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Classification of Renal Stone Types during Ultrasound using Texture Analysis Technique

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ABSTRACT:- This Study is intended to Classification of Renal Stone Types Using Ultrasound Machine in Elobied N.K.S in the Sudan. The stone type was measured to 90 patients (CT +U/S) in three centers in Elobied, the mean stone density in this study was found to be 808HU. The mean of stone length was found 1.54cm, the mean stone width was found 1.09cm, while the mean age of patient was 49 years and the mean stone Area was 2.27cm^{2,} 12 patient female and 78males, 61patient type one and 29 type two. As in lit the stone density less than 1000HU named as **type one** and more than 1000HU as **type two** using CT in this study and texture analysis that Extracted from the stone it has been found that there is linear relationships between the stone type and the texture feature that extracted from the stone shown Ultrasound image, these first order statistics feature include entropy, Kurtosis, variance, and means.

Keywords:- Renal Stone, texture analysis, Computed Tomography, Ultrasound

I. INTRODUCTION:

Kidney stones affect up to 5% of the population, with a lifetime risk of passing a kidney stone of about 8-10%. [1]. Increased incidence of kidney stones in the industrialised world is associated with improved standards of living and is strongly associated with race or ethnicity and region of residence.[2]. A seasonal variation is also seen, with high urinary calcium oxalate saturation in men during summer and in women during early winter. [3] Stones form twice as often in men as women. The peakage in men is 30 years; women have a bimodal age distribution, with peaks at 35 and 55 years. Once a kidney stone forms, the probability that a second stone will form within five to seven years is approximately 50%. [1].

Urinary tract stones are common, with a lifetime incidence of up to 12% and recurrence rates of up to 50%. In diagnostic and treatment algorithms, stone burden is the most important factor to consider and forms the basis of all clinical decision making [4].Thus, accurate measurement of all calculi is crucial. Since its introduction [5], unenhanced helical computed tomography (CT) has replaced intravenous urogram and is now regarded as the reference standard in the work-up of renal colic, owing to its high sensitivity and specificity [5]. Apart from being the diagnostic standard, CT has the advantage of providing detailed anatomical information, can identify secondary signs of stone passage, and is useful for ruling out alternate pathologies in cases of diagnostic uncertainty . Despite the advantages of unenhanced CT , ultrasound (US) is also commonly used as a diagnostic tool in the management of urolithiasis. US is recognized to be both less sensitive and specific than CT; however, it is commonly available, inexpensive to operate and poses no risk of radiation exposure. In many cases, renal and ureteric calculi are incidentally diagnosed in the workup of other conditions. It has been reported that US may detect stones as small as 0.5 mm under optimal conditions. For these reasons, some centers may still use US in the initial work-up of renal colic [6].

Detection of urinary stones on ultrasound (US) may be problematic when the stones are obscured by ultrasonic beam-attenuating tissue, such as renal sinus fat, mesenteric fat, and bowel, or when their posterior acoustic shadowing is weak [7-9]. Despite the technical advances of US, radiologists have difficulty confirming or excluding the presence of urinary stones when the gray-scale findings are indeterminate. The twinkling sign is a color-flow US artifact described behind calcifications and presenting as a random color encoding in the region were shadowing would be expected on gray-scale images [10]. Recent studies have reported that the twinkling sign may be useful for detection of urinary stones [11-13].

II. METHODOLOGY:

This Study Intended to classification of renal stone using U/S scan from different soft images of U/S machine during abdomen U/S. The data of this Study was collected from three clinical centers in Elobied.(

University of kordufan diagnostic centre, Elsalama clinic Centre and eldaman hospital) and by data sheets, U/S soft image and CT KUB reports , the data has been collected from April 2019 to October 2019.

Patient samples: A total of 90 patients were examined in three centers in Elobied. Table 3.2 (Excel) shows the number of all patients, Data were collected using a data collection sheet for all patients in order to maintain consistency of the information. The following parameters were recorded (Pt code, age, Gender, Stone density, stone size derived from (width* length) cm and Stone site) were recorded.

Imaging technique:-

A kidney ultrasound may be performed on an outpatient basis or as part of your stay in a hospital. Although each facility may have different protocols in place, generally an ultrasound procedure follows this process:

You will be asked to remove any clothing, jewelry, or other objects that may interfere with the scan. If asked to remove clothing, you will be given a gown to wear. You will lie on an examination table on your abdomen.

Ultrasound gel is placed on the area of the body that will undergo the ultrasound examination. Using a transducer, a device that sends out the ultrasound waves, the ultrasound wave will be sent through that patient's body. The sound will be reflected off structures inside the body, and the ultrasound machine will analyze the information from the sound waves.

