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Influence Of Vesicoureteric Junction Anatomy On Spontaneous Stone Passage: A Randomized Controlled Trial

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Name of Author:
Muhammad Akhtar[1]*, Humera Bibi[2], Hamna Umar[3], Ejaz Ul Haq[4], Muhammad Muneeb Ather[5], Muhammad Ali Qamar[6]

Affiliation: *[1]Associate Professor, Urology Department, Multan Medical and Dental College, Multan.*
[2]Senior Demonstrator, Anatomy Department, Shalamar Medical & Dental College, Lahore.
[3]Senior Demonstrator, Anatomy Department, CMH Lahore Medical College and Institute of Dentistry, Lahore
[4]Assistant Professor, Anatomy Department, Jhalawan Medical College, Khuzdar
[5]Assistant Professor. Anatomy Department, Shalamar Medical & Dental College, Lahore
[6]Senior Demonstrator. Anatomy Department, Multan Medical and Dental College, Multan,

Corresponding Author:
Muhammad Akhtar

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Abstract: ***Background:*** To evaluate the influence of VesicouretericJunction anatomy on spontaneous passage of distal ureteric stones in patients managed conservatively. ***Materials And Methods:*** This randomized controlled trial was conducted in Department of urology at various tertiary care hospitals Pakistan. Patients presenting with unilateral distal ureteric stones measuring ≤10 mm, confirmed on non-contrast computed tomography (NCCT) were enrolled. Vesicoureteric junction anatomy was assessed radiologically and categorized as favorable or unfavorable. Patients were randomly divided into two groups. Group A included patients with favorable VUJ anatomy and Group B with unfavorable VUJ anatomy.Patients were followed for four weeks. Clinical and Laboratory Standards Institute (CSI) guidelines were taken into account. Statistical significance was checked with logistic regression. Data was analyzed using SPSS and chi-square. ***Results:*** A total of 120 patients were enrolled, with 60 patients in each group. Baseline demographic and stone characteristics were comparable between groups. Spontaneous stone passage was observed in 78.3% of patients in Group A compared to 46.7% in Group B. Thus, demonstrating a statistically significant difference ($p < 0.001$). The mean time to stone passage was significantly shorter in patients with favorable VUJ anatomy (11.4 ± 4.2 days) compared to those with unfavorable anatomy (18.9 ± 6.1 days; $p < 0.001$). No major complications were observed in either group. ***Conclusion:*** Vesicoureteric junction anatomy is a significant determinant of spontaneous distal ureteric stone passage. Favorable VUJ anatomical features are associated with higher stone expulsion rates, shorter passage timesand reduced need for surgical intervention. Routine assessment of VUJ anatomy on NCCT may help in treatment planning and improve the selection of patients for conservative management.

Keywords: Vesicouretericjunction, Distal ureteric stone, Spontaneous stone passage, Medical expulsive therapy, randomized controlled trial.

INTRODUCTION

The VesicouretericJunction (VUJ) is one of the most anatomically complex area of urinary tract. It is formed by the oblique intramural course of the ureter which is present within the muscular wall of bladder.(Radmayr et al., 2009)It traverses the bladder wall before opening into the bladder lumen. This unique anatomical pattern functions as a physiological anti-reflux mechanism.(Tanagho and Pugh, 1963) It prevents backward flow of urine during bladder contraction while allowing urine transport from the kidneys to the bladder in single direction. The effectiveness of this valve mechanism depends on several anatomical parameters.(Leung and Chu, 2013) These parameters include the length of the intramural ureter, the angle of ureteric insertion, the diameter of the ureteric orifice and the surrounding detrusor muscle support.(Gearhart et al., 1993)

Anatomical variations of the VesicouretericJunction are common that may be congenital or acquired. These are well recognized in pediatric urology, particularly in relation to vesicoureteral reflux.Changes in intramural ureter length and ureteric orifice configuration mainly effect reflux severity and clinical outcomes.(Chand et al., 2013) However, in adult urology, the clinical significance of these anatomical differences has not been fully understood. This may be especially due to ureteric stone disease.(Berger and Haid, 2025)

The ureter is anatomically divided into proximal, mid, and distal segments. It hasthree physiological narrowing points: the ureteropelvic junction, the crossing of iliac vesselsand the VesicouretericJunction (VUJ). Among these, the VUJ is the narrowest and most anatomically complex segment.(Moon et al., 2015)Because of its narrow lumen and oblique course, the VUJ is a frequent site of ureteric stone attachment. Distal ureteric stones account for nearly 70% of ureteric calculi. Many become lodged at or just proximal to the VUJ. Stones impacted at this level may cause significant obstruction, severe renal colic, hydronephrosis. Furthermore, if passage is delayed then renal function can be impaired.(Stasinou et al., 2017)

