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Original Article: Petro graphic Analysis of Urinary Calculi

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Abstract:
Aim*: - Urolithiasis is a global phenomenon. Accurate determination of a urolith yields fundamental information on calculogenesis, choosing treatment modalities and preventing recurrences. Integrated petro logical analysis provide the necessary signature for certainty and composition of a urolith.*
Methodology*: - Urinary calculi have been analyzed and studied by different techniques with diverse merits and demerits. Uroliths are stones with crystalline and non-crystalline components. Petro logical analysis yield more information texture mineralogical features and greater accuracy in knowing the composition of urinary calculi.*
Result: *- Chemical spot test" showed 2% error in detecting calculi components. Petro logical assessment by X-ray diffraction based on unique diffraction pattern, diffraction angles and'd' value showed pure stones in 36.67% with mixed stones in 63.33%. Architectural nuclear pattern by Polarized transmission microscopy revealed crystal, matrix and nucleus interrelationship of concentrically laminated 30%, plexiform-cum laminated 13.33% and multinucleated in 6.67% of urinary calculi.*
Conclusion :- *Petro logical assessment of urinary calculi provided an accurate determination and identify quickly and certainty different Urates, Oxalates and Phosphates that cannot be equaled or attempted by any other technique and typify a learning on calculogenesis, prevention and recurrences of future stone formation Petro graphic analysis of urinary calculi based on specific X-Ray diffraction patterns and optical properties are the best method to decipher the architectural and ultra structural details of a Urolith.*
Keywords: *- Urolith, Urinary calculi, Petrography, X-ray diffraction, Chemical spot test, Polarized transmission Microscopy, Moh's Hardness Scale.*

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I. Introduction

Urolithiasis is a global phenomenon. Accurate determination of urinary stone composition yields fundamental information on calculogenesis, choosing treatment modalities and preventing recurrences. The urinary calculi are multi component systems with crystalline and non crystalline constituents [1] [2]. Identification of the constituents in a urinary calculus the enable the investigator to accurately characterize the ionic condition, unravel fundamental information regarding calculogensis and serve as reference to prevention and palliation of a specified urolith [3].

Petro graphic analysis of urinary calculi using x-ray diffraction and petro graphic optical microscopy based on specific X-RD patterns and optical properties are the best method to decipher the architectural and ultra structural details of the stone. [4] [5].Integrated petro logical examination of a urinary calculus, thin section provide the necessary signature which is as important to for evaluation of a Urolith- Dana Mineralogy 1993; Optical Mineralogy Kerr 1991[6].Constituents within a urolith can be identified, compared and typified with reference set of standard values for a known urolith with optical criteria to decipher architectural patterns[7].Petro graphic analysis provide accurate identification, analysis of components of urinary calculi and crystal matrix interrelationship of a urolith [8].

II. Research Methodology

This study was carried out in the Department of Urology, I.M.S BHU in collaboration with Department of Geology and Metallurgical Engineering IIT, B.H.U. 30 randomly selected urinary stones were picked from Urology "Rockery".

(A)Chemical "spot test"

The powder collected from a stone was pulverized in a small agate mortar and used for "SPOT TEST" of Winer and Mattice in Urology Department, I.M.S B.H.U. Qualitative analysis by spot test has few limitation – there were 2% error in detection of components of calculi. Chemical tests for carbonate were not accurate in presence of oxalates. Only radicals rather than exact compound may be identified Rodger 1982. Chemical methods cannot differentiate between the hydrate of oxalates or between various types of phosphates and has poor sensibility for uric Acid identification (Wran, Beeler, Brain, Hazarikka 1988) [9] [10] [11].

(B)X –ray Diffraction

Rigaku X-ray diffraction technique for analysis of urinary calculi is of Beeler 1964, modified by Rodger, Nassimbeni and Mulder 1982 recorded the X-ray Diffraction pattern by using Philips powder camera of radius 28.65 nm mounted on X-ray generator fitted with Nickel filters. The stones were crushed to powdered specimen to produce smooth diffraction lines. The powdered calculi are placed in thin walled Lidermann Glass capillary tube. The diffraction pattern is unique for particular crystalline component present with diffraction angles and “d” value (Lattice spacing) relative intensity matched with standard values [12]. First 3 most intense line with d-value s were matched with reference of standards of Sutor [13] [14] [15].

