International Surgery Journal
Arreola-Ramírez D et al. Int Surg J. 2025 May;12(5):723-728
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20251166

Original Research Article

Calcification of ureteral stents: a determinant factor in renal function deterioration in patients with urolithiasis

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Received: 06 December 2024
Revised: 17 January 2025
Accepted: 03 April 2025

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ABSTRACT

Background: Ureteral stents play a crucial role in managing urinary tract obstructions, significantly advancing urological care. However, complications such as stent calcification present significant challenges.
Methods: This retrospective case-control study included 72 patients with ureteral stents placed for urolithiasis between 2020 and 2023. Patients were divided into two groups: calcified stents (n=36) and non-calcified stents (n=36). Data on demographics, comorbidities, stent duration, and renal function parameters were collected. Statistical analyses included Mann-Whitney, Fisher, and Chi-squared tests, with odds ratios (OR) calculated for associations ($p<0.05$). Ethical approval was obtained from the hospital's ethics committee.
Results: Calcified stents were strongly associated with chronic kidney disease (CKD) (OR=2.667, 95% CI: 1.093–6.507) and renal function deterioration (OR=2.200, 95% CI: 0.804–6.018). Prolonged stent durations (>3 months) significantly increased calcification risk (OR=4.375, 95% CI: 2.322–8.243), while durations <3 months were protective (OR=0.156, 95% CI: 0.062–0.396). CKD prevalence was significantly higher in the calcified group (38.9%) compared to controls (11.1%) ($p=0.006$).
Conclusions: Stent calcification is associated with CKD and renal function decline. Timely removal (<3 months) is critical. Further research with larger cohorts is necessary to confirm these findings and guide preventive strategies.

Keywords: Urolithiasis, Calcified ureteral stent, Chronic kidney disease, Renal function

INTRODUCTION

The introduction of the permanent ureteral catheter by Zimskind et al in 1967 marked a milestone in the treatment of urinary tract obstructions, becoming one of the most widely used devices in urology. Later, the introduction of the double J ureteral stent by Finney et al in 1978 established ureteral stent placement as a routine procedure in urological practice.[1,2]

Modern ureteral stents, designed in a double-coiled configuration and made of synthetic polymers such as polyurethane or polyethylene, have significantly advanced the management of urological conditions. These devices are essential for treating urolithiasis, resolving benign or malignant obstructions, promoting ureteral healing, and controlling urinary leaks. They are also frequently used after endourological and surgical procedures to ensure urinary flow until edema resolves or incisions heal.[3-7]

Despite their importance, ureteral stents are not free from complications. Among the most common issues are infection, encrustation or calcification, and patient discomfort.[6,8] Calcification, characterized by the deposition of minerals on the stent's surface and lumen, can impair functionality, hinder removal, and, in severe cases, require multiple interventions. These complications are increasingly frequent and represent a significant challenge in urological practice.[7,9,10]

The management of calcified stents is complex, and no international guidelines with strong evidence currently exist to standardize treatment. While classifications, such as the one developed by Acosta-Miranda et al, help systematize encrustation characteristics and severity, therapeutic approaches still depend on limited retrospective data.[11,15]

Moreover, the COVID-19 pandemic exacerbated this issue by disrupting appropriate patient follow-ups, leading to prolonged stent durations and an increase in calcification incidence.[14,21] This highlights the need for preventive strategies and better clinical follow-up to avoid these complications.

Although ureteral stents are indispensable tools in urology, their calcification is associated with severe complications, including renal function deterioration, increased incidence of urinary tract infections, and higher healthcare costs. However, the lack of evidence regarding their impact on renal function and the influence of comorbidities such as diabetes, hypertension, and CKD underscores the need for further research in this field.[12,16,18]

Objectives

The primary objective of this study is to evaluate the association between calcified ureteral stents and renal function deterioration in patients with urolithiasis during the period from January 2020 to June 2023. This study seeks to understand the potential adverse effects of ureteral stent calcification on the urinary tract and its impact on renal function. This evaluation aims to provide clinically relevant information for medical decision-making, such as the need for early intervention and appropriate treatment of calcified ureteral stents to ensure their safe removal.

METHODS

An observational, retrospective case-control study was conducted at the Urology Department of the Manuel Gea González General Hospital. The study included patients with ureteral stents placed for urolithiasis from January 2020 to June 2023.