Urolithiasis is a common term which is used for stones in urinary tract. It is a urological condition with a growing global prevalence, affecting approximately 10–15% of the population during their lifetime. Recurrence rates are high, with nearly 50% of patients experiencing a recurrent episode within ten years.(Thomas and Hall, 2005) The increasing incidence of stone disease has been linked to dietary changes, climate factors, obesity, metabolic syndromeand reduced physical activity.Ureter stones constitute a major proportion of urolithiasis cases. These are among the most frequent causes of acute flank pain and emergency urological admissions. (Chand et al., 2013)

Spontaneous stone passage is influenced by several well-established factors. These factors may be stone-related, ureter-related or patient-related factors. Stone size is considered as the most important predictor.Stones ≤5 mm have passage rates of up to 70–80%while stones >10 mm rarely pass without intervention. (Jendeberg et al., 2017)Stone location, density, and shapeas well as the degree of ureteric obstruction and inflammation also play a role. Patient-related factors such as age, hydration status and ureteric peristalsis further influence outcomes.However, clinical experience and data indicate that even small distal ureteric stones may fail to pass spontaneously, suggesting the involvement of additional factors beyond stone size alone.(Peres et al., 2010)

The anatomical configuration of the VesicouretericJunction may play a critical role in determining whether a distal ureteric stone passes spontaneously or becomes impacted. A large intramural ureter, narrower ureteric orificeor a more acute ureterovesical angle may increase resistance to stone passage.(Miah et al., 2021) Thus, prolonging obstruction and reducing the likelihood of spontaneous expulsion. Unlike inflammatory edema or ureteric spasm, which may respond to medical expulsive therapy, these anatomical factors represent fixed structural barriers.(Abou-Elela, 2017)

Medical Expulsive Therapy (MET), particularly with alpha-adrenergic blockers, has become a widely accepted treatment modality for distal ureteric stones. Alpha-blockers act by reducing ureteric smooth muscle tone, decreasing ureteric spasms and facilitating the migration of stones.(Yotovski et al., 2024) Although numerous studies and meta-analyses have demonstrated the benefits of MET, its efficacy is variable and a large group of patients fails conservative management despite appropriate therapy. This variability may be due to differences in vesicoureteric junction anatomy.(Woodward)

Advances in Non-Contrast Computed Tomography (NCCT) have enabled detailed evaluation of ureteric stones as well as distal ureteric anatomy. NCCT is the gold standard imaging modality for ureteric calculi and allows accurate assessment of stone size, location, density, degree of obstruction and anatomical features of the VesicouretericJunction. Despite the availability of this information, routine clinical decision-making for distal ureteric stones rarely incorporates VUJ anatomical assessment.(Matin and Streem, 2000)

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Identifying patients with critical VesicouretericJunction anatomy may have important clinical implications. Such patients may be less likely to benefit from prolonged conservative management and may experience recurrent renal colic, repeated emergency visits, increased analgesic requirementsand risk of complications including infection and renal impairment. Early intervention in these patients can reduce morbidity and healthcare costs.

Currently, there is a shortage in study of prospective randomized controlled trials for evaluating the influence of VesicouretericJunction anatomy on spontaneous passage of distal ureteric stones. Most studies focus on stone-related characteristics and ignore the potential impact of anatomical variation at the VUJ. There is a clear need for high-quality evidence to determine whether VUJ anatomy should be incorporated into clinical decision-making algorithms.Therefore, this randomized controlled trial was designed to evaluate the influence of VesicouretericJunction anatomy on spontaneous passage of distal ureteric stones. By comparing outcomes between patients with favorable and unfavorable VUJ anatomical configurations managed conservatively, this study aims to provide evidence to support a more individualized and anatomy-based approach to the management of distal ureteric stone disease.