(C)**Petro graphic Analysis**

The external lab morphology and the internal molecular structure of the urinary crystals are distinct, constant and characteristic Prien, Frondel 1941. The urinary calculi were cut into two halves and cut surface polished on a Glass plate using Carborundum powder. The polished petrography thin section (.03mm) was mounted on a glass slide with help of cooked Canada balsam as cementing material. The final preparation of the slide was done by washing excess of Carborundum powder and Canada balsam removed with cotton soaked in methylated spirit of Xylol. Cover slip applied over the section with help of warm Canada Balsam.The slide prepared was for petro logical assessment using sensitivity to analyze for the architectural pattern of a given stone from nucleus, mid zone and periphery of a given urolith. [16][17].

III. Observation

Retrospective stone analysis of 30 calculi was done. External morphology showed that majority are oval 33.33%, Grayish in appearance 40% with hardness on Moh’s scale 2-4 70%. Chemical “Spot Test revealed calcium oxalate in 30% while in mixed calculi most common combination had oxalate+ phosphate+ Urate constitute 20% followed by oxalate+ uric acid and oxalate+ phosphate 13.33% each.The x-ray diffraction patterns of the powdered specimen recorded as spectral peaks of varying intensity unique as finger printing of the crystalline constituents. Simple measurement permit the calculation of the characteristic distance between lattices “d” plane of atoms compared with standard reference of Sutor. Pure stones constituted 36.67% of calculi. Majority of mixed urinary tract calculi were mixed variety with oxalates in 26.64% and phosphates 36.67%. Petro graphic Architecture Morphological cut surface study on Rath and Nath design showed a majority of urinary calculi were Type A 60% which contained ill defined central nucleus surrounded by a few laminations at periphery. 33% calculi were Type B with distinct central nucleus with concentric light and dark colored lamination.

Table I : Salts by “Spot Test”

Type of Stone	%
I. Pure	**46.67**
Calcium Oxalate	30.00
Phosphate	13.33
Uric Acid	3.34
II. Mixed	**53.33**
Oxalate + Uric Acid	13.33
Oxalate + Uric Acid + Ammonium	13.33
Oxalate + Phosphate	6.67
Oxalate + Phosphate + Uric Acid	20.00
Total	**100%**

Table II: X-ray Diffraction Analysis of Pure Stone

Type of Stone	%
Whewellite	26.67
Weddellite	3.33
Struvite	3.33
Hydroxyapatite	3.33
Total	36.67

Table III: X-ray Diffraction Analysis of Mixed Stone

Type of Stone	%
1. Oxalate	**26.64**
Whewellite + Uric Acid	6.67
Whewellite + Uric Acid+AAU	6.67
Whewellite + Weddellite +AAU	3.33
Whewellite +AAU+ Brushite	3.33
Whewellite+AAU+Newberrite	3.33
Wedellite + UA+ Xanthine	3.33
2. Phosphate	**36.67**
Struvite + Hydroxyapatite	6.67
Struvite + Hydroxyapatite+ Whewellite	6.67
Struvite + Whewellite	3.33
Hydroxyapatite+ AAU	3.33
Struvite+ AAU	6.67
Hydroxyapatite + UA+ Whewellite	3.33
Hydroxyapatite + Whewellite + Weddellite	6.67
Total	**63.31**

Table IV: Architecture on Zeiss Polarized Microscopy”

Architectural Pattern	%
Laminated Concentrically	30
Plexiform	6.67
Plexiform Cum Laminated	13.33
Multinucleated	6.67
Multinucleated cum Laminated	6.67
Miscellaneous	36.67
Tombstone	10.00
Compact	10.00
Crystalline Aggregate	10.00
Sun-ray	6.67
Total	100%

