ORIGINAL ARTICLE

# Diagnostic accuracy of twinkling artifact for diagnosis of urinary tract stones keeping CT scan as gold standard

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**Background: Ultrasound does not have ionizing radiation exposure. By three dimensional images of the stone and the surrounding structural anatomy, CT-KUB helps exact measurement and localization of the stone, however, this comes at a cost of exposing the patient to ionizing radiation.**
**Objective: To determine the diagnostic accuracy of twinkling artifact for diagnosis of urinary tract stones in patients presenting with flank pain taking non-contrast CT as a gold standard.**
**Study design: Cross Sectional study.**
**Setting: Department of Diagnostic Radiology, Jinnah Postgraduate Medical Centre, Karachi**
**Duration: 1st July 2019 to 31st December 2019**
**Material and Methods: Total 230 patients were included. The patient directly underwent limited ultrasound scan of kidneys, ureters, and urinary bladder. Ultrasound evaluation of urinary tract was done in greyscale and color Doppler modes. Size, location of urinary calculus, and presence or absence of twinkling artifact was reported. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of ultrasound were calculated taking non-contrast CT scan as gold.**
**Results: There was 53.9% male and 46.1% female patients. Total 10.9% cases were diagnosed by twinkling artifact and mean stone size was 2.36±0.63 mm. The non-contrast CT findings showed 29.6% stone and mean stone size was 2.75±2.18 mm. Sensitivity, Specificity, PPV, NPV and accuracy were 88.0%, 77.6%, 32.4%, 98.1%, and 78.7% respectively.**
**Conclusion: Ultrasonography (Twinkling artifact) does not require use of radiation, hence with low diagnostic accuracy it can be used as an alternative of non contrast CT scan.**

**Keywords: Diagnostic accuracy, twinkling artifact, urinary tract stones, flank pain, non-contrast CT**

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## Introduction:

Urinary tract stones, also termed as urolithiasis, are a third common cause of urological presentation after urinary tract infections and prostate disease.[1] It has a variable prevalence worldwide.[2-4] Genetic and environmental factors are the possible contributing factors to development of stones.[2,5] In Pakistani population the prevalence of urinary calculi is reported to be 24.9%.[6]

Imaging of urinary tract stones is important as it aids in diagnosis and provides initial step in management by estimation of stone size and location.[7] Moreover, there has been a drastic increase observed in the number of imaging modalities ordered for the detection and evaluation of urinary stones, especially the use of computed tomography (CT).[8]

At the time of initial presentation in the emergency, many patients have stones located at either pelvi-ureteric junction or uretero-vesical junction.[9] The available imaging modalities for evaluation of urinary tract stones include plain KUB radiograph, ultrasound, CT, and magnetic resonance imaging (MRI). Ultrasound is a low cost technique for stone evaluation, does not has ionizing radiation exposure and has sensitivity and specificity of 84% and 53% respectively. Plain KUB radiograph uses low ionizing radiation for evaluation of renal stones however, it has a low sensitivity and specificity of about 57% and 76% respectively.[10]

Non-contrast CT (CT-KUB) has become the modality of choice for evaluation of stone diseases and carries the highest sensitivity and specificity among all the available modalities. By generating a three dimensional (3D) image of the stone and the surrounding structural anatomy, CT-KUB helps exact measurement and localization of the stone, however, this comes at a cost of exposing the patient to ionizing radiation. Non-contrast CT has sensitivity and specificity of 95% and 98% respectively for identifying urinary tract stones and is now the gold standard for diagnosis of urinary tract stones.[11]

Twinkling artifact is a special type of artifact produced by color dopppler ultrasound imaging behind a reflective objects such as stones. This artifact appears as mosaic of colors during Doppler ultrasound behind an echogenic focus such as stone.[12] It can improve specificity of ultrasound by identifying stones from other echogenic structures.[13,14] The reported sensitivity and specificity of twinkling artifact for urinary stone detection is 83%[15] and 74%[14] respectively.

Stones anywhere in the urinary tract may cause obstruction leading to severe renal or ureteric colic which is urological emergency. It can lead to hematuria and urinary tract infections. Determination of stone size and location is important for the disease management.