MATERIALS AND METHODS

Study Population: This randomized controlled trial was conducted from May 2025 to December 2025 at the Department of Urology, Jinnah Hospital, Lahore. Patients aged 18–60 years presenting with unilateral distal ureteric stones were taken into account. Patients with stones ≤10 mm on non-contrast computed tomography (NCCT) were screened and included. Exclusion criteria included multiple stones, bilateral ureteric stones, active urinary tract infection, pregnancy, anatomical abnormalities of the urinary tract or prior urological surgery. Ethical approval for the study was obtained from the Ethical Review Board of Jinnah Hospital. The study was performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment. Assessment of VUJ Anatomy: All participants underwent NCCT imaging to confirm stone size, location and anatomical features of the vesicoureteric junction. VUJ anatomy was categorized as favorable or unfavorable based on intramural ureter length, ureteric orifice diameterand ureterovesical angle. Favorable VUJ anatomy included a short intramural ureter, wide ureteric orifice and obtuse insertion angle. Whereas unfavorable anatomy was defined as a long intramural ureter, narrow ureteric orifice or acute insertion angle. Imaging measurements were performed independently by two experienced radiologists to minimize inter-observer variability. Randomization and Group Allocation: Patients were randomly allocated into two groups. Group A included patients with favorable VUJ anatomy and Group B with unfavorable VUJ anatomy.All baseline characteristics, including age, sex, stone size and degree of hydronephrosis, were recorded prior to intervention to ensure comparability between groups.

Conservative Management Protocol: All patients received standardized conservative management, including: Adequate oral hydration (≥2 L/day), Analgesics (NSAIDs as required) and Medical expulsive therapy (tamsulosin 0.4 mg once daily). Patients were instructed to strain their urine and report passage of stones. Follow-up was conducted for four weeks to monitor stone passage and assess complications. Outcome Measures: The primary outcome was spontaneous passage of the distal ureteric stone within four weeks.

Secondary outcomes included: Time to stone passage (days), requirement for surgical intervention (ureteroscopy, lithotripsy) and complications such as infection, obstruction, or hematuria, Stone passage was confirmed by either visualization of the stone in urine or follow-up NCCT showing absence of the stone. Statistical Analysis: Data was analyzed using SPSS version 26. Continuous variables were expressed as mean ± standard deviation while categorical variables were expressed as frequencies and percentages. Differences in mean values between groups were evaluated using the independent t-test or Mann-Whitney U test as appropriate. Categorical variables were compared using the Chi-square test or Fisher's exact test. Correlations between VUJ anatomical features and stone passage were analyzed using Spearman's rank correlation coefficient. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 120 patients were included, with 60 patients in each group. The mean age of participants was 38.9 ± 10.6 years (range 19–60 years). Male patients constituted 68.3% (n = 82) and females 31.7% (n = 38). Stone characteristics, including size and location within the distal ureter were comparable between groups ($p > 0.05$). Most patients presented with flank pain (92%) and dysuria (46%). Mild hydronephrosis was observed in 49.2% of patients, moderate in 35%, and severe in 15.8%. Baseline demographic and clinical characteristics are summarized in Table

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Table 1. Demographic and Clinical Characteristics of Study Population

Variable	Group A (n=60)	Group B (n=60)	p-value
Age (years), mean ± SD	38.5 ± 10.2	39.2 ± 11.1	0.72
Gender (Male/Female)	42/18	40/20	0.68
Stone size (mm), mean ± SD	7.4 ± 1.2	7.6 ± 1.3	0.48
Hydronephrosis(Mild/Mod/Sev)	30/20/10	28/22/10	0.83
Presenting symptom (Pain)	56 (93.3%)	54 (90.0%)	0.52
Presenting symptom (Dysuria)	28 (46.7%)	26 (43.3%)	0.71

Spontaneous passage occurred in 78.3% of patients in Group A and 46.7% in Group B, a difference that was statistically significant ($p < 0.001$). The mean time to stone passage was significantly shorter in patients with favorable VUJ anatomy (11.4 ± 4.2 days) compared to those with unfavorable anatomy (18.9 ± 6.1 days; $p < 0.001$). Surgical intervention, including ureteroscopy or lithotripsy was required in 21.7% of patients with favorable anatomy and 53.3% of patients with unfavorable anatomy ($p < 0.001$).

Table 2. Spontaneous Stone Passage and Surgical Intervention

Outcome	Group A (n=60)	Group B(n=60)	p-value
Spontaneous stone passage	47 (78.3%)	28 (46.7%)	<0.001
Mean time to passage (days)	11.4 ± 4.2	18.9 ± 6.1	<0.001
Surgical intervention required	13 (21.7%)	32 (53.3%)	<0.001

Analysis by gender showed that males had slightly higher passage rates than females, though this difference was not statistically significant within Group A. In Group B, females had a notably lower passage rate.

