Original Article

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Correlation of Bacterial Colonisation with Time Duration in Indwelling Ureteral Double J Stents: A Prospective Observational Study

Microbiology Section

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ABSTRACT

Introduction: Ureteral Double J (DJ) stents are commonly used in urology to ensure urinary drainage. However, prolonged indwelling time increases the risk of bacterial colonisation and biofilm formation, which can lead to infections and antibiotic resistance. Understanding the correlation between stent duration and microbial colonisation is crucial for optimising patient management and reducing complications.

Aim: To evaluate the correlation between stent indwelling time and bacterial colonisation of ureteral DJ stents in patients with urologic indications.

Materials and Methods: A prospective observational study was conducted from February 2024 to February 2025 on 70 patients who underwent DJ stenting for urological indications such as urolithiasis, ureteric stricture, pyelonephritis, or postoperative shunting in Department of Microbiology, Government Medical College and Department of Urology, Super-specialty Hospital, Nagpur, Maharashtra, India. The demographic profile of patients including age and gender were recoded and analysed for correlation with colonisation. The stents were aseptically removed after varying indwelling durations up to 12 weeks; Upper and lower segments of stent were cultured by roll plate method and flushing with trypticase soya broth on blood and MacConkey's agar. Bacterial isolates were identified and subjected to antimicrobial susceptibility testing as per Clinical and Laboratory Standards Institute (CLSI) 2023 guidelines. Biofilm formation was quantified using microtiter plate assay. Data were analysed using Statistical Package for the Social Sciences (SPSS) software and statistical significance was determined by the Chi-square test with p-value<0.05 considered significant.

Results: Bacterial colonisation was found in 39 stents (55.71%). The predominant organism was *Escherichia coli*-14 (35.90%) isolates, followed by *Klebsiella pneumoniae*-8 (20.51%) isolates and *Pseudomonas aeruginosa*-7 (17.95%) isolates. Colonisation rates increased with stent duration: 3 (7.69%) at 0-2 weeks, 9 (23.08%) at 2-4 weeks and 17 (43.58%) at 4-6 weeks indicating a positive correlation between stent indwelling time and bacterial colonisation of ureteral DJ stents in patients with urologic indications. Biofilm formation was detected in 28 (71.79%) of isolates, with higher intensity in longer indwelling stents. Multidrug resistance was observed in 11 (28.21%) of isolates.

Conclusion: Longer stent duration correlates with higher bacterial colonisation and biofilm formation. These findings highlight the need for timely stent removal and targeted antibiotic therapy to mitigate infection risk and resistance.

Keywords: Urolithiasis, Biofilm, *Escherichia coli*, Multidrug-resistant

INTRODUCTION

Ureteral Double-J (DJ) stents are extensively utilised in urological practice to manage upper urinary tract obstructions and prevent postoperative complications following procedures such as ureteroscopy and percutaneous nephrolithotomy [1]. These stents maintain ureteral patency, ensuring effective urine drainage from the kidneys to the bladder. Despite their therapeutic advantages, indwelling DJ stents are prone to bacterial colonisation and biofilm formation, which can lead to significant clinical complications, including Urinary Tract Infections (UTIs), encrustation, and stent obstruction [2]. Biofilms act as physical barriers against drugs and host immune responses, leading to resistance to antimicrobial treatment. Biofilms reduce the possibility of eradicating infections and cause relapses after the traditional appropriate treatment [3]. Recent studies have highlighted that the persistence of bacterial colonisation and biofilm formation on indwelling stents increases with time, underscoring the need for strategies to disrupt early biofilm development [3].

The duration of stent placement has been identified as a critical factor influencing the rate of bacterial colonisation and biofilm development. There is a direct correlation between prolonged indwelling times and increased colonisation rates. A study by Mainali P et al., reported colonisation rates of 2.2% for stents indwelling less than four weeks, 2.9% for four to six weeks, and a significant increase to 25% for stents retained beyond six weeks [4]. Similarly, Ozgur BC et al., reported bacterial colonisation in 7.7% of double-J stents (10/130 cases), with bacteriuria detected in only 10% of the colonised patients [5]. The spectrum of pathogens implicated in stent colonisation is diverse, with *Escherichia coli*, *Pseudomonas aeruginosa*, and *Enterococcus* species being the most frequently isolated organisms. The formation of biofilms by these pathogens on stent surfaces complicates treatment, as biofilms confer resistance to both the host immune response and antibiotic therapy [6].

