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Texture Examinations on Grain and Thin Section Preparations of Calcium Oxalate Calculi and Their Relations to Pathogenetic Parameters

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Summary. Texture examinations were made on 416 thin section and on 1,000 grain preparations of calcium oxalate calculi. The frequency of occurrence of four basic texture types in relation to pathological urine parameters, age and sex of the patients as well as types of stone removal are discussed. Percentage share of texture type I that correlates to hyperuricosuria shows a steady increase with increasing age. The proportions of types III and IV that are linked to hypercalciuria decrease with increasing age. The examinations show the feasibility of texture-type determinations within routine stone analysis and create the precondition for texture types to be included in metaphylaxis of calcium oxalate lithiasis.

Key words: Calcium oxalate urolithiasis, Texture examination, Polarising microscopy, Hypercalciuria, Hyperuricosuria, Metaphylaxis.

Introduction

A number of various hydrate stages of calcium oxalate and their transformations give rise to a great diversity of textures in calcium oxalate calculi [11]. It can be assumed that these represent different basic pathological stone-forming conditions. In order to establish the relationships between texture and pathological parameters of urine and serum it is mandatory to define texture types. Seyfarth [13] has made a very detailed texture system of whewellite calculi. Schäfer and Bausch [9] have established a genetically based texture system with special regard to calcium oxalate trihydrate. In our comprehensive texture examinations we have come to reduce the variety of textures to four basic types [10, 12].

It has been the object of our study to examine the occurrence of the basic texture types in relation to the following factors: pathological parameters in serum and urine; age and sex of the patients; and surgical removal or spontaneous passing of the stone.

Material and Methods

Using a combined crystal-optical X-ray diffraction method of analysis [2, 3], the stone laboratory of the Urological Clinic of the Berlin-Friedrichshain Hospital semi-quantitatively examines the phases of all urinary calculi received in Berlin/GDR. This therefore is representative of a big city population. After semi-quantitative phase-analysis, special examinations are made on selected calculi, among others polarisation microscopic thin section examinations. 416 calcium oxalate calculi were used in texture examinations on calcium oxalate concrements. Proceeding from semi-quantitative analysis, the following aspects were examined: the distribution of the different components in the stone; the morphological appearance of the grains or crystals; the grain or crystal patterns and their mutual and genetic relations.

Using the experience gathered in thin section examinations, a method was developed to facilitate texture determinations on grain preparations in routine stone analysis. To this end, an additional stereo light microscopic examination is made of the fraction area of the calculus. The polarisation-microscopic examination of the grain preparation must be made on the largest possible aggregates or grains in order that the original crystallite texture is at least retained in fractions. For this analysis texture examinations of 1,000 calcium oxalate stones were made in our stone laboratory over a period of 6 months. The 1,000 calcium oxalate stones were received from 743 male and 257 female patients. 159 calculi were removed surgically, 22 instrumentally and 819 were passed spontaneously.

In 86 calcium oxalate lithiasis patients of the Urological Clinic in our hospital calcium, inorganic phosphate, uric acid, magnesium, cystine, pH-value, sodium, potassium, chloride, type of bacteria and, in most cases, oxalic acid were determined in the urine. In the serum, creatinine clearance, the total amount of protein, inorganic phosphate, uric acid, calcium, magnesium, sodium, potassium and chloride were analysed.

The microscopic texture examinations of these patients' concrements were mostly made using the thin section method.

For clarification, a special examination was made on 16 patients with calculi of texture Type II in which the above-mentioned parameters were determined twice.