**Materials and Methods**:
This cross sectional study was conducted at Department of Diagnostic Radiology, Jinnah Postgraduate Medical Centre, Karachi over a period of 6 months from 1st July 2019 to 31st December 2019. Total 230 patients were included. The patient directly underwent limited ultrasound scan of kidneys, ureters, and urinary bladder. Ultrasound evaluation of urinary tract was done in greyscale and color Doppler modes. Size, location of urinary calculus, and presence or absence of twinkling artifact was reported. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of ultrasound were calculated taking non-contrast CT scan as gold. Patients aged 15-75 years for non-contrast CT of KUB region for flank pain of any duration (CT scan was advised to the patients by their primary physicians) were included. Both male and female patients would be included. Patients with known case of acute or chronic renal failure, patients already diagnosed for urinary tract infection (UTI) and patients already diagnosed with stone disease and presenting for follow up were excluded. The study was carried out after the approval of ethical review committee of Jinnah Postgraduate Medical Center (JPMC). Informed consent was taken from all patients before enrolling them in the study. Patients were enrolled before undergoing a CT scan, therefore while performing the ultrasound it was unknown if there was a calculus present.

CT scan was performed on a 16-slicer CT scanner. The reporting was done by radiologist with more than 5 years of experience in reporting non-contrast CT scans. The radiologist was blind to the ultrasound results and evaluated the CT scan and described the findings indicating the location and size of stones, if present.

While the patient was waiting to undergo CT scan, the patient directly underwent a limited ultrasound scan of both kidneys, ureters and the urinary bladder. This examination was performed on an ultrasound machine equipped with a 3.5 MHz probe. It was performed by a trained sinologist having more than 5 years of experience using a curved low-frequency probe (2-5 MHz). Ultrasound evaluation of the urinary tract was done in greyscale and color Doppler modes. The sonologist was reported the size and location of urinary calculus as well as the presence or absence of twinkling artifact on urinary tract stones.

Data were analyzed using SPSS version 20. Quantitative outcome variables such as age, duration of symptoms, and size of calculus were

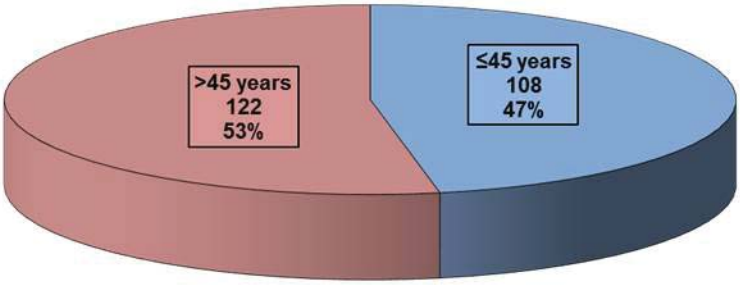


**Figure 1: Frequency and percentage of patients according to age groups (n=230)**

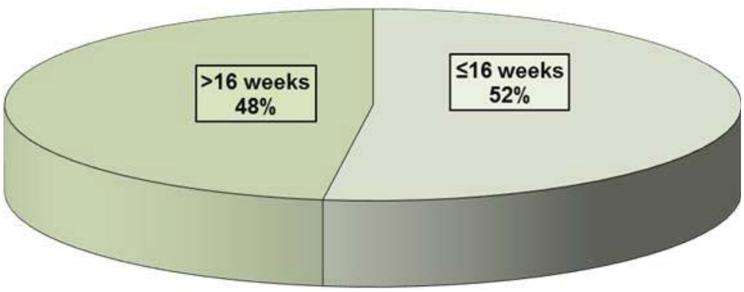


**Figure 2: Frequency and percentage of patients according to symptoms duration groups (n=230)**

Table 1:Diagnostic accuracy of twinkling artifact for diagnosis of stone taking non-contrast ct findings as gold standard (n=230)

| | **Non-contrast CT** | | | **P-Value** |
|---|---|---|---|---|
| Twinkling artifact | Yes | No | Total | |
| Yes | 22 (88) | 3 (12) | 25 | |
| No | 46 (22.4) | 159 (77.6) | 205 | 0.000* |
| Total | 68 | 162 | 230 | |
| **Sensitivity** | **Specificity** | **PPV** | **NPV** | **Accuracy** |
| 88% | 77.6% | 32.4% | 98.1% | 78.7% |