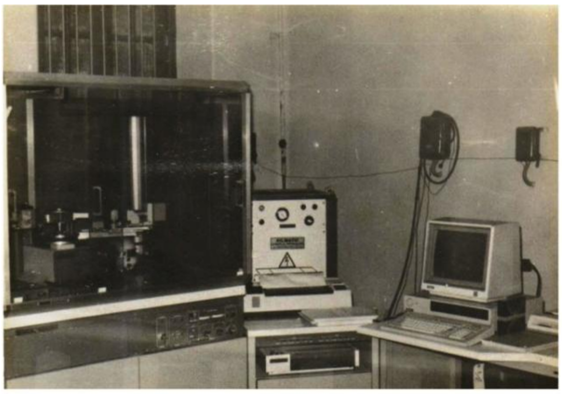

Fig. I:RIGAKU X-RAY DIFFRACTOMETER

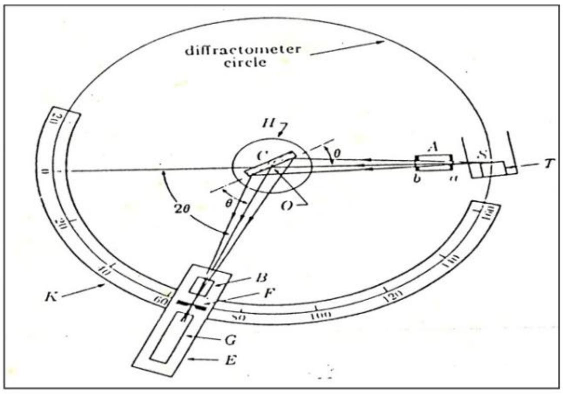

Fig. II : SCHEMATIC WORKING PRINCIPLE OF X-RAY DIFFRACTOMETER

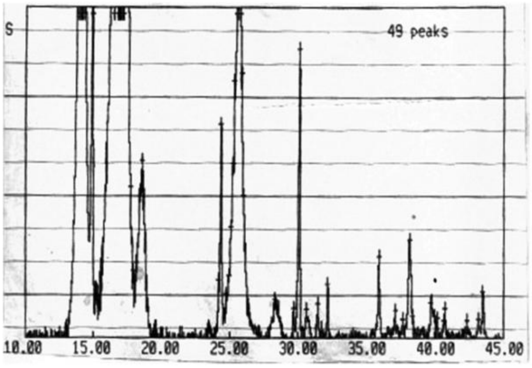

Fig. III : X-RAY DIFFRACTION PATTERN OF STRUVITE + HYDROXYAPATITE+ WHEWELLITE

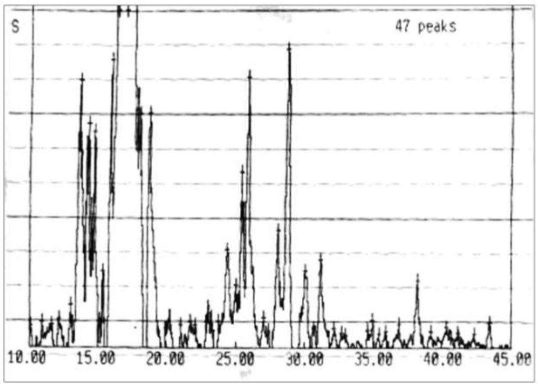

Fig. IV: X-RAY DIFFRACTION PATTERN OF HYDROXYAPATITE+ WHEWELLITE+ URIC ACID

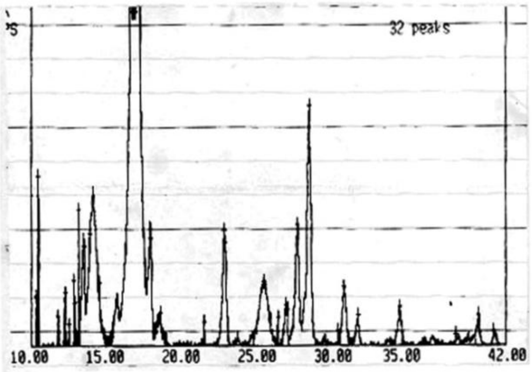

Fig. V: X-RAY DIFFRACTION PATTERN OF STRUVITE + HYDROXYAPATITE

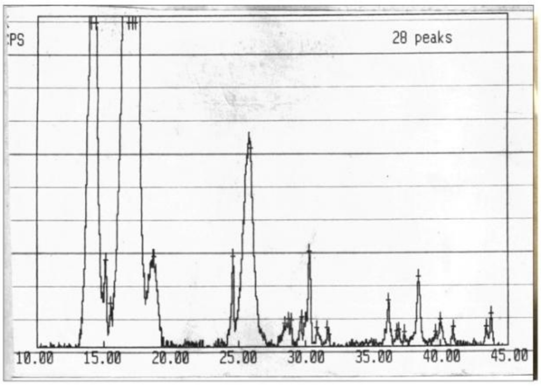

Fig.VI: X-RAY DIFFRACTION PATTERN OF WHEWELLITE+ WEDDELLITE

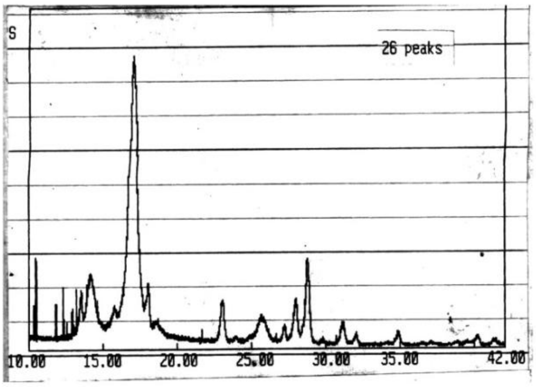

Fig. VII: X-RAY DIFFRACTION PATTERN OF STRUVITE

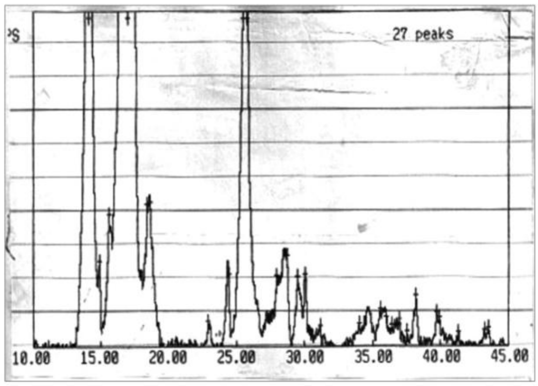

Fig. VIII: X-RAY DIFFRACTION PATTERN OF WHEWELLITE + BRUSHITE + AAU

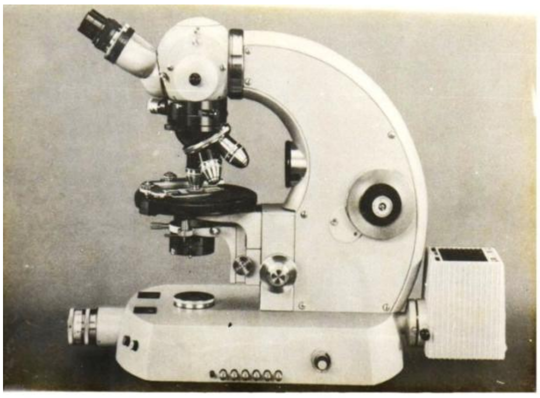

Fig. IX: ZEISS POLARIZING MICROSCOPE

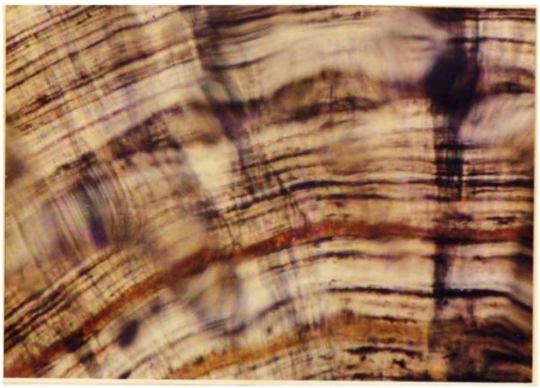

Fig. X: CONCENTRICALLY LAMINATED STRUCTURAL PATTERN

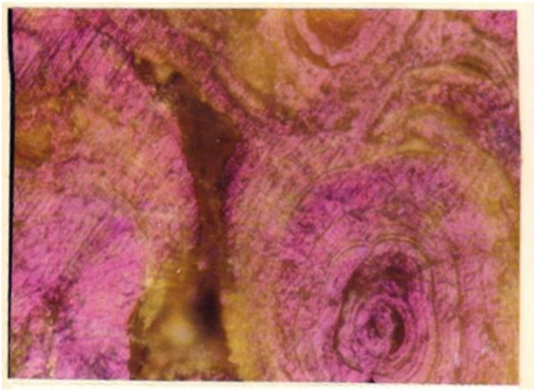

Fig. XI: MULTINUCLEATED STRUCTURAL PATTERN

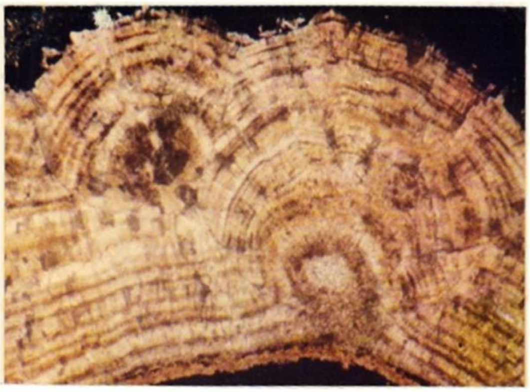

Fig. XII: MULTINUCLEATED CUM LAMINATED STRUCTURAL PATTERN

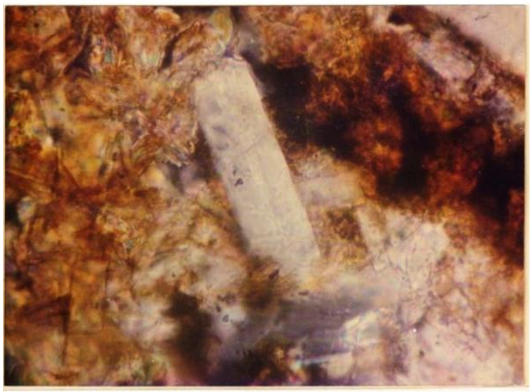

Fig. XIII: TOMB STONE COFFIN LID STRUCTURAL PATTERN

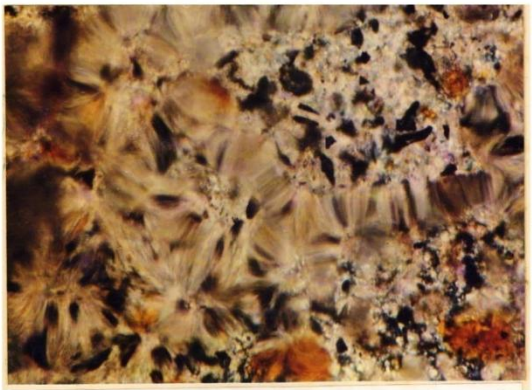

Fig. XIV: CRYSTALLINE AGGREGATE STRUCTURAL PATTERN

IV. Discussion

Blandy 1977 postulates that the urinary stones have an elaborate structure in which there is an organic scaffold and a filling of crystalline material. Winer & Mattice's spot test is a simple, reliable method of detecting presence of radicals which showed 2% error in detecting calculi components. Rigaku x-ray Diffraction