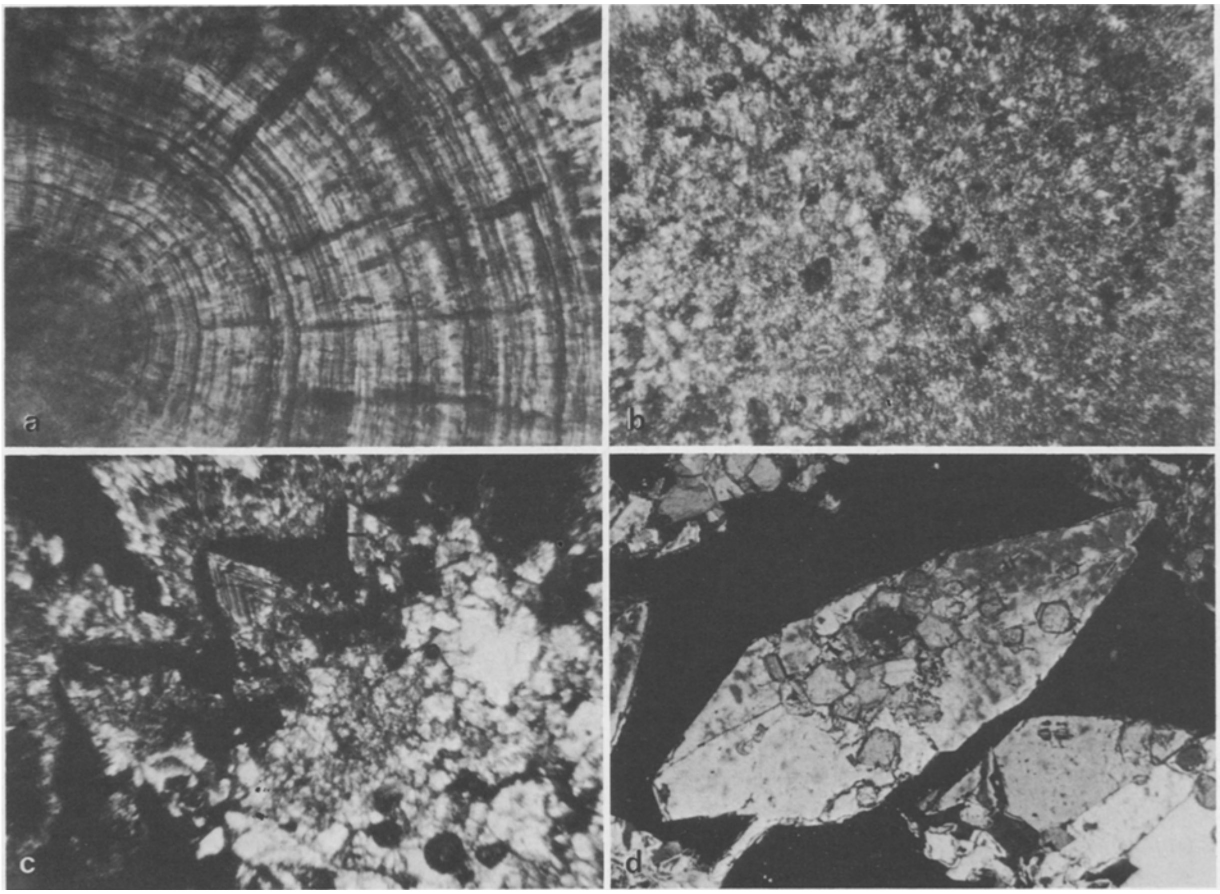

Fig. 1. Microphotographs of thin sections of calcium oxalate urinary calculi, crossed polarizers. **a)** Texture Type I, **b)** Texture Type II, **c)** Texture Type III, **d)** Texture Type IV

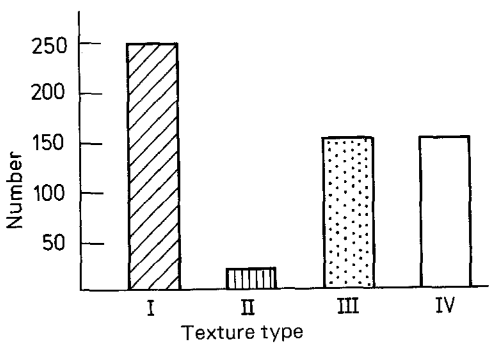

Fig. 2. Distribution of texture types in 416 thin sections preparations of calcium oxalate calculi

Results

Texture Examinations on Thin Sections

On the strength of texture examinations on thin sections of calcium oxalate calculi the texture forms observed can be classified into the following basic texture types:

Type I: concentric, shell-like whewellite texture with radial whewellite pattern (annual rings texture) (Fig. 1a)

Type II: very fine-grained, irregular whewellite texture (Fig. 1b)

Type III: mosaic texture of whewellite crystals, often with weddellite components. (Fig. 1c)

Type IV: idiomorphic, irregular weddellite crystal texture in isotropic basic matter, mostly with different gradual stages of transformation into whewellite (Fig. 1d)

All the textures observed by us are contained in this schematic order even if there are transitory forms between different types.

The frequency of occurrence of the four texture types in 416 thin slices examined is shown in Fig. 2. One calculus may contain more than one texture type. In all the 416 thin sections the four texture types were found 571 times.