*Chi square test was applied. P-Value ≤0.05 considered as significant.*

** Significant at 0.05 level.*

noted as mean and standard deviation. Qualitative outcome variables such as gender and location of the stone were noted as percentage and frequency. Sensitivity, specificity, PPV, NPV and diagnostic accuracy of the twinkling artifact were calculated using 2 x 2 table taking findings of non-contrast CT scan as gold standard. Effect modifiers such as gender, age, duration of symptoms and location of stones were stratified to see the effect of these on outcome variables. Post stratification, diagnostic accuracy was calculated to see their effect on outcome variables.

**Results**:

Total 230 patients of either gender with age between 15 years to 75 years meeting inclusion criteria of study were included to determine the diagnostic accuracy of twinkling artifact for diagnosis of urinary tract stones in patients presenting with flank pain taking non-contrast CT as a gold standard. Statistical package for social sciences (SPSS 20) was used for data compilation and analysis. Mean±SD were calculated for quantitative variables and frequency and percentages were calculated for qualitative variables Sensitivity, Specificity, positive predictive value and negative predictive value were computed for twinkling artifact taking non-contrast CT as gold standard.

There was 53.9% male and 46.1% female patients. The overall mean age was 46.41±9.26 years. The age was further stratified in two groups as presented in Graph-1.

The overall mean duration of symptoms was 16.61±8.84 weeks.

In our study 10.9% cases were diagnosed with urinary tract stone by twinkling artifact as presented in Table-6. Among 25 diagnosed cases, stone was located at right side in 40% patients and 60% patients had stone in left side. The mean stone size was 2.36±0.63 mm.

As far as non-contrast CT findings are concerned, 29.6% were diagnosed with stone as presented in Table-9. Among 68 diagnosed cases, stone was located at right side in 38.2% patients and stone was located in left side among 61.8% patients. The mean stone size was 2.75±2.18 mm

Sensitivity, Specificity, Predictive values and diagnostic accuracy of twinkling artifact for the detection of stone taking non-contrast CT findings as gold standard were calculated. The results showed that by twinkling artifact, 22 patients were true positive, correctly diagnosed and 159 patients were true negative, correctly diagnosed. Sensitivity, Specificity, PPV, NPV and accuracy were 88.0%, 77.6%, 32.4%, 98.1%, and 78.7% respectively as presented in Table-1.

**Discussion**:

Renal calculus is one of the most common concerns of people with a possible occurrence of 12% for men and 6% for women.[16-18] Accordingly, the most common causes of renal calculus are kidney and urinary tract stones.[17] Ultrasound and computed tomography (CT) scan are used as modalities to diagnose the disease.[19] In addition, CT scan is used as a gold standard for the detection of urolithiasis,[16-18,20] but due to the excessive use of this modality and the side effects and risks of using it, low-dose CT protocols are used which may reduce sensitivity in detecting small stones in the kidney and urinary tract.[16]

There are also circumstances in which CT scan is not available, including pregnancy, children, and people who are scared of CT scan.[19] Accordingly, many patients with a history of urolithiasis (kidney stones) need to keep track of their condition and repeated CT scans do not seem to be appropriate for these people.[16] Therefore, it is necessary to look for an alternative method for CT scan. Ultrasound is one of these alternatives which, despite its limitations, has an acceptable sensitivity and specificity in detection of urolithiasis.[17] However, in ultrasound, small stones may not be differentiated from normal kidney tissue or create acoustic shading. Moreover, the stones in the ureter's middle part may not be detected due to intestinal and lipid gases.[18]

Today, technological advances and changes in ultrasound devices and probes have made them high quality and better devices which can be used to detect urolithiasis. Twinkling artifact, which is observed in color Doppler ultrasound, is characterized by rapid changes in the composition of blue and red colors of the ecologically stable structures such as calcification, bone, and stones.[18-20,21] It was initially defined by Rahmouni et al. in 1996.[18,22-24]