Understanding the correlation between indwelling time and the extent of bacterial colonisation and biofilm formation is pivotal for optimising stent management protocols, reducing the incidence of stent-associated infections, and improving patient outcomes. This study is novel in correlating clinical, microbiological and biofilm parameters simultaneously, providing region specific insights that can guide evidence based timing of stent removal and infection control strategies. This study aimed to evaluate correlation between stent indwelling time and bacterial colonisation of ureteral DJ stents in patients with urologic indications. The primary objective of the study was to study bacterial profile and the antimicrobial susceptibility pattern of the isolate while the secondary objective was to study biofilm formation of the isolates obtained from the culture of DJ stents.

MATERIALS AND METHODS

This prospective, observational study was conducted at Government Medical College and Super-specialty Hospital, Nagpur, Maharashtra, India for a period of one year from February 2024 to February 2025. The approval of Ethics committee in Government Medical College was taken for the study with the approval No. EC/Pharmac/GMC/NGP/3578. A total of 70 patients who underwent DJ stent placement for various urological conditions, including ureteral obstruction, post-lithotripsy management, and ureteral strictures, were enrolled [7].

Inclusion criteria: Patients with existing DJ stent placement were included in the study.

Exclusion criteria: Patient diagnosed with UTI prior to DJ stenting; patients having previous medical history of UTI one week before DJ stenting; patients on antibiotics one week before DJ stenting were excluded from the study.

Study Procedure

Stent insertion and retrieval: DJ stents were inserted under aseptic conditions following standard urological procedures. The duration of stent placement varied among patients, with a maximum indwelling period up to 12 weeks. The stents were retrieved aseptically using a cystoscope to prevent external contamination [8].

Sample collection and processing: Upon removal, each stent was aseptically sectioned into two parts - 1-3 cm of upper and lower segments to recover adherent bacteria and biofilms from the outer surface of lumen and each segment was flushed with 1 mL of sterile Tryptic Soy Broth (TSB) to recover adherent bacteria and biofilms from the inner surface of lumen [9,10].

Method of culture: After stent removal, stent segments were inoculated by the roll-plate method [11] and the TSB flush solutions were cultured on blood agar and MacConkey agar plates at 37°C for 18-24 hour [8]. If no growth was observed, the culture was reported as "no growth." All colonies were identified by standard microbiological techniques such as roll plate method (semiquantitative culture method) and biochemical tests such as carbohydrate fermentation tests, indole test, methyl red test, citrate utilisation test, urease test, triple sugar iron test, lysine-ornithine-arginine decarboxylase tests were performed [12]. Identified isolates underwent antimicrobial susceptibility testing using the Kirby-Bauer disc diffusion method on Mueller-Hinton agar, following CLSI 2023 guidelines [11]. Detection of various antimicrobial resistance mechanisms was studied. Extended spectrum beta lactamases were detected by combined disc diffusion test, Amp C beta lactamases were detected using AmpC disc (Tris-EDTA) with cefoxitin (30 µg) and flattening of inhibition zone towards Amp C disc, Metallo beta lactamase production was identified by the imipenem-EDTA combined disc test. Methicillin Resistant *Staphylococcus aureus* (MRSA) was detected using cefoxitin disc diffusion test. Quality control strains used were *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Klebsiella pneumoniae* ATCC 700603 and *Staphylococcus aureus* ATCC 25923 [11]. Multidrug resistant isolates were defined as the isolate which showed resistance to at least one antimicrobial agent in ≥3 antimicrobial categories [10].

Biofilm detection: Biofilm production by the bacterial isolates was assessed using the microtiter plate assay. Isolates were categorised based on their optical density (OD) values: non biofilm producers (OD ≤0.120), moderate biofilm producers (OD >0.120 to ≤0.240), and strong biofilm producers (OD >0.240). *Staphylococcus aureus* ATCC 25923 was used as positive control for testing biofilm production by isolates [13].

STATISTICAL ANALYSIS

Data were analysed using SPSS software version 25.0 and statistical significance was determined by the Chi-square test with p-value <0.05 considered significant. Spearman's rank correlation (r-value) was calculated using rank values using the formula:

$$\rho = 1 - \frac{6 \Sigma d_i^2}{n(n^2-1)}$$

Where, ρ is the r-value.

