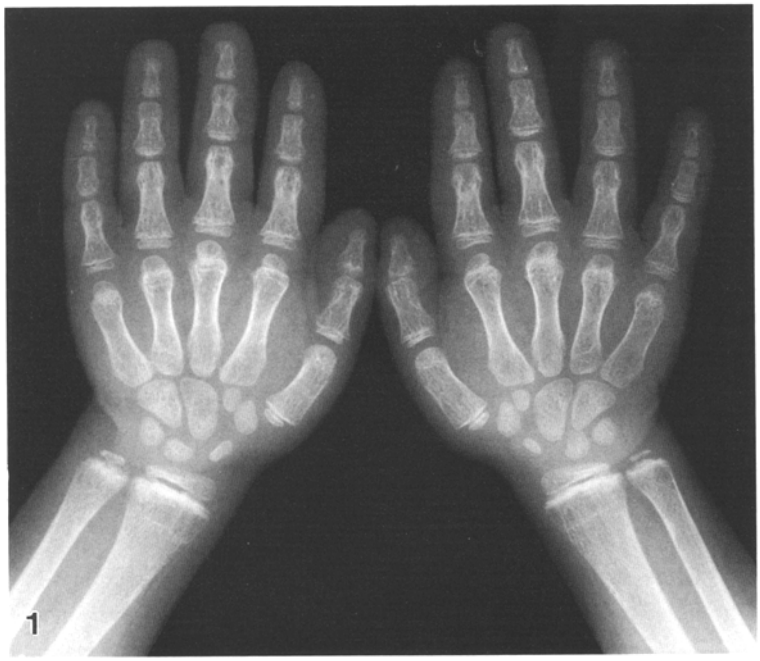
Two radiologists carefully analyzed radiographs of the hands and wrists independently. The presence of metaphyseal sclerosis, subperiosteal resorption, osteopenia, distal tuft resorption, and soft-tissue calcification was graded 0–3. Nine patients had more than one wrist examination, with at least 12 months between first and last radiographs. Three patients had radiographic examinations spanning at least 3 years. Bone age was evaluated in all patients. In addition, lateral chest radiographs were used in 12 cases for assessment of vertebral body sclerosis (rugger-jersey spine); a thoracic spine series was performed in one patient.

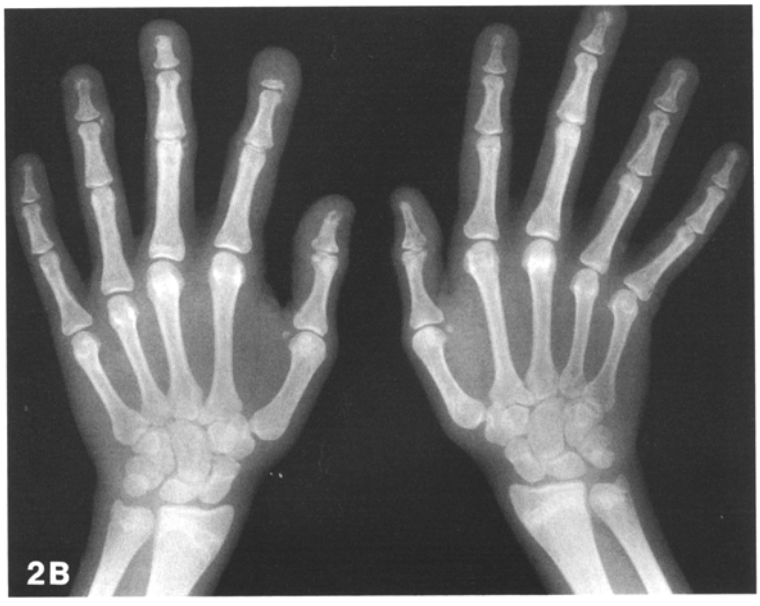
Serum calcium and phosphorus levels measured within 1 year of radiographic examinations as well as at the time of appearance of metaphyseal sclerosis were evaluated. Serum aluminum levels were obtained in 9 of the 13 patients. Seven of these were within 1 year of the radiographs showing sclerosis.