Although the reason for the development of this artifact is not clear, many studies have investigated its use in increasing the diagnostic accuracy of ultrasound for kidney and urinary tract stones.[16] It is used to detect calcifications in various tissues such as prostate, testicular, kidney, bladder, liver, bile duct, pancreas, breast, and ureter, as well as non-calcified bilirubin stones and irregular hard and reflexive surfaces.[22] Studies suggest that this artifact can increase the sensitivity and specificity of ultrasound in diagnosis of kidney stones.[25] It can also transform the management and treatment of kidney stones.[24]

Yavuz et al.[17] showed that there was no significant difference in the sizes of kidney stones detected through CT and Doppler ultrasound.[17] The fact that there is no difference between the accuracy of the two methods in determining the size of the stone indicates the high reliability of these diagnostic methods. After the twinkling artifact was discovered in the color Doppler ultrasound, it was expected that this artifact could improve detection of the stones by ultrasound. The sensitivity of ultrasound for detecting kidney stones increased from 48.66% in B-mode ultrasound to 99.55% in ultrasound with twinkling artifact.[18,26]

Studies have also shown that color Doppler ultrasound twinkling artifact is very sensitive and can detect very small kidney stones.[17,27] Gliga et al.[27] observed twinkling artifact in 92% of renal calculus patients. Besides, sensitivity, specificity, positive, and negative predictive value of twinkling artifact compared to non-contrast CT were 99.12%, 90.91%, 99.12%, and 91.90%, respectively.[27]

In another study, Lee et al. found that 83% of kidney stones were detected by twinkling artifacts in the color Doppler ultrasound.[28] Kielar et al showed that the positive predictive value and sensitivity of twinkling artifact were 94% and 83%, respectively. This artifact also had 6 false positive (5.3%) and 22 false negative values (19.3%). As a result, twinkling artifact with a high positive predictive value can increase ultrasound diagnostic accuracy for kidney and urinary tract stones.[22]

Abdel-Gawad et al reported false negative values in four cases (0.4%). In those four cases, twinkling artifact was not observed and the Doppler ultrasound could not detect kidney stones. This was seen in overweight and obese people with a body mass index (BMI) higher than [35,16]

In addition, in a retrospective study, Dillman et al. compared the overall sensitivity of twinkling artifact with CT scanning for diagnosing urolithiasis and showed that the overall sensitivity of the former was 55%. They showed that the positive predictive value of twinkling artifact in detecting kidney stones was 78%. The true and false positive twinkling values of CT were 49% and 51%, respectively. These findings indicate that this artifact has a high false positive value, while it has low sensitivity. Accordingly, it is not very sensitive to be used in routine evaluation of urolithiasis.[25]

Despite the high efficiency of twinkling artifact in detecting kidney stones, it is unclear why this artifact does not exist in some stones, while it is present in some kidneys without stones. Currently, it is not clear what causes these false positives and in particular false negatives, but it may be related to the chemical composition of the stones, fine microlithiasis stones, ultrasound device settings, or the age/generation of the ultrasound device.[29]

The appearance of the twinkling artifact depends on the hardness of the stone. The harder the stone, the larger the artifact will be.[30] Gliga et al.[27] also attributed the lack of artifacts in 10 cases to the smooth surface of the stone.[27]

According to reports, twinkling artifact depends on the device settings, the biochemical composition of the stone, and the level of calcification. Most quantitative studies have focused on small-size kidney stones and consisted of a small number of patients.[31] The radiologist's experience can also be effective in this regard. Therefore, by knowing this artifact, it will possible to improve the process of detection of stones, especially in the kidneys. In another study, Abdel-Gawad et al.[16] investigated the diagnostic accuracy of the twinkling artifact for diagnosing kidney stones and showed that the results of color Doppler ultrasound and the observation of twinkling artifact were significantly affected by the size of kidney stones.[16] Abdel-Gawad et al. reported that there was no relationship between the twinkling artifact and kidney stone size.[16]

Mitterberger et al.[26] showed that posterior acoustic shadow was observed in 76% of kidney stones, while twinkling artifact was observed in 97% of cases.