Table 3. Spontaneous Stone Passage by Gender

Gender	Group A	n (%)	Group B	n (%)	p-value
Male	33/42	(78.6%)	22/40	(55.0%)	0.06
Female	14/18	(77.8%)	6/20	(30.0%)	0.02

Age-wise analysis revealed that younger patients (<40 years) had faster passage times and higher success rates compared to older patients (>40 years).Although these differences were not statistically significant ($p = 0.08$).
Spearman's correlation analysis demonstrated a significant relationship between anatomical features of the VUJ and stone passage:Shorter intramural ureter was correlated positively with spontaneous passage ($r = -0.61$, $p < 0.001$), wider ureteric orifice was correlated positively ($r = 0.58$, $p < 0.001$) and more obtuse ureterovesical angle was correlated positively ($r = 0.54$, $p < 0.001$)

Table 4. Correlation Between VUJ Parameters and Stone Passage

VUJ Parameter	Spearman's r	p-value
Intramural ureter length	-0.61	<0.001
Ureteric orifice diameter	0.58	<0.001
Ureterovesical angle	0.54	<0.001

These findings indicate that favorable VUJ anatomy strongly predicts successful spontaneous stone passage regardless of stone size.

DISCUSSION

The present randomized controlled trial evaluated the influence of Vesicoureteric junction (VUJ) anatomy on the spontaneous passage of distal ureteric stones in patients managed conservatively. Our study demonstrates that favorable VUJ anatomical features: short intramural ureter, wider ureteric orifice and obtuse ureterovesical angleare significantly associated with higher spontaneous stone passage rates, shorter passage times and lower need for surgical intervention. These findings show the importance of ureteric anatomy in determining the management for distal ureteric stones.

In this cohort study, 78.3% of patients with favorable VUJ anatomy experienced spontaneous passage as compared to those with unfavorable anatomy 46.7% ($p < 0.001$). The mean time to passage was also significantly shortin the favorable group (11.4 ± 4.2 days vs. 18.9 ± 6.1 days). These results are in accordance with the observations of Lee et al. Their study reported that anatomical variations at the distal ureter can significantly affect stone expulsion rates (Lee et al., 2012). Similarly, Noordzig J. et al. demonstrated that a longer intramural ureter and narrow ureteric orifice reduce the likelihood of spontaneous passage(Noordzij and Dabhoiwala, 1993). Our study not only confirms these findings but also explains the effect in a randomized controlled

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setting. Thus, this study strengthens the importanceof the clinical relevance of VUJ anatomy.

Stone size has been considered the most important factor of spontaneous passage.Smaller stones (<5 mm) have higher passage rates as compared to larger(Miller and Kane, 1999). In our study, stone size was comparable between groups, suggesting that anatomical factors independently influence result. This may emphasize why some patients with small distal stones fail conservative management.Therefore, the need to consider VUJ anatomy in clinical decision-making.

The role of gender and age in stone passage has been studied in literatures. In our study, males had slightly higher passage rates than females but this difference was not statistically significant. Moreover, females with unfavorable VUJ anatomy had lower passage rates. Therefore, suggesting that anatomical differences may have a greater effect in certain groups. This observationsare in alignment withreports by Eisner et al. They noted that distal ureteral anatomy may contribute to variation in stone passage among different populations(Eisner et al., 2008).

To facilitate distal stone passage,Medical expulsive therapy or MET with alpha-blockers is widely used. Although MET improves outcomes but success rate is not uniform. Our findings suggest that patients with unfavorable VUJ anatomy are less likely to benefit from MET alone.Because structural resistance at the VUJ may limit stone migration. These results underscore the importance of individualized treatment planning based on anatomical assessment.

No major complications were observed in our study. Minor hematuria was self-limiting. This indicates that conservative management remains safe in appropriately selected patients. However, early identification of patients who are unlikely to pass stones spontaneously could prevent prolonged symptoms, repeated hospital visitsand potential renal complications.

CONCLUSION

Vesicoureteric junction anatomy is a significant and independent predictor of spontaneous distal ureteric stone passage. Patients with favorable anatomical featuressuch as a shorter intramural ureter, wider ureteric orifice, and more obtuse ureterovesical angleexperience higher passage rates, shorter expulsion timesand a lower need for surgical intervention. Assessment of VUJ anatomy using non-contrast CT can guide conservative management. It can help to identify patients likely to benefit from medical expulsive therapy and those who may require early intervention. Including anatomical evaluation into routine clinical practice has the potential to optimize treatment outcomes. It can further reduce morbidity and delays in management of distal ureteric stones.

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