Results

Radiologic findings

Metaphyseal sclerosis was seen in 13 of 33 patients (39%, 8 male and 5 female) on at least one examination (Fig. 1). Of the 9 patients with more than one examination, 2 had bandlike metaphyseal sclerosis on examinations obtained 24 and 15 months after earlier negative





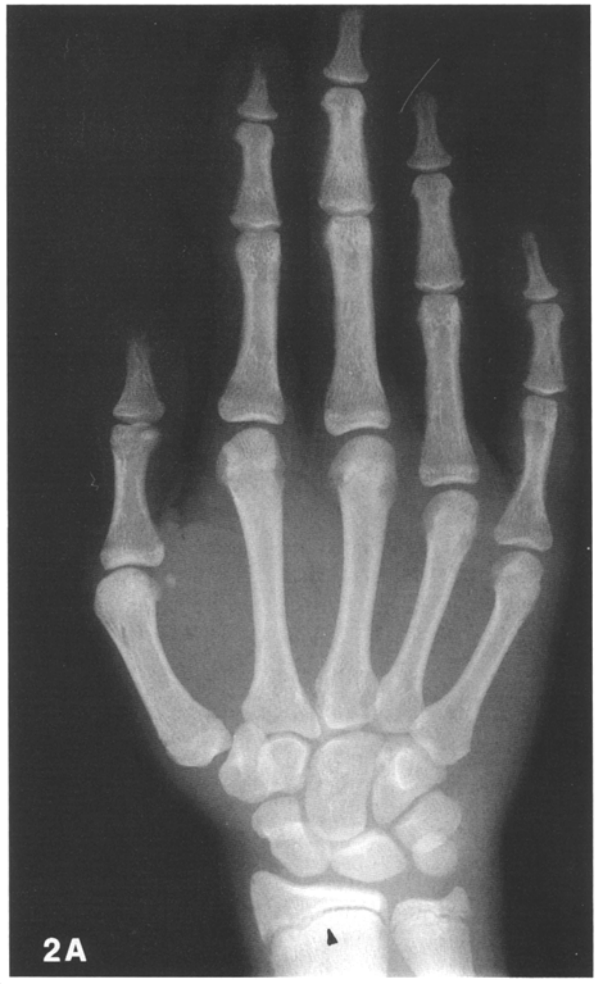


Fig. 1. Striking osteopenia present in this 13-year-old boy (bone age approximately 7 years, 6 months) is accompanied by band-like metaphyseal sclerosis of the distal radius and ulna

Fig. 2. A Subtle, band-like sclerosis across the distal radial (*arrowhead*) and ulnar growth plates in a 15-year-old girl. Note the lack of a widened physis or frayed metaphysis. **B** Three years later metaphyseal sclerosis has progressed after growth plate closure. The finding is also present in the metacarpals. Acro-osteolysis, subperiosteal resorption, and periarticular calcification have increased

radiographs. Another 2 patients with metaphyseal sclerosis subsequently had resolution of the finding 24 and 14 months later. One patient initially demonstrated no sclerosis, but moderate sclerosis was seen on an examination 15 months later; the sclerosis resolved completely after 14 months. Another patient initially had metaphyseal sclerosis, which subsequently increased on a 3-year follow-up examination (Fig. 2). Subperiosteal resorption was seen in 69% of patients with metaphyseal sclerosis, osteopenia in 85%, distal tuft resorption in 54%, and soft-tissue calcification in only 8% (Table 1). Of the 33 patients in our study, only 5 (15%) demonstrated no abnormality. Four of these patients had only one examination. Three patients had radiographs taken before beginning dialysis.