Texture Type II, which is relatively rare, mostly occurs in a limited area within the core of Type I calculi. It may, however, also be found in connection with Type III texture. Type IV often forms the peripheral area of calculi with Type I or Type III cores. The absence of weddellite components in textures of Type I indicates that this type has primarily been formed through whewellite crystallisation. On the other hand, the presence of weddellite components proves that the whewellite texture of Type III has been formed

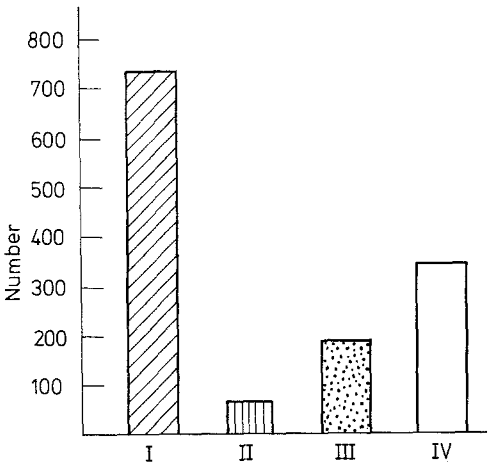

Fig. 3. Distribution of texture types in 1,000 grain preparations of calcium oxalate calculi

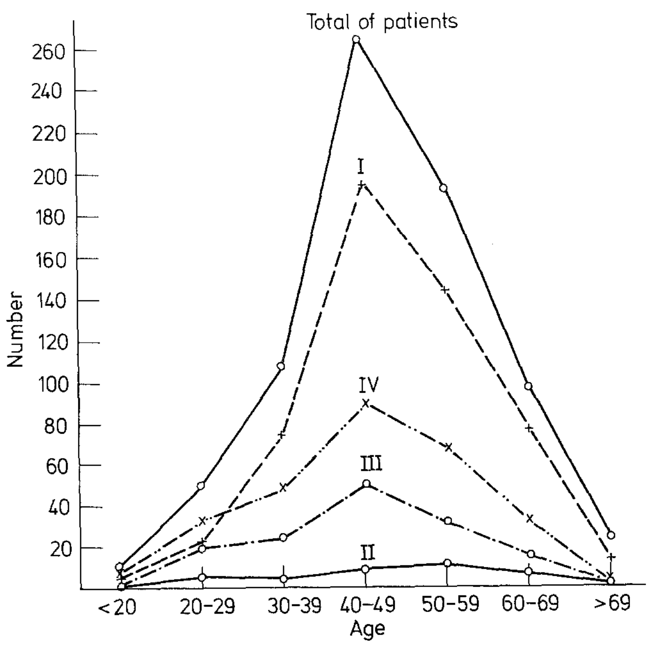

Fig. 4. Frequency of texture types in 743 male calcium oxalate stone patients in dependence on age

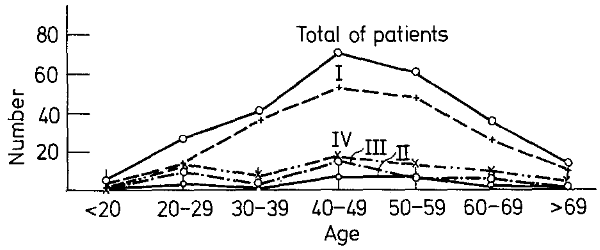

Fig. 5. Frequency of texture types in 257 female calcium oxalate stone patients in dependence on age

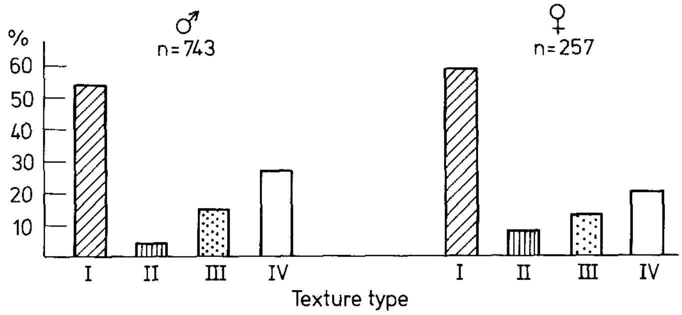

Fig. 6. Percentage texture-type distribution in 1,000 grain preparations of calcium oxalate stone patients, separated into sexes

through a primary weddellite crystallisation with subsequent transformation into whewellite. Owing to their common origins by way of primary weddellite crystallisation Types III and IV form a unit.

Texture Examinations on Grain Preparations

Our method of texture determination on grain preparations allows for a comprehensive registration of every calcium oxalate stone from a closed catchment area within a certain period of time. That is why representative conclusions about the frequency of the texture types may be drawn from a survey of these results. As a result of the examination of 1,000 grain preparations, Fig. 3 shows the absolute frequency of the calcium oxalate texture types. Type I, which has absolute pride of place, is followed by Types IV, III, and II, in that order; the latter occurring much less frequently.