RESULTS

Of the 70 patients included in the study, 39 were males and 31 were females. Bacterial stent colonisation was found in 23/39 males and 16/31 female patients. [Table/Fig-1] shows time duration with colonisation of DJ stents indicating a progressive increase in colonisation with longer stent indwelling duration. No colonisation was observed in stents removed within one week. Maximum colonisation rate was seen in stents with indwelling duration of >six weeks-10 (14.28). Overall 39/70 (55.71%) stents were colonised. The p-value showed significant correlation between the duration of stent indwelling and bacterial colonisation. In [Table/Fig-2] Spearman's rank correlation (r-value) was calculated using rank values shows the association between duration of indwelling DJ stent and bacterial colonisation where the duration was treated as an ordinal variable and colonisation as a proportional outcome giving a r-value of 0.89. This shows that the colonisation clearly increases with duration of stent.

Duration of indwelling (in weeks)	Colonised n (%)	Non colonised n (%)	Total number of stents n (%)	p-value
<1	0	04/70 (5.71)	04/70 (5.71)	0.041
1-2	03/70 (4.28)	05/70 (7.14)	08/70 (11.42)	
2-3	03/70 (4.28)	07/70 (10)	10/70 (14.28)	
3-4	06/70 (8.57)	03/70 (4.28)	09/70 (12.85)	
4-5	09/70 (12.85)	05/70 (7.14)	14/70 (20)	
5-6	08/70 (11.42)	03/70 (4.28)	11/70(15.71)	
>6	10/70 (14.28)	04/70 (5.71)	14/70 (20)	
	39/70 (55.71)	31/70 (44.29)	70/70 (100)	

[Table/Fig-1]: Bacterial colonisation with time duration of in dwelling Double-J (DJ) stents with p-value representation n=70.
χ^2=13.02, df=6, p-value=0.041

Duration of indwelling (in weeks)	Rank X	Colonised/Total number of stents	Colonisation %	Rank Y
<1	1	00/04	0	1
1-2	2	03/08	37.5	2
2-3	3	03/10	30	3
3-4	4	06/09	66.7	4
4-5	5	09/14	64.3	5
5-6	6	08/11	72.7	6
>6	7	10/14	71.4	7

[Table/Fig-2]: Bacterial colonisation with time duration of in dwelling Double-J (DJ) stents with r-value representation.
d=difference between Rank X and Rank Y; n= number of paired observations (n=7)

[Table/Fig-3] shows that urolithiasis was the most common indication for DJ stenting in 43/70 (61.42%) patients followed by ureteric strictures in-17/70 (24.28%) patients. Urolithiasis had the highest colonisation rate -26/70 (37.14%) while postoperative shunting cases had the lowest colonisation rate-2/70 (2.85%). The p-value was <0.05 showing a significant correlation between the colonisation of stent with different clinical indications.

[Table/Fig-4] shows various clinical indications for removal of DJ stents. The most common indication for stent removal was scheduled removal (51.42%), followed by resolution of ureteral obstruction in 15 patients (21.42%).

Out of 70 indwelling DJ ureteral stents analysed, bacterial colonisation was detected in 39/70 (55.71%) of the stents with 39 significant bacterial isolates [Table/Fig-5]. *Escherichia coli* was the most predominant coloniser, accounting for 14/39 (35.90%)

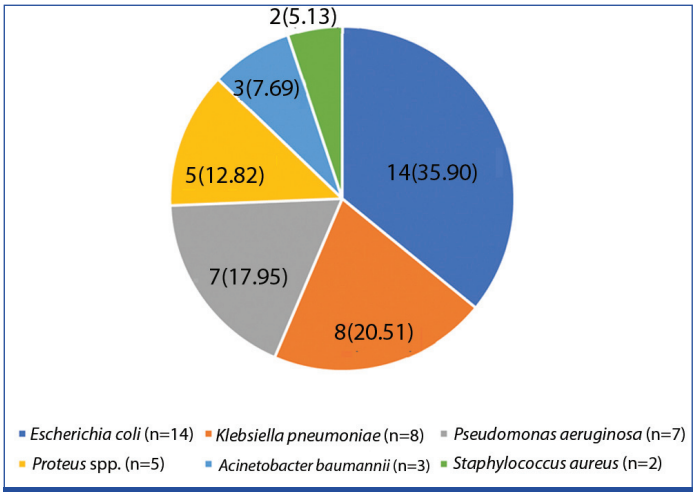
of all isolates. *Pseudomonas aeruginosa* was recovered mostly from stents that had remained for >six weeks and from patients with urolithiasis. *Staphylococcus* isolates are known to form biofilm "slime" on stents with indwelling duration of less than two weeks. No polymicrobial growth was noted in present study.