Inclusion criteria

Inclusion criteria were patients aged ≥18 years with tomographic confirmation of urolithiasis and serum creatinine measurements before stent placement and one month after removal.

Exclusion criteria

Exclusion criteria included patients with incomplete records or other causes of renal dysfunction unrelated to stents.

Patients were divided into calcified (n=36) and non-calcified (n=36) groups. Data collection involved demographics, comorbidities, stent duration, and renal function parameters. Statistical analyses included Mann-Whitney, Fisher's exact test, Kruskal-Wallis, and Chi-squared tests. Odds ratios were calculated to evaluate associations.

The procedure included reviewing medical records, extracting relevant data, and performing statistical analyses to determine associations between calcification and renal function.

RESULTS

The demographic results obtained from patients in the case group (calcified ureteral stents) and control group (non-calcified ureteral stents) showed statistically significant differences in the following variables: stent duration in months (p=0.000), chronic kidney disease (CKD) (p=0.006), initial creatinine levels (p=0.015), initial CKD-EPI (p=0.009), post-removal CKD-EPI (p=0.049), initial KDIGO staging (p=0.001), and post-removal KDIGO staging (p=0.004). The remaining variables did not show statistically significant differences between groups.

The median duration of ureteral stents was 8 months (IQR=13) for the case group and 2 months for the control group. The presence of type 2 diabetes mellitus and systemic arterial hypertension did not show statistically significant differences between cases and controls. CKD was identified in 14 patients (38.9%) in the case group and 4 patients (11.1%) in the control group, with a statistically significant difference between groups (p=0.006). Among the cases, 3 patients (8.3%) were newly diagnosed with CKD following stent removal, while no new cases were recorded in the control group; this difference was not statistically significant. Renal function deterioration was observed in 9 patients (25%) in case group and 3 patients (8.3%) in control group, with a non-significant difference due to a minimal range (p=0.056) (Tables 1 and 2).

Associations between variables and the presence or absence of stent calcification were analyzed. Stent duration (in months) showed the highest association; patients with stent durations <3 months had a lower probability of calcification (OR=0.156, 95% CI: 0.062-0.396). Conversely, stent durations >3 months were associated with a higher probability of calcification (OR=4.375, 95% CI: 2.322-8.243), with a Cramer's V strength of association of 0.671. CKD was also associated

with stent calcification (OR=2.667, 95% CI: 1.093-6.507), while the absence of CKD acted as a protective factor (OR=0.524, 95% CI: 0.349-0.786). Non-deterioration of renal function was associated with a lower likelihood of stent calcification (OR=0.6, 95% CI: 0.390-0.922), whereas renal function deterioration showed a higher probability of stent calcification (OR=2.200, 95% CI: 0.804-6.018). Other variables showed low associations (Table 3). The association between ureteral stent calcification and reduced renal clearance was quantified with an OR=1.583 (95% CI: 0.962-2.696) compared to non-calcified stents and renal clearance reduction with an OR=0.639 (95% CI: 0.398-1.027). The strength of association was measured as 0.223 using Cramer's V (Table 4).

Table 1: General characteristics of the case and control populations.