In another study, Shanna et al.[22] compared the ability of posterior acoustic shadow and color Doppler twinkling artifact in an in vitro environment and observed that the twinkling artifact out-performed posterior acoustic shadow on detecting the pattern of color variations. Accordingly, twinkling artifact is more resistant against barriers such as out-of-focus scans caused by beam aberration resulting from patient body structure.[11]

**Conclusion**:
The results showed 88.0% sensitivity, 77.6% specificity and 78.7% diagnostic accuracy of ultrasonography (Twinkling artifact) while taken non-contrast CT scan as gold standard. With these findings it can be concluded that as the ultrasonography (Twinkling artifact) does not require use of radiation hence with lower sensitivity, specificity, and diagnostic accuracy it can be used as an alternative of non contrast CT scan for the diagnosis of urinary tract stones.

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**Role and contribution of authors**:
Kahkashan Hameed, collected the data, references and did the initial writeup

Mariam Yamin, collected the data and helped in introductin writing.

Kelash Kumar, collected the references and helped in result and discussion writing.

Shaista Shoukat, critically review the article and made the final changes.

## References:


1. Muslumanoglu AY, Binbay M, Yuruk E, Akman T, Tepeler A, Esen T, et al. Updated epidemiologic study of urolithiasis in Turkey. I: Changing characteristics of urolithiasis. Urol Res. 2011 Aug 1; 39(4):309-14.
2. Rodgers AL. Race, ethnicity and urolithiasis: a critical review. Urolithiasis. 2013 Apr 1; 41(2):99-103.
3. Romero V, Akpinar H, Assimos DG. Kidney stones: a global picture of prevalence, incidence, and associated risk factors. Rev Urol. 2010;12(2-3):e86-96.
4. López M, Hoppe B. History, epidemiology and regional diversities of urolithiasis. PediatrNephrol. 2010; 25(1):49-59.
5. Monico CG, Milliner DS. Genetic determinants of urolithiasis. Nat Rev Nephrol. 2012; 8:151-62.
6. Ahmad F, Nada MO, Farid AB, Haleem MA, Razack SM. Epidemiology of urolithiasis with emphasis on ultrasound detection: a retrospective analysis of 5371 cases in Saudi Arabia. Saudi J Kidney Dis Transpl. 2015; 26:386.
7. Türk C, Petřík A, Sarica K, Seitz C, Skolarikos A, Straub M, et al. EAU guidelines on diagnosis and conservative management of urolithiasis. Eur Urol. 2016 Mar 31; 69(3):468-74.
8. Fwu CW, Eggers PW, Kimmel PL, Kusek JW, Kirkali Z. Emergency department visits, use of imaging, and drugs for urolithiasis have increased in the United States. Kidney Int. 2013; 83:479–86.
9. Ordon M, Schuler TD, Ghiculete D, Pace KT, Honey RJ. Stones lodge at three sites of anatomic narrowing in the ureter: clinical fact or fiction? J Endourol. 2013; 27:270–76.
10. Fulgham PF, Assimos DG, Pearle MS, Preminger GM. Clinical effectiveness protocols for imaging in the management of ureteral calculous disease: AUA technology assessment. J Urol. 2013; 189:1203–13.
11. Coursey CA, Casalino DD, Remer EM, Arellano RS, Bishoff JT, Dighe M, et al. ACR Appropriateness Criteria® acute onset flank pain–suspicion of stone disease. Ultrasound Q. 2012 Sep 1; 28(3):227-33.
12. Sapozhnikov O, Lu W, Bailey MR, Kaczkowski P, Crum LA. Bubbles trapped on the surface of kidney stones as a cause of the twinkling artifact in ultrasound imaging. Proc Meet Acoust. 2013; 19(1):075033.
13. Ray AA, Ghiculete D, Pace KT, Honey RJ. Limitations to ultrasound in the detection and measurement of urinary tract calculi. Urol. 2010; 76:295–300.