distinguishes different Urates, Oxalates and Phosphates and considered as gold standard technique for identification and differentiation of crystals. X-ray diffraction analysis in my series is in confirmation with the survey by Herring 1962, Sutor, Wooley, Illinguorth & Rodgers 1974.[18] [19] [20]. X-ray diffraction identify quick with certainity very small samples Sutor 1969. X-ray diffraction can readily distinguish different Urates, Oxalates and Phosphates with certainty unequalled or attempted by any other technique, Rodger 1982. X-ray diffraction is a reference technique for identification of crystals Khan 1981 [21].

Table V: Composition Difference Technique wise % Distribution

Techniques	**Pure**		**Mixed**
	Oxalate	Phosphate	
X-ray Diffraction	30	6.67	63.34
Spot Test	30	13.2	53.33

Keeping XRD Technique of stone as the gold standard in pure stone 6.67% Phosphate were detected on X-RD and 13.2% on spot test where as 63.34% in mixed stone and 53.33% respectively. Zeiss Polarizing Petro graphic analysis show that color of oxalate stones are brown due to presence of iron pigment (blood).On examination of cut thin petro graphic film stones show cluster of crystals embedded on a soft matrix or in microscopic units of whorl like arrangement of crystal lattice in a lamellar pattern. Whorl formation in thin section looks like festoon cross bending on contemporaneous deformation as seen in sedimentary rock in nature. The presence of intercommunicating micro channels, lamellar arrangement of life deposit festoon cross bending, contemporaneous deformation feeding micro channels lends the identification by typification of the type of components in a whorl. The architectural pattern were concentrically laminated, multinucleated concentrically laminated, Plexiform, tombstone and sunray spikes.[23] [24] [25]. Oxalate had concentric pattern- plexiform-cum laminated whereas phosphate had diverse architectural pattern tombstone, crystalline aggregated sunray spikes.

V. Summary and Conclusion

Knowledge of composition of urinary calculi and structural studies by petro logical assessment yields fundamental information regarding calculogenesis, therapeutic modalities stone prevention and stone recurrences. The stones are multi component system with crystalline and non-crystalline constituents. Urinary calculi analyzed by different technique with merit and demerits. Since urinary calculi are "rock" in human urinary system, petro graphic analysis yield more information than other techniques Architectural details like thin petro graphic Zeiss Microscopy yields ultra structural and greater accuracy in analysis of urinary calculi

Laskowski (1965) has attempted to combine the most beneficial method petrography with chemical analysis to give a definite description of the calculus. He utilized technique described by Elliot for initial micro dissection of the calculus with subsequent petro graphic examination under the Zeiss Polarizing Microscope using Elliot's method for precise composition of all urinary calculi can be determined. In petro graphic analysis studying the assemblage and grain contact – the inclusion and mega crypt are examined and integrated examination of rock thin section provides the necessary signature which can serve as an important tool of petro graphic analysis of a urolith.

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Ethical issue: None

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