Variables	Cases (n=36) (%)	Controls (n=36) (%)	Total (n=72) (%)
Sex			
Female	22 (61.1)	21 (58.3)	43 (59.7)
Male	14 (38.9)	15 (41.9)	29 (40.3)
Age (in years)	49 (17)	47.5 (26)	48.5 (21)
Duration of double J stent (months)	8 (13)	2 (2)	4 (6)
Stent laterality			
Right	14 (38.9)	14 (38.9)	28 (38.9)
Left	20 (55.6)	16 (44.4)	36 (44.4)
Bilateral	2 (5.6)	6 (16.7)	8 (16.7)
Type 2 diabetes mellitus (DM2)			
Yes	8 (22.2)	8 (22.2)	16 (22.2)
No	28 (77.8)	28 (77.8)	56 (77.8)
Hypertension (HAS)			
Yes	7 (19.4)	9 (25)	16 (22.2)
No	29 (80.6)	27 (75)	56 (77.8)
Chronic kidney disease (CKD)			
Yes	14 (38.9)	4 (11.1)	18 (25)
No	22 (61.1)	32 (88.6)	54 (75)
Initial creatinine	1.075 (0.56-8.02)	0.83 (0.48-2.33)	0.91 (0.48-8.02)
Initial CKD-EPI	71.5 (6-139)	97 (30-124)	88 (6-139)
Initial KDIGO			
Grade 1	11 (30.6)	23 (63.9)	34 (47.2)
Grade 2	9 (25)	9 (25)	18 (25)
Grade 3	10 (27.8)	4 (11.1)	14 (19.4)
Grade 4	5 (13.9)	0 (0)	5 (6.9)
Grade 5	1 (2.8)	0 (0)	1 (1.4)
Post-removal creatinine	1.045 (0.5-5.91)	0.82 (0.52-1.89)	0.92 (0.52-5.9)
Post-removal CKD-EPI	71 (9-128)	95 (39-124)	86.5 (9-128)
Post-removal KDIGO			
Grade 1	13 (36.1)	22 (61.2)	35 (48.6)
Grade 2	7 (19.4)	10 (27.8)	17 (23.6)
Grade 3	10 (27.8)	4 (11.1)	14 (19.4)
Grade 4	4 (11.1)	0 (0)	4 (5.6)
Grade 5	2 (5.6)	0 (0)	2 (2.8)
Renal function deterioration			
Yes	9 (25)	3 (8.3)	12 (16.7)
No	27 (75)	33 (91.7)	60 (83.3)
FECal			
0	0 (0)	36 (100)	36 (50)
1	5 (13.9)	0 (0)	5 (6.9)
2	11 (30.6)	0 (0)	11 (15.3)
3	3 (8.3)	0 (0)	3 (4.2)
4	11 (30.6)	0 (0)	11 (15.3)
5	6 (16.7)	0 (0)	6 (8.3)

Table 2: Comparative analysis of demographics, comorbidities, and renal parameters between calcified and non-calcified ureteral stents.

Variables	Calcified stents (n=36) (%)	Non-calcified stents (n=36) (%)	P value
Sex			
Female	22 (61.1)	21 (58.3)	0.5
Male	14 (38.9)	15 (41.9)	
Age (in years)	49 (17)	47.5 (26)	0.884
Duration of double J stent (months)	8 (13)	2 (2)	0.0001
Stent laterality			
Right	14 (38.9)	14 (38.9)	0.295
Left	20 (55.6)	16 (44.4)	
Bilateral	2 (5.6)	6 (16.7)	
Type 2 diabetes mellitus (DM 2)			
Yes	8 (22.2)	8 (22.2)	0.611
No	28 (77.8)	28 (77.8)	
Hypertension (HAS)			
Yes	7 (19.4)	9 (25)	0.389
No	29 (80.6)	27 (75)	
Chronic kidney disease (CKD)			
Yes	14 (38.9)	4 (11.1)	0.006
No	22 (61.1)	32 (88.6)	
Initial creatinine	1.075 (0.56-8.02)	0.83 (0.48-2.33)	0.015
Initial CKD-EPI	71.5 (6-139)	97 (30-124)	0.009
Initial KDIGO			
Grade 1	11 (30.6)	23 (63.9)	0.004
Grade 2	9 (25)	9 (25)	
Grade 3	10 (27.8)	4 (11.1)	
Grade 4	5 (13.9)	0 (0)	
Grade 5	1 (2.8)	0 (0)	
Post-removal creatinine	1.045 (0.5-5.91)	0.82 (0.52-1.89)	0.056
Post-removal CKD-EPI	71 (9-128)	95 (39-124)	0.049
Post-removal KDIGO			
Grade 1	13 (36.1)	22 (61.2)	0.004
Grade 2	7 (19.4)	10 (27.8)	
Grade 3	10 (27.8)	4 (11.1)	
Grade 4	4 (11.1)	0 (0)	
Grade 5	2 (5.6)	0 (0)	
Renal function deterioration			
Yes	9 (25)	3 (8.3)	0.056
No	27 (75)	33 (91.7)	

Table 3: Population characteristics, associations, and odds ratios for cases and controls.