The age distribution of the four types (Figs. 4 and 5) in general corresponds to the age distribution of calcium oxalate patients with a peak in the 40–49 years age group. This peak is especially pronounced with regard to Types I, III, and IV in male patients. The age distribution maximum in female patients is remarkably lower. There is no indication of a peak in Types II, III, and IV. A negative bend in the 30–39 years age group is remarkable in the age-dependent distribution which is especially noteworthy with regard to texture Types II, III, and IV in female patients.

To be able to compare texture distribution among the various age groups and in the groups of surgically removed or spontaneously passes calculi we shall henceforth use percentages of texture type distribution; this reflects the relation between the frequency of one texture type in one group and the sum of all types encountered in a group.

A comparison of the percentages of the different texture types for male and female patients (Fig. 6) shows a larger share of Types I and II and a lower one of Types III and IV in female patients.

Some very obvious tendencies in the percentage representation of texture type distribution in relation to age emerge in the analysis of spontaneously passed calculi (Fig. 7). The share of texture Type I shows a steady rise with increasing age whereas the share of Type IV very clearly decreases in

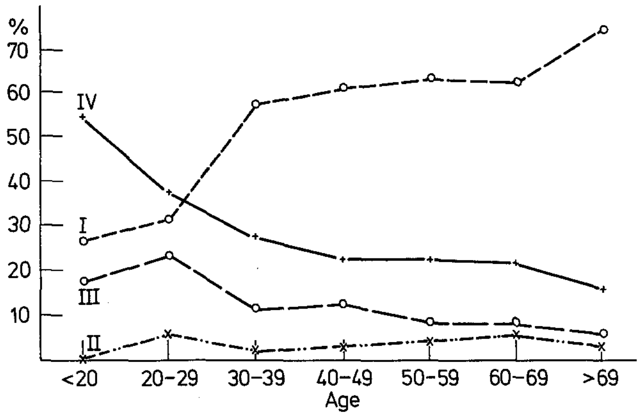

Fig. 7. Percentage texture-type distribution in spontaneously passed urinary calculi in dependence on the patients' age

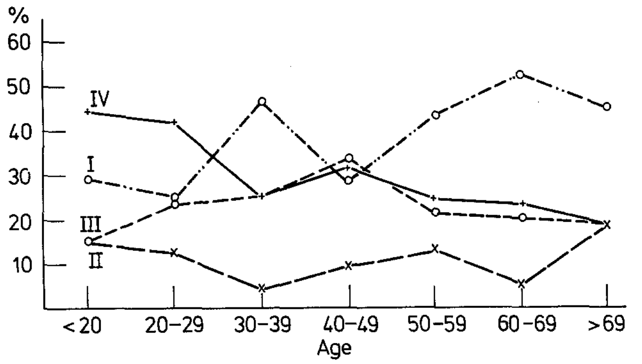

Fig. 8. Percentage texture-type distribution in surgically removed urinary calculi in dependence on patients' age

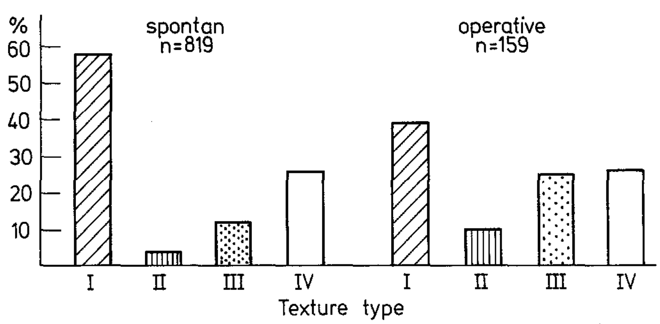

Fig. 9. Percentage texture-type distribution in dependence on type of stone removal and passing respectively

Table 1. Frequency of calcium oxalate texture types in different patient groups (number of pts. $n = 50$)

Patient group	Texture type I	II	III	IV
Hypercalciuria	4	1	8	13
Hyperuricosuria	16	1	–	–
Hypercalciuria and hyperuricosuria	6	–	4	4
Hyperuricaemia	8	3	3	4

the higher age groups. Type III also shows this tendency. Texture type II is nearly evenly distributed in all age groups.

