Evaluating shear wave elastography as a predictor of extracorporeal shock wave lithotripsy outcomes and stone composition in children “A prospective study”

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INTRODUCTION

The incidence of pediatric urolithiasis is rapidly increasing worldwide, driven by changes in diet and lifestyle. This increasing trend poses significant clinical challenges and escalates healthcare costs [1]. Recent technological advances have shifted treatment modalities from open surgeries to minimally invasive procedures [2]. Among these, extracorporeal shock wave lithotripsy (ESWL) has emerged as the first-line treatment for kidney stones in children due to its low complication rates and high efficacy. Its advantages include outpatient applicability, effective sedation, repeatability, and a less invasive profile compared with other treatments [3].

Factors influencing the outcome of ESWL include the child’s age, stone size and location, stone hardness, body mass index (BMI), operator experience, and renal anatomy [4]. Of these factors, only Hounsfield unit (HU) measurements obtained from computed tomography (CT) provide an indication of stone hardness. Consequently, HU is widely used to predict ESWL success, especially in adult patients [5]. However, patients with a history of kidney stones often undergo multiple CT examinations, resulting in a high cumulative radiation dose [6].

Given the longer life expectancy and increased radiation sensitivity in pediatric patients, the use of CT is limited [7]. Therefore, development of alternative, radiation-free methods to assess stone hardness without relying on CT is necessary. Shear wave elastography (SWE) is a radiologic technique that utilizes ultrasonography (US) to visualize and quantify tissue stiffness [8].

In a previous pilot study on adults that demonstrated that SWE could be used to predict the success of ESWL and serve as an alternative to HU [9]. In the present study, we aimed to evaluate the applicability of SWE in predicting ESWL outcomes in a pediatric patient population, for whom radiation exposure is a greater concern.

AIM OF THE Work

Primary objective:

To evaluate whether baseline renal stone SWE predicts ESWL success in pediatric renal calculi.

Secondary objectives:

correlation between SWE and HU

prediction of stone composition

number of ESWL sessions needed

Materials and methods

This **prospective** study will be initiated after obtaining approval from the Committee of our University Faculty of Medicine Beni-Suef university. Pediatric patients under the age of 18 years who presented to our outpatient clinic between

December 2025 and December 2026 with a diagnosis of kidney stones and will be followed up for at least 3 months were included in this study.

Inclusion criteria:

1- Single Renal stones measured 6- 20 mm in maximal dimension.
2- ESWL will be planned as the first line of treatment.

Exclusion Criteria:

Patients with internal ureteral stent, ureteral stones, or abnormal renal anatomies (pelvic kidney, horseshoe kidney, and rotational anomaly), active UTI at time of ESWL, and coagulopathy will be excluded from the study.

Study Design:

Written informed approval will be obtained from parents of all patients for the legal representatives before the procedure.

Proper history, examination and basic laboratory investigations (CBC, coagulation profile, kidney and Liver functions, urine analysis and urine culture and sensitivity) will be performed for all participants.

Low dose CTUT will be performed as usual for all patient to record stone location, size (maximum longitudinal and transverse dimensions), and HU.

Renal stone elastography values will be measured by a single radiologist using grayscale renal US and SWE.

SWE measurements will be performed once prior to ESWL. A Philips EPİQ7 system (Philips Medical Systems, Bothell, WA) with a 1–5-MHz abdominal probe

will be used for the procedure. Stone localization was determined using renal US examination while the patients are in supine and lateral decubitus positions. Subsequently, SWE measurements of the stone will be obtained in kilopascals (kPa).

ESWL will be performed under sedation and analgesia (midazolam: 0.05–0.1 mg/kg, ketamine: 1 mg/ kg). ESWL will be performed at 14–21 kilovolts (kV), at a rate of 60 shocks per minute, with 2000 shocks per session. In all cases, the power will be gradually increased, starting from lower values. ESWL will be performed using an Elmed device (Elmed Medical Systems Multimed Classic, Turkey).

All patients will be monitored during the session for vital signs and potential cardiac arrhythmias, and appropriate fluid replacement was administered.

The participants will be kept under observation for 2 h after the procedure.

FOLLOW-UP:

Following each session, stone fragmentation will be evaluated after the first week using X-ray and US. In cases with fragments measuring > 2 mm, ESWL will be repeated at intervals of at least 15 days, with a maximum of three sessions.

All patients will be evaluated using X-ray and US every two weeks for 3 months. The absence of stone fragments on imaging as well as the presence of clinically insignificant fragments ≤ 2 mm that did not cause urinary infection or obstruction were considered indicative of a positive response to ESWL.

The patients will be subsequently categorized into two groups: responders and non-responders, and stone elastography values along with other parameters were compared between the groups. The correlation between HU and SWE will also be examined. Stone analysis will be done to detect stone composition after stone passage by chemical analysis.

Sample Size:

We will compare baseline SWE (kPa) between eventual ESWL responders and non-responders using a two-sample t-test (two-sided $\alpha=0.05$). Although the pediatric literature reports a very large difference in SWE between groups (Cohen's $d\approx2.6$) (Demir et al., 2025), to avoid optimism bias we plan with a conservative standardized difference $d=0.80$ and an expected 3:1 responder : non-responder ratio. Using G*Power v3.1 (t tests: Means: difference between two independent means, two groups; tails=two; $\alpha=0.05$; power=0.95; allocation ratio $N_2/N_1=0.33$), the required total sample is N=108.

ETHICAL Consideration:

This study protocol will be revised and approved by the research ethics committee of the Faculty of Medicine of Beni-Suef University. The study followed the

declaration of Helsinki for research ethics standards. Ethical approval number FMBSUREC/02122025/Badawy

Outcome measures:

Primary outcome

Success of ESWL at 3 months

Secondary outcomes

Correlation between SWE and HU

Number of ESWL sessions required

Need for auxiliary procedure

Correlation between SWE and stone composition

Predictive cutoff value of SWE for ESWL success

AUC/sensitivity/specificity if you plan ROC analysis

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