In all patients bone age was less than chronologic age. In females, bone age averaged 2 years and 4 months less than chronological age. In males, the average difference was 2 years and 8 months. The chronologic age of patients exhibiting metaphyseal sclerosis ranged from 6 to 19 years with a mean of approximately 14 years.

Laboratory findings

Of the 13 patients with bandlike metaphyseal sclerosis, 2 had elevated phosphorus levels at the time of positive radiographic diagnosis. One patient had a low serum calcium level. Otherwise, all patients with metaphyseal sclerosis were within the normal range in our hospital

Table 1. Incidence of associated radiographic findings in 33 patients with renal osteodystrophy

No. of patients	Radiographic findings	Metaphyseal sclerosis	Subperiosteal resorption	Osteopenia	Distal tuft resorption	Soft-tissue calcification
13	Metaphyseal sclerosis	–	9 (69%)	11 (85%)	7 (54%)	1 (8%)
20	Subperiosteal resorption	9 (45%)	–	19 (85%)	11 (55%)	1 (5%)
23	Osteopenia	11 (48%)	17 (74%)	–	13 (57%)	0 (0%)
14	Distal tuft resorption	8 (57%)	9 (64%)	13 (93%)	–	1 (7%)
1	Soft-tissue calcification	1 (100%)	1 (100%)	0 (0%)	1 (100%)	–

(8.8–10.4 mg/dl for calcium and 2.5–4.9 mg/dl for phosphate). All 9 patients with measured serum aluminum levels and sclerosis had normal levels (0–10.0 μg/l). Only in 2 were the aluminum levels assessed more than 1 year after the positive radiographic examination.

Discussion

Although generalized sclerosis and sclerosis of the bone ends, periosteum, and vertebral end-plates have been reported in patients with renal osteodystrophy [3, 4], isolated, bandlike metaphyseal sclerosis in the skeletally immature patient with renal failure has not been emphasized. Apparently this finding is not rare as it occurred in 13 of our 33 patients.

Osteoblastic activity and bone sclerosis in association with secondary hyperparathyroidism in chronic renal failure may have many different pathogeneses. Subperiosteal neostosis in adults has been described by Meema et al. [10] and Ritchie et al. [12], who considered the new sclerotic bone formation a result of exuberant reactive osteoid which may or may not subsequently mineralize. Norfray et al. [11] have noted that focal regions of sclerosis occur in the bony pelvis and postulated that the changes may also be attributed to increased osteoid volume. Sclerosis of the epiphyses and ends of the long bones has also been reported as an unusual manifestation of renal osteodystrophy [6, 8]. In our series, no patients showed signs of osteosclerosis in the epiphyses or bone ends. Osteonecrosis with resultant sclerosis has also been documented secondary to steroid therapy in transplant patients or to maintenance hemodialysis. However, none of our patients exhibited the classic characteristics of avascular necrosis. End-plate sclerosis in vertebral bodies, the so-called rugger-jersey spine, is another form of sclerosis often witnessed in chronic renal failure. Although the exact etiology is uncertain, this entity, too, may involve an increased osteoid content [10]. Only one of our patients with metaphyseal sclerosis exhibited coexisting changes characteristic of the rugger-jersey spine.

The metaphyseal sclerosis in the present series was not related to the underlying cause of renal failure or the methods and/or complications of its treatment (Table 2). As many patients also exhibited osteopenia, it is conceivable that the metaphyseal region may be relatively spared from the resorptive processes occurring elsewhere. Alternatively, the metaphyses may be the region in which attempted recovery of retarded bone growth occurs, as all of our patients demonstrated significantly delayed bone age. A combination of factors is probably involved.

Table 2. Primary disease vs. the incidence of metaphyseal sclerosis

Primary disease	No. of patients	Metaphyseal sclerosis	
		Yes	No
Hereditary interstitial	11	4	7
Glomerular	10	4	6
Obstructive, hereditary, urologic	9	2	7
Polycystic	2	2	0
Hematologic	1	1	0

Although we cannot account for the exact etiology of the bandlike metaphyseal sclerosis, it is important for the radiologist to recognize this as a manifestation of chronic renal osteodystrophy rather than some other cause, such as rickets, healing fracture, osteonecrosis, aluminum toxicity, or normal variation (such as "lines of Park").