Variables	Cases (n=36) (%)	Controls (n=36) (%)	OR (95% CI)	P value
Sex				
Female	22 (61.1)	21 (58.3)	1.060 (0.658-1.707)	0.058
Male	14 (38.9)	15 (41.9)	0.944 (0.592-1.505)	
Duration of double J stent (months)				
<3	32.4		0.156 (0.062-0.396)	32.4
>3	4.375		4.375 (2.322-8.243)	
Type 2 diabetes mellitus (DM2)				
Yes	8 (22.2)	8 (22.2)	1.0 (0.574-1.743)	0.0001
No	28 (77.8)	28 (77.8)		
Hypertension (HAS)				
Yes	7 (19.4)	9 (25)	0.857 (0.515-1.428)	0.321
No	29 (80.6)	27 (75)	1.184 (0.643-2.178)	

Continued.

Variables	Cases (n=36) (%)	Controls (n=36) (%)	OR (95% CI)	P value
Chronic kidney disease (CKD)				
Yes	14 (38.9)	4 (11.1)	2.667 (1.093-6.507)	0.007
No	22 (61.1)	32 (88.6)	0.524 (0.349-0.786)	
Creatinine				
Normal	22 (61.1)	30 (83.3)	0.604 (0.394-0.927)	0.035
Elevated	14 (38.9)	6 (16.7)	1.923 (0.947-3.907)	
Renal function deterioration				
Yes	9 (25)	3 (8.3)	2.200 (0.804-6.018)	0.056
No	27 (75)	33 (91.7)	0.6 (0.390-0.922)	

Table 4: Comparative analysis of demographics, comorbidities, and renal parameters between calcified and non-calcified ureteral stents.

Variables	Normal renal clearance (%)	Reduced renal clearance (%)	OR (95% CI)	P value
Non-calcified catheter	15 (41.7)	21 (58.3)	0.639 (0.398–1.027)	3.567
Calcified catheter	23 (63.9)	13 (36.1)	1.583 (0.962–2.696)	0.223

DISCUSSION

Ureteral stent calcification represents an increasingly frequent complication in Urology, yet it is entirely preventable through adequate follow-up and patient education about the importance of timely stent removal, preferably within 3 months. In this study, 8.3% of patients with calcified stents developed chronic kidney disease (CKD).

CKD was documented in 38.9% of patients with calcified stents compared to 11.1% in the control group, revealing a strong association between CKD and stent calcification (OR=2.667, 95% CI: 1.093-6.507). CKD emerged as an independent risk factor for stent calcification, while its absence acted as a protective factor (OR=0.524, 95% CI: 0.349-0.786), with a strength of association of 0.321 (Cramer's V). Conversely, comorbidities such as hypertension and type 2 diabetes mellitus showed weak associations with stent calcification.

Stent duration was a critical variable. Removal within 3 months significantly reduced the likelihood of calcification (OR=0.156, 95% CI: 0.062-0.396). Prolonged stent duration (>3 months) substantially increased calcification probability (OR=4.375, 95% CI: 2.322-8.243), consistent with previous studies reporting a mean stent lifespan of 3 to 6 months for polymer-based devices.

A notable association was identified between stent calcification and renal function deterioration. Patients with calcified stents had a higher probability of renal function decline (OR=1.583, 95% CI: 0.962-2.696), compared to non-calcified stents, which were associated with a lower likelihood of renal impairment (OR=0.639, 95% CI: 0.398-1.027). Renal function deterioration was observed in 25% of patients with calcified stents and in 8.3% of the control group, with a strength of association of 0.224 (Cramer's V).

This study demonstrates a strong association between stent calcification and renal function decline, consistent with prior findings by Ibilibor et al and Zahran et al, who reported similar risks with retained stents.[19,20] Longer stent durations were a significant risk factor, aligning with studies highlighting the need for timely removal to prevent calcification and subsequent complications.

Limitations

Limitations include the small sample size and retrospective design, which may limit generalizability. Future prospective studies with larger cohorts are needed to validate these findings.

CONCLUSION

This study confirms that calcified ureteral stents are strongly associated with renal function deterioration and chronic kidney disease, emphasizing the clinical impact of these findings. The results underscore the importance of timely stent removal within three months and robust follow-up protocols to reduce complications. These findings provide critical insights into improving patient care, emphasizing the need for proactive strategies, clinical monitoring, and patient education to optimize outcomes for individuals requiring ureteral stents.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Arreola-Ramírez D, Martínez-Arroyo C, Anceno A, Cervantes-Zorrilla R, Haddad-Servín A, Domínguez-Castillo RE, et al. Calcification of ureteral stents: a determinant factor in renal function deterioration in patients with urolithiasis. Int Surg J 2025;12:723-8.