Clinical indication	Colonised n (%)	Non-colonised n (%)	Number of patients n (%)	p-value
Urolithiasis	26/70 (37.14)	17/70 (24.28)	43/70 (61.42)	p-value =0.032
Ureteric strictures	6/70 (8.57)	11/70 (15.71)	17/70 (24.28)	
Pyelonephritis	5/70 (7.14)	1/70 (1.42)	6/70 (8.57)	
Postoperative shunting	2/70 (2.85)	2/70 (2.85)	4/70 (5.71)	
Total	39/70 (55.71)	31/70 (44.29)	70/70 (100)	

[Table/Fig-3]: Common indication for DJ stenting.
χ^2 =8.71, df=3, p-value= 0.032

Clinical indications	Number of patients n (%)
Scheduled removal	36/70 (51.43)
Resolution of ureteral obstruction	15/70 (21.42)
Urinary Tract Infection (UTI)	10/70 (14.29)
Patient discomfort or pain	5/70 (7.14)
Forgotten stent	4/70 (5.71)
Total	70/70 (100)

[Table/Fig-4]: Clinical indications for removal of DJ stents.



[Table/Fig-5]: Microbial spectrum in Double-J (DJ) stents.

Stent indwelling time showed a significant positive association with the likelihood of colonisation. Colonisation rates increased with stent duration: 3 (7.69%) at 0-2 weeks, 9 (23.08%) at 2-4 weeks, 17 (43.58%) at 4-6 weeks and 10 (25.64%) at 4-6 weeks indicating a positive correlation. These findings suggest that prolonged stent dwell time is the single most consistent predictor of stent colonisation.

The colonisation of the stents was analysed separately in their upper (renal) and lower (bladder) segments for outer surface as well as inner surface. The outer surface colonisation was found only in upper segment-15/70 (21.42%), only in the lower segment 11/70 (15.71%) and in both segments simultaneously-13/70 (18.57%). Internal colonisation of lumen showed that - only upper segment was colonised in 12/70 (17.14%) stents, only lower segment in 8/70 stents (11.42%) and both segments simultaneously in 19/70 (27.14%) stents. *Escherichia coli* was more frequently isolated from - only in lower segments 7/14 (50%), only in upper segment-4/14 (28.57%) and both segments-3/14 (21.42%) , reinforcing bladder contamination as a source. Other organisms identified included *Klebsiella pneumoniae* 8/3 9(20.51%) predominantly from upper segments, *Pseudomonas aeruginosa* -7/39 (17.95%) equally distributed across segments. *Proteus* species was isolated exclusively from the lower segments -5/39 (12.82%), possibly reflecting its propensity to form biofilms and crystalline deposits in alkaline urine environments.

The biofilm forming capability of the isolates was studied using the microtiter plate method and represented in [Table/Fig-6]. Biofilm formation was detected in 28/39 (71.79%) isolates. Indwelling stent duration more than six weeks had a significantly higher proportion of strong biofilm producers- 5/10 (50%) compared to those less than six weeks- 5/28(18%). As the r-value was 0.48, the intensity of biofilm production significantly correlated with colonisation duration.

Biofilm forming capability	Number of isolates (%)	r-value	p-value
Strong biofilm producers	12 (42.86)	0.48	0.018
Moderate biofilm producers	16 (57.14)		
Non biofilm producers	11 (28.21)		
Total biofilm producers	28 (71.79)		
Total isolates	39 (100)		

[Table/Fig-6]: Biofilm forming capability of isolates.
p-value= 0.018, d=difference between Rank X and Rank Y
n= number of paired observation

[Table/Fig-7] depicts the antimicrobial resistance patterns of isolates.

The study identified 11 (28.21%) isolates as multidrug-resistant which included *Escherichia coli*-5 (45.45%) isolates, *Pseudomonas aeruginosa*-3 (27.27%) isolates and *Klebsiella pneumoniae*-3 (27.27%) isolates. Out of the 39 isolates, 14 were ESBL producers, including *Escherichia coli*-9 (64.28%) isolates, *Klebsiella pneumoniae* -4 (28.57%) isolates, and *Proteus mirabilis*-1 (7.14%) isolate. AmpC production was seen in 10 isolates, comprising *Escherichia coli*-5 (50%) isolates, *Klebsiella pneumoniae*-3 (30%) isolates, and *Proteus mirabilis*-2 (20%)isolates. Metallo-Beta-Lactamase (MBL) production was found in nine isolates, notably in *Escherichia coli*-4 (44.44%) isolates, *Klebsiella pneumoniae* 2 (22.22%) isolates, and *Proteus mirabilis*-3 (33.33%) isolates. Among two isolates of Gram-positive organisms, one *Staphylococcus* isolate (50%) was MRSA.