The ultrasound machine will create images of these structures on a monitor. These images will be stored digitally. If the bladder is examined, you will be asked to empty your bladder after scans of the full bladder have been completed. Additional scans will be made of the empty bladder.

There are no confirmed adverse biological effects on patients or instrument operators caused by exposures to ultrasound at the intensity levels used in diagnostic ultrasound. While the kidney ultrasound procedure itself causes no pain, having to lie still for the length of the procedure may cause slight discomfort, and the clear gel will feel cool and wet. The technologist will use all possible comfort measures and complete the procedure as quickly as possible to minimize any discomfort.

In CTKUB You may be asked to change into a patient gown. If so, a gown will be provided for you. A locker will be provided to secure personal belongings. Please remove all piercings and leave all jewelry and valuables at home. are most frequently done with and without a contrast media. The contrast media improves the radiologist's ability to view the images of the inside of the body. Some patients should not have an iodine-based contrast media. If you have problems with your kidney function, please inform the access center representative when you schedule the appointment. You may be able to have the scan performed without contrast media or have an alternative imaging exam.The most common type of CT scan with contrast is the double contrast study that will require you to drink a contrast media before your exam begins in addition to the IV contrast. The more contrast you are able to drink, the better the images are for the radiologist to visualize your digestive tract.

Statistical Texture Analysis

First-order texture analysis measures use the image histogram, or pixel occurrence probability, to calculate texture. The main advantage of this approach is its simplicity through the use of standard descriptors (e.g. mean and variance) to characterise the data (Press, 1998). However, the power of the approach for discriminating between unique textures is limited in certain applications because the method does not consider the spatial relationship, and correlation, between pixels. For anysurface, or image, grey-levels are in the range $0 \le i \le N_g - 1$ where N_g is the total number of distinct grey-levels , If (N_i) is the number of pixels with intensity i and M is the total number of pixels in an image, it follows that the histogram, or pixel occurrence probability, is given by,

$$P(i) = \frac{N(i)}{M}.$$

In general seven features commonly used to describe the properties of the image histogram, and therefore image texture, are computed. These are: mean; variance; coarseness; skewness; kurtosis; energy; and entropy.

III. RESULTS:

Table 1. show statistical parameters for all patients:

Variables	Mean	Std. Deviation	Variance	Minimum	Maximum
Age	49.26	23.82	567.59	6	80
Stone density	808.41	411.44	169284.49	139	1460
Stone length	1.548	0.927	.859	0.4	5.3
Stone Width	1.094	0.671	.450	0.3	3.6
Stone rea	2.272	3.395	11.528	0.160	19.08

Table 2. multiple linear regression coefficient and the selected variables for prediction of stone types.

Coefficients	**Un standardized Coefficients**	**Std. Error**	**Standardized Coefficients**	**t**	**Sig.**
	B		Beta		
(Constant)	2.587	.471		5.488	.000
Entropy	.008	.002	6.573	3.504	.001
Kurtosis	.370	.047	.493	7.844	.000
Variance	.0001	.000	-.202	-3.203	.002
Mean	-.066	.021	-5.985	-3.192	.002
Dependent Variable: stone type					

Table 3. classification coefficient of stone type into two classes with the selected first order features

Classification Function Coefficients		
	Stone type	
	type 1 (<1000)	type 2 (> 1000)
Mean	11.206	10.392
Variance	.010	.005
Kurtosis	-11.562	-6.967
Entropy	-1.315	-1.211
(Constant)	-132.670	-118.775
Fisher's linear discriminant functions		

