Renal osteopathy has been known for many years now [1–3]. It is characterized by different histological features, which are due to disturbances in calcium (Ca), phosphate, aluminum, and vitamin D metabolism (Chapter 11). Three major types of histological changes exist, which do not represent separate disease entities, but may appear as mixed forms. Despite an agreement on the types of lesions, some differences in nomenclature exist.

Features of renal bone disease were already observed in mild to moderate renal failure [4, 5]. There histological lesions did not correlate with an increase in parathyroid hormone (PTH) levels. With decreasing glomerular filtration rate (GFR), osteoid volume and surface increase. Endosteal fibrosis was observed only with a GFR below 30 ml/min. A mineralization defect could be demonstrated with a GFR below 40 ml/min. Thus, the histological lesions in early CRF are qualitatively identical to the changes in advanced CRF and to those of patients on renal replacement therapy. The findings, however, might be influenced by the use of aluminum-containing phosphate binders, resulting in an accumulation of aluminum in bone and a low turnover osteomalacia [6]. In end-stage renal failure, all patients exhibit signs of renal bone disease [7]. For several reasons [Ca supplementation, aluminum-containing phosphate binders, dietary intake of phosphate and Ca, racial/geographical differences (?), vitamin D metabolite supplementation], the distribution of the different types of lesions is extremely variable [8–12].
BONE DISEASE IN EARLY AND ADVANCED RENAL FAILURE

Data on the impact of early dietary and medical intervention, i.e., Ca supplementation, phosphate restriction, PR restriction, and vitamin D metabolites, on the development of histological lesions are scarce, missing, or even contradictory.

Data concerning a pure Ca supplementation for the prevention of renal bone disease are not available, as at the same time that such a supplement is given, acidosis is treated. Furthermore, Ca forms an insoluble salt with phosphate, resulting in an unknown amount of Ca being absorbed. Then absorption is dependent on the timing of the Ca intake and the amount of phosphate in the diet. The same is true for the phytate content.

Phosphate restriction is known to prevent secondary hyperparathyroidism (HPTH) in experimental CRF [13, 14]. Data on the effects of such diets are difficult to interpret, as in general, phosphate restriction also means protein (PR) restriction. It seems to be established that a dietary phosphate restriction causes an increase in 1,25(OH)2D3 and Ca levels, and a decrease in PTH [15, 16]. Thus phosphate restriction seems to be useful in the prevention of renal bone disease.

Concerning a pure PR restriction, data concerning renal osteodystrophy are missing, as such a restriction also means a phosphate restriction. Fiaschi et al. [12] analyzed the influence of a low-protein diet (LPD) on renal bone disease. They observed osteomalacia in 42–51% of their patients. As some of their patients had received vitamin D, it is not clear whether this high incidence of osteomalacia is the consequence of overtreatment. The analysis of their data is also complicated by the fact that the Ca intake of the patients was highly variable, ranging from 500 to 2000 mg/day. Also, in the long-term analysis of these patients, osteomalacia was the predominant type of bone disease [17].

Fröhling et al. [18] treated patients with a LPD supplemented with amino and keto acids, which resulted in a Ca supplementation of roughly 700 mg/day. In addition, they gave vitamin D. Serum phosphate levels were controlled by using aluminum-containing phosphate binders. This type of treatment resulted in a normal bone histology in 18% of their patients, but in osteomalacia in 42%. This high incidence of osteomalacia might be due to the aluminum intake.

A preliminary analysis of bone histology in patients on long-term dietary management treated in Pisa for more than 2 years with a pure vegetarian diet, supplemented (SD) with keto acids and Ca carbonate, revealed only minute changes in bone histology. Five of these patients exhibited a normal and three exhibited a mixed osteodystrophy with a mild degree of osteopenia and minimal signs of HPTH (endostfibrosis), while two of them might be classified as having osteomalacia (figure 29–1). As the changes observed in the latter two patients were not very pronounced, (figure 29–1), and as tetracycline labeling had not been performed, it is difficult to exclude the possibility that even these patients exhibit a normal bone histology. A com-