DISCUSSION

Indwelling ureteral stents are prone to bacterial colonisation and biofilm formation, with colonisation rates varying widely across studies, ranging from as low as 5% to 90% [9]. This variability reflects differences in study populations, stent dwell times, and methodologies. Nevertheless, a clear positive correlation between indwelling time and stent colonisation has been demonstrated in numerous investigations. In the present study, the likelihood of positive stent cultures rose markedly with longer stent duration, which was consistent with prior reports. Shabeena KS et al., reported no bacterial growth on stents retrieved within the first two weeks, whereas stents removed at 2-3 months had a colonisation rate of ~67%, reaching 81% by 3-4 months [14]. Likewise, a Turkish study by Ozgur BC et al., found colonisation in merely 2.2% of stents kept [5].

The spectrum of microorganisms colonising ureteral stents is diverse and varies with clinical context. *Escherichia coli* is often the predominant isolate in many studies [14,15]. In the present study, *E. coli* was among the most predominant colonisers (35.90% of isolates). Shabeena KS et al., found *E. coli* to comprise 20% of stent isolates as the single most common species [14]. Similarly, Nishanth S et al., demonstrated a predominance of *E. coli* accounting for 33% of isolates in paediatric patients with indwelling stents [15]. Neheman A et al., reported *E. coli* as a frequent organism associated with ureteral stent colonisation and urinary tract infections in children undergoing minimally invasive pyeloplasty [16]. Ferroni MC et al., identified *E. coli* among the commonly isolated organisms in patients with indwelling stents following pyeloplasty [17]. Braga LH et al., also demonstrated bacterial colonisation in stented patients, including *E. coli*, in their outcome analysis [18]. Ben-Meir D et al., reported *E. coli* as a predominant organism in colonised double-J

Antimicrobials	*Escherichia coli* (n=14) (%)	*Proteus* spp. (n=5) (%)	*Klebsiella pneumoniae* (n=8) (%)	*Pseudomonas aeruginosa* (n=7) (%)	*Acinetobacter baumannii* (n=5) (%)
Ampicillin	14 (100)*	05 (100) *	-	-	-
Amoxiclav	10 (71.4) *	03 (60) *	06 (75%) *	-	-
Cefazolin	14 (100) *	05 (100) *	08 (100%) *	-	-
Cefoxitin	06 (42.9) *	02 (40) *	04 (50%) *	-	-
Cefotaxime	08 (57.1) *	03 (60) *	04 (50%) *	-	-
Cefepime	06 (42.9) *	02 (40) *	03 (37.5%) *	02 (28.6%) *	03 (60%) *
Ceftazidime	-	-	-	04 (57.1%) *	02 (40%) *
Aztreonam	08 (57.1) *	03 (60) *	05 (62.5%) *	02 (28.6%) *	-
Piperacillin- Tazobactam	06 (42.9) *	02 (40) *	03 (37.5%) *	01 (14.3%) *	04 (80%) *
Meropenem	04 (28.6) *	02 (40) *	02 (25%) *	01 (14.3%) *	04 (80%) *
Gentamicin	10 (71.4) *	04 (80) *	06 (75%) *	04 (57.1%) *	02 (40%) *
Tobramycin	08 (57.1) *	03 (60) *	06 (75%) *	02 (28.6%) *	04(80%) *
Amikacin	08 (57.1) *	03 (60) *	06 (75%) *	02 (28.6%) *	04 (80%) *
Netilmycin	-	-	-	05 (71.4%) *	-
Ciprofloxacin	11 (78.6) *	04 (80) *	04 (50%) *	04 (57.1%) *	04 (80%) *
Levofloxacin	11 (78.6) *	04 (80) *	04 (50%) *	04 (57.1%) *	04 (80%) *
Norfloxacin	06 (42.9) *	02 (40) *	03 (37.5%) *	-	-
Cotrimoxazole	07 (50) *	02 (40) *	04 (50%) *	-	02 (40%) *
Nitrofurantoin	05 (35.7) *	-	03 (37.5%) *	-	-