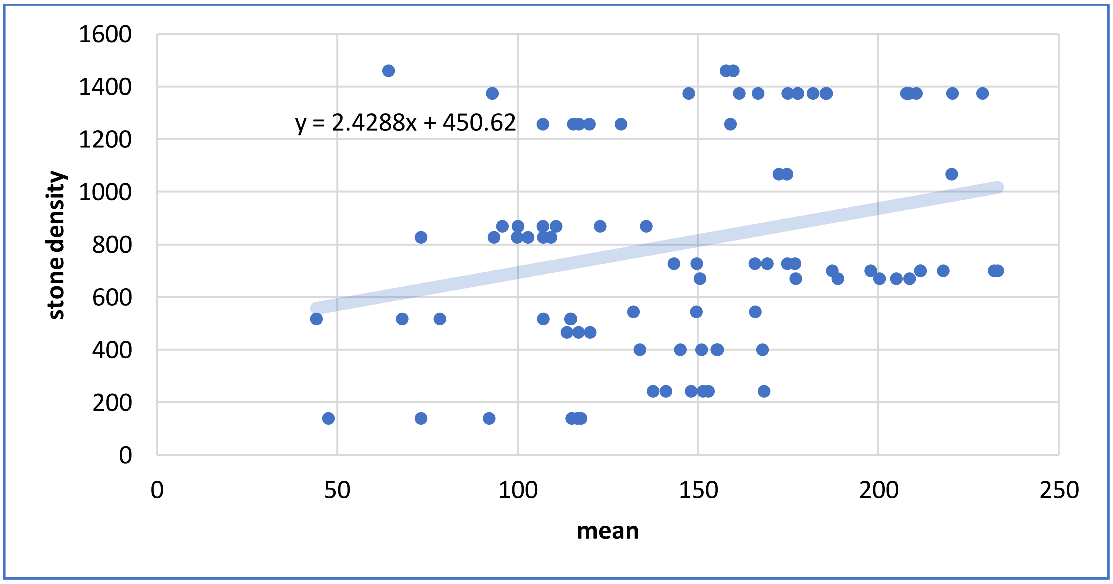

Figure 1. Scatter plot shows a direct linear relation of the mean (feature) with stone density

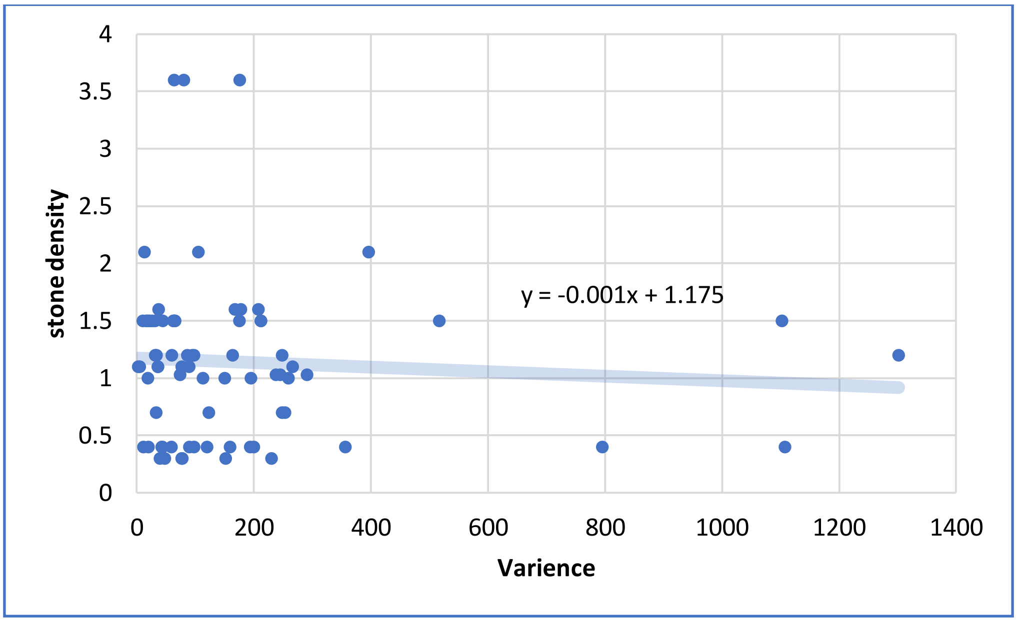

Figure 2. Scatter plot shows a direct linear relation of the variance (feature) with stone density

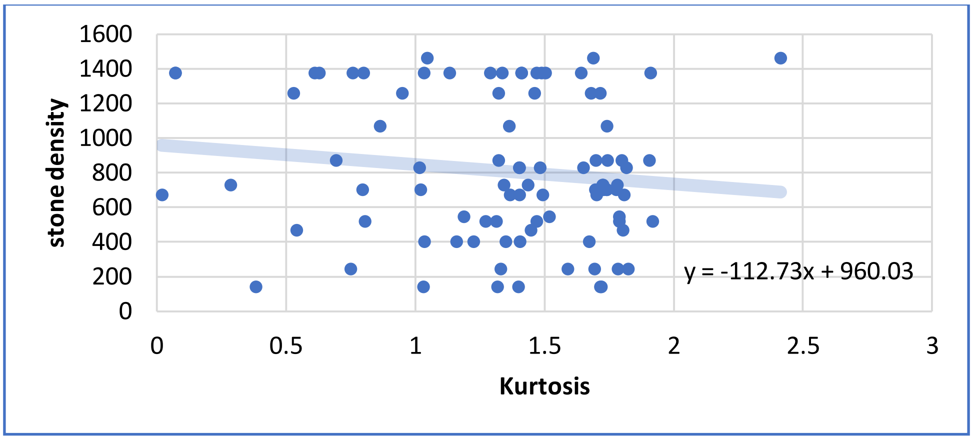

Figure 3. Scatter plot shows a direct linear relation of the kurtosis (feature) with stone density.