Metaphyseal sclerosis is a well-described radiographic feature of resolving rickets, often seen in the setting of a healing fracture [1]. Altered vitamin D metabolism may account, in part, for the sclerosis in the metaphysis that we describe here, but our patients did not manifest any other signs of rickets, such as widened or frayed metaphyses.

Although a normal serum aluminum level does not completely exclude aluminum toxicity as the cause of sclerosis, the distribution of sclerosis in our patients appears different from the typical pattern associated with aluminum toxicity. The latter entity demonstrates a slightly broader and more diffuse picture within the ends of the bones [7, 9]. We also found no relationship between serum calcium and phosphorus levels and metaphyseal sclerosis.

Focal, axially orientated metaphyseal sclerosis resulting from calcified cartilaginous discs of the growth plate merging with dense cartilaginous spongiosa of developing bone can be normal but varies in prominence at different ages in the same patient or among individual patients of similar ages. Typically, this increased sclerosis is seen in mid childhood, often between the ages of 2 and 5 years [2]. In addition, thin sclerotic lines seen toward the ends of immature long bones have been well described. They are seen in both healthy and ill children

and are due to growth resumption or recovery from transient growth arrest [5]. The sclerosis present in our population tends to be spread broader and is always located at the metaphysis, features which help to differentiate this entity from the usual "lines of Park".

In conclusion, we would like to emphasize that isolated, bandlike metaphyseal sclerosis, which may be discovered incidentally, is likely to be a distinct, important sign which the radiologist should recognize as part of the radiographic manifestation of renal osteodystrophy in skeletally immature patients.

References

1. Barmeir E, Dubowitz B, Hudson GA, Milne FJ, Meyers AM (1984) Radiography of healing dialysis osteodystrophy. Acta Radiol 25:107
2. Caffey J (1978) Pediatric X-ray diagnosis, vol II, 7th edn. Year Book Medical, Chicago, p 1120
3. Chan Y-L, Furlong TJ, Cornish CJ, Posen S (1985) Dialysis osteodystrophy. A study involving 94 patients. Medicine 64:296
4. Cohen MEL, Cohen GF, Ahad V, Kaye M (1970) Renal osteodystrophy in patients on chronic hemodialysis. A radiological study. Clin Radiol 21:124
5. Garn SM, Silverman FN, Hertzog KP, et al. (1968) Lines and bands of increased density: their implication to growth and development. Med Radiogr Photogr 44:58
6. Garver P, Resnick D, Niwayama G, Guerra J Jr (1981) Epiphyseal sclerosis in renal osteodystrophy simulating osteonecrosis. AJR 136:1239
7. Hernandez RJ, Sedman AB, Smid DM, Goodman WG (1987) Radiographic manifestations of experimental aluminium toxicity in growing bone. Skeletal Radiol 16:209
8. Lewis VL, Keats TE (1982) Bone end sclerosis in renal osteodystrophy simulating osteonecrosis. Skeletal Radiol 8:275
9. Llwellyn CH, Resnik CS, Brower AC (1984) Case report 288. Skeletal Radiol 12:223
10. Meema HE, Oreopoulus DG, Rabinovich S, Husdan H, Rapoport A (1974) Periosteal new bone formation (periosteal neostosis) in renal osteodystrophy. Radiology 110:513
11. Norfray J, Calenoff L, Del Greco F, Krumlovsky FA (1975) Renal osteodystrophy in patients on hemodialysis as reflected in the bony pelvis. AJR 125:352
12. Ritchie WGM, Winney RSJ, Davison AM, Robson JS (1975) Periosteal new bone formation developing during hemodialysis for chronic renal failure. Br J Radiol 48:656