14. Sorensen MD, Harper JD, Hsi RS, Shah AR, Dighe MK, Carter SJ, et al. B-mode ultrasound versus color Doppler twinkling artifact in detecting kidney stones. J Endourol. 2013 Feb 1; 27(2):149-53.
15. Kielar AZ, Shabana W, Vakili M, Rubin J. Prospective evaluation of Doppler sonography to detect the twinkling artifact versus unenhanced computed tomography for identifying urinary tract calculi. J Ultrasound Med. 2012 Oct 1; 31(10):1619-25.
16. Abdel-GawadM ,Kadasne R, Chandrashekar C, Elsobky E. Value of color doppler ultrasound, kub and urinalysis in diagnosis of renal colic due to ureteral stones. IBJU. 2014;40:513–9.
17. Yavuz A, Ceken K, Alimoglu E, Kabaalioglu A. The reliability of color Doppler "twinkling" artifact for diagnosing millimetrical nephrolithiasis: Comparison with B-Mode US and CT scanning results. J Med Ultrason. 2015; 42:215–22.
18. Winkel RR, Kalhauge A, Fredfeldt KE. The usefulness of ultrasound colour Doppler twinkling artefact for detecting urolithiasis compared with low dose non-enhanced computerized tomography. Ultrasound Med Biol. 2012;38:1180–7.
19. Korkmaz M, Aras B, Sanal B, Yücel M, Güneyli S, Koçak A, et al. Investigating the clinical significance of twinkling artifacts in patients with urolithiasis smaller than 5 mm. Jpn J Radiol. 2014; 32:482–6.
20. Sorensen MD, Harper JD, Hsi RS, Shah AR, Dighe MK, Carter SJ, et al. B-mode ultrasound versus color Doppler twinkling artifact in detecting kidney stones. J Endourol. 2013; 27:149–53.
21. Masch WR, Cohan RH, Ellis JH, Dillman JR, Rubin JM, Davenport MS. Clinical Effectiveness of Prospectively Reported Sonographic Twinkling Artifact for the Diagnosis of Renal Calculus in Patients Without Known Urolithiasis. AJR Am J Roentgenol. 2016; 206:326–31.
22. Sharma G, Sharma A. Clinical implications and applications of the twinkling sign in ureteral calculus: a preliminary study. J Urol. 2013; 189:2132–5.
23. Kielar AZ, Shabana W, Vakili M, Rubin J. Prospective evaluation of Doppler sonography to detect the twinkling artifact versus unenhanced computed tomography for identifying urinary tract calculi. J Ultrasound Med. 2012; 31:1619–25.
24. Ozan E, Atac GK, Gundogdu S. Twinkling artifact on color Doppler ultrasound: An advantage or a pitfall? J Med Ultrason. 2016; 43:361–71.
25. Shang M, Sun X, Liu Q, Li J, Shi D, Ning S, et al. Quantitative evaluation of the effects of urinary stone composition and size on color Doppler twinkling artifact: A phantom study. J Ultrasound Med. 2017; 36:733–40.
26. Mitterberger M, Aigner F, Pallwein L. Sonographic detection of renal and ureteral stones. Value of the twinkling sign. IntBraz J Urol. 2009; 35:532–41.
27. Gliga ML, Chirila CN, Podeanu DM, Imola T, Voicu SL, Gliga MG, et al. Twinkle, twinkle little stone: An artifact improves the ultrasound performance! Med Ultrason. 2017; 19:272–5.
28. Lee JY, Kim SH, Cho JY, Han D. Color and power Doppler twinkling artifacts from urinary stones: Clinical observations and phantom studies. AJR Am J Roentgenol. 2001; 176:1441–5.
29. Sorensen MD, Harper JD, Hsi RS, Shah AR, Dighe MK, Carter SJ, et al. B-mode ultrasound versus color Doppler twinkling artifact in detecting kidney stones. J Endourol. 2013; 27:149–53.
30. Rahmouni A, Bargoin R, Herment A, Bargoin N, Vasile N. Color Doppler twinkling artifact in hyperechoic regions. Radiology. 1996; 199:269–71.
31. Wang M, Li J, Xiao J, Shi D, Zhang K. Systematic analysis of factors related to display of the twinkling artifact by a phantom: An optimized investigation. J Ultrasound Med. 2011; 30:1449–57.