In the surgically removed calculi (Fig. 8) the distribution chart is not so clear. Yet in this case too, increasing age shows a rise of Type I and a decrease of the frequency of Type IV. There is an evidently greater share of texture Types II and III in surgically removed calculi among all age groups. Notable differences of texture type distribution can be observed in all age groups between the group of spontaneously passed calculi and that of surgically removed ones (Fig. 9). Type I takes clear superiority in the first group whereas Types II and III only have a minor share. It is remarkable that among the surgically removed stones Types III and IV have about the same high share (altogether about half of all the stones). In contrast to spontaneously passed calculi, texture Type II was found more than twice as frequently. The share of Type I has only a slight superiority among the surgically removed stones.

Texture Examinations on Certain Groups of Patients

Proceeding from urine and serum examinations in calcium oxalate patients we tried to establish relations between the frequency of the different texture types and certain pathological parameters. Owing to the great complexity of the textures examined it is not easy to find such relations. One calculus often contains more than one texture type. The occasional proof of very small crystal aggregates of other texture types in calculi with one dominating texture type was not taken into account. Pathogenetic grouping of patients was done only on the basis of multiple determinations of urine and serum parameters respectively.

No correlations to a certain texture type were found in the majority of the parameters examined. Only increased urine excretions of calcium and uric acid showed a dominance of certain texture types (Table 1). When hypercalciuria is diagnosed, texture Types III and IV clearly show superiority. In hyperuricosuria Type I is observed nearly exclusively. No dominance of certain texture types could be witnessed in patients with normal values and all other pathological parameters.

In the special test series on the position of the rare type II we attempted to find out in how far these patients show pathological parameters in the serum and/or urine. In the 16 patients we encountered four with hyperuricosuria, one with hypermagnesuria and two with hyperuricaemia. With regard to the total number of stone patients the age and sex distribution of the patients examined by us showed nothing noteworthy. Altogether we can state that at present no unequivocal relations between Type II of calcium oxalate and certain lithogenous factors can be established.

Discussion

There is an unmistakable correlation between calculi formed through primary weddellite crystallisation (Types III and

IV) and hypercalciuria. The findings of our examinations thus correspond to those of C. Delatte [4] and his stone type descriptions in hypercalciuria. Also the priority of weddellite crystallisation with excessive calcium in the urine as found in Schäfer's and Dosch's experiments [8] supports this relation between hypercalciuria and texture Types III and IV.

According to our experience, the stability of primary formed weddellite in the presence of calculi in the urinary system (Type IV) or its partial dehydratation towards the mosaic whewellite structure depends on the following factors:

1. The different stability of weddellite resulting from a different incorporation of stabilising ions, e.g. magnesium (5)

2. A change of the exterior urine milieu that can stabilise or destabilise weddellite

3. The duration of the presence in the urinary system

In how far the above-mentioned factors influence the formation of types III and IV will still have to be established in detail.

The correlation we found between hyperuricosuria and oxalate texture Type I must be linked to the well-known role of uric acid in calcium oxalate stone formation. It can be asssumed that uric acid inactivates the inhibiting function of acid mucopolysaccarides [6, 7].

With increasing age the share of Type I calculi increases as this is closely connected to hyperuricosuria. This corresponds to the established fact that gout and hyperuricaemia occur more frequently with increasing age. The opposite tendency of a decrease of the share of Types III and IV with increasing age has to be explained by a decreased effect of hypercalciuria as a pathogenic factor in stone formation. The higher share of Type I in spontaneously passed calculi in contrast to that in surgically removed stones certainly has to be seen in the smoothness of the round whewellite stones of Type I that can more easily be passed than the sharp-edged stone of type IV.

The double share of Type III in surgically removed stones in contrast to that in spontaneously passed ones is due to a higher transformation activity of weddellite stones in this group. It is not easy to find out which of the above-discussed factors causes this increased transformation of weddellite into whewellite. Certainly the longer presence of these calculi – which is the indication of their surgical removal – in the urinary system does not play an unimportant role [1].

Texture examinations on calcium oxalate stones have shown that the various texture forms or types are not distributed accidentally but are determined through certain pathogenic factors like hypercalciuria and hyperuricosuria. It is to be assumed that further relations between texture formation of the various calculi and certain lithogenous factors can be established. The occurrence of the texture types may depend on age, sex and type of stone removal or passing points to relations between the factors that influence concrement formation and the further growth and the textures of the calculi formed. The results of the examinations prove the possibility of texture-type determination within routine analysis without greater effort. Thus the preconditions is given to include texture types into metaphylaxis of calcium oxalate urolithiasis.

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