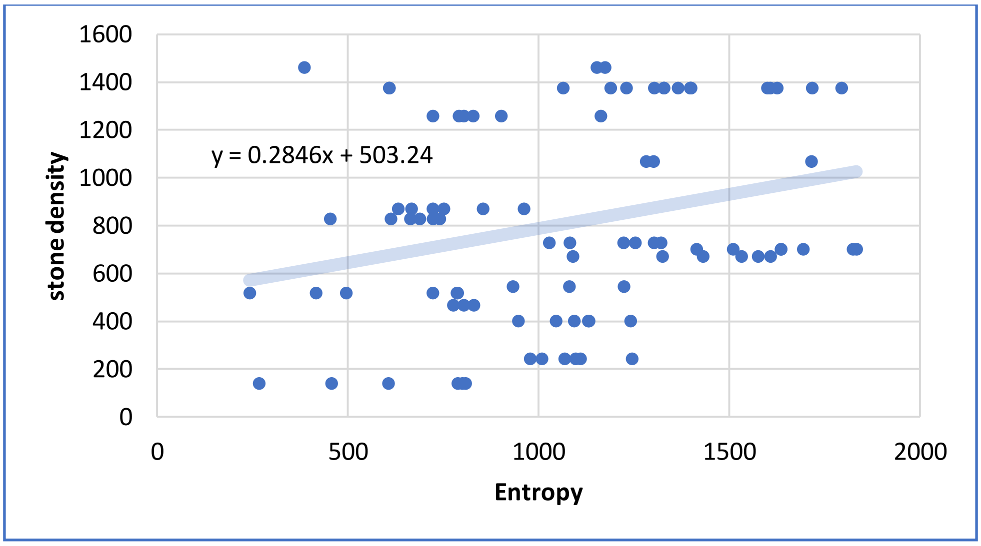

Figure 4. Scatter plot shows a direct linear relation of the entropy (feature) with stone density.

IV. DISCUSSION:

This Study is intended to Classification of Renal Stone Type Using Ultrasound Machine in Elobied N.K.S in the Sudan. The stone type was measured to 90 patients (CT +U/S) in three centers in Elobied, the mean stone density in this study was found to be 808HU, the results summarized in table 1. The mean of stone length was found 1.54cm, the mean stone width was found 1.09cm, while the mean age of patient was 49 years and the mean stone Area was $2.27cm^{2,}$ 12 patient female and 78males, 61 patient type one and 29 type two. As shown in table 1.

As in lit the stone density less than 1000HU named as **type one** and more than 1000HU as **type two** using CT in this study and texture analysis that Extracted from the stone it has been found that there is linear relationships between the stone type and the texture feature that extracted from the stone shown Ultrasound image, these first order statistics feature include entropy, Kurtosis, variance, and means table 2 & 3.

As the mean texture increases the stone density increases linearity. Where the density increase by 2.4 HU per one unite of texture feature mean starting at 451, also the stone density decreases by 0.001 unite per one unite of variance as well as it decreases by 112.7HU per one unite of kurtosis, 960Hu, finally stone density increases as entropy increase by 0.28 HU per one unite of entropy starting 503HU figures 1- 4.

V. CONCLUSIONS:

The results obtained show that the texture features could be used to classify kidney stones. By analyzing many more images by IDL and other statistical methods a suitable decision rule can be found in future.

As in lit the stone density less than 1000HU named as **type one** and more than 1000HU as **type two** using CT in this study and texture analysis that Extracted from the stone it has been found that there is linear relationships between the stone type and the texture feature that extracted from the stone shown Ultrasound image, these first order statistics feature include entropy, Kurtosis, variance, and means. For stone type can use the following

Equations:

$$Stone\ type = (0.008 \times Entropy) + (0.370 \times Kurtosis) + (0.0001 \times Variance) + (-0.066 \times mean) + 2.587$$

$$stone\ type1 = (mean\ \times 11.2) + (Variance \times 0.01) + (Kurtosis \times -11.562) + (Entropy \times -1.315) + (constant \times -132.670)$$

$$Stone\ type2 = (mean\ \times 10.39) + (Variance \times 0.005) + (Kurtosis \times -6.96) + (Entropy \times -1.211) + (constant \times -118.775)$$

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