[Table/Fig-7]: Antimicrobial resistance pattern of isolates.
*- as per CLSI the number of isolates less than 30 are not significant. However, this data has been presented here for epidemiological reasons, so that it can be later on pooled in a different meta-analysis.

stents in children [19]. Likewise, García-Aparicio L et al., observed *E. coli* as one of the most frequently isolated organisms in paediatric patients with ureteral stents [20]. It is evident that indwelling stents provide an ideal surface for bacteria to adhere and form biofilms. Within hours of insertion, a conditioning film of host proteins (e.g., fibrinogen, albumin, Tamm-Horsfall protein) coats the stent, facilitating bacterial attachment. Once attached, microorganisms multiply and secrete an extracellular polymeric matrix, maturing into a structured biofilm community. Bacteria embedded in biofilms exhibit phenotypic changes - including slowed metabolic rates and expression of protective genes - that enhance their survival.

Biofilm formation on stents has been implicated as the key factor in both persistent colonisation and encrustation with urinary salts [2]. The present study finding of increasing biofilm density measured by optical density method and encrustation on stents with longer indwelling durations is in line with this paradigm. Bacteria often colonise the stent along its entire length once a biofilm is established. The study identified a bacterial colonisation rate of 55.71% (39 out of 70 stents), with colonisation observed on the outer surface in the upper segment 15/70 (21.42%), lower segment 11/70 (15.71%), and both segments simultaneously 13/70 (18.57%). These findings underscore the propensity for bacterial colonisation along multiple segments of the stent once colonisation is established. A study by Riedl CR et al., reported a colonisation rate of 69.3% [7], indicating a substantial prevalence of bacterial adherence to stents. Similarly, a study at Tribhuvan University Teaching Hospital observed a colonisation rate of 27/48 (56.25%) stents, with *Escherichia coli* being the most frequently isolated organism [4]. Furthermore, a study by Kehinde EO et al., reported a bacterial colonisation rate of 42% in patients with indwelling ureteral stents [21]. Schaeffer A, reported that the risk of catheter-associated bacteriuria increases by approximately 5-10% per day of catheterisation [22]. Similarly, Bregg K and Riehle RA, highlighted the morbidity associated with indwelling ureteral stents following shock wave lithotripsy, particularly in relation to infection and stent-related complications [23]. Garibaldi RA et al., demonstrated that bacteriuria develops in approximately 50% of patients within 7-10 days of catheterisation [24]. Likewise, Warren JW et al., reported that bacteriuria occurs in nearly 100% of patients with long-term indwelling catheters [25]. These consistent findings across diverse populations suggest that bacterial colonisation of ureteral stents is a widespread occurrence. The bacterial isolates from indwelling stents often demonstrate high rates of antimicrobial resistance, which has important clinical implications. This mirrors the findings of Shabeena KS et al., who reported that more than half of stent associated isolates in their series were resistant to antibiotics such as ampicillin (52.5% resistant) and erythromycin (55%), with substantial resistance to piperacillin (42.5%) [14]. The propensity of stent biofilm bacteria to resist antibiotics is due not only to acquired resistance genes but also to the biofilm mode of growth. Embedded in biofilm matrices, bacteria are shielded from antibiotics and host defenses; diffusion of drugs is impeded and metabolic dormancy further reduces antibiotic efficacy [3]. Prolonged indwelling time duration of ureteral DJ stents significantly increase the risk of bacterial colonisation, biofilm formation and antimicrobial resistance emphasising the importance of timely stent removal and culture guided antibiotic therapy to prevent infection related morbidity and optimise patient outcomes.

Limitation(s)

Being a single centre study with a relatively small sample size limits the generalisability of the findings. Molecular characterisation of resistance mechanisms was not performed restricting deeper insights into genetic mechanisms of antimicrobial resistance.

CONCLUSION(S)

The present study was one of the few from India to comprehensively analyse bacterial colonisation of DJ stents in relation to indwelling time and stent segment. The present study data support current recommendations to limit the duration of ureteral stenting to the minimum necessary. In the Indian context, delayed or forgotten stents are unfortunately encountered, which can lead to encrusted, infected stents with serious complications. The strong correlation between indwelling time and biofilm load in the present study reinforces the need for diligent follow-up systems to ensure timely stent removal. Whenever feasible, culture of the removed stent for pathogen identification is advisable, especially in high-risk patients or those who present with infection. Routine stent culture can guide targeted therapy in patients at risk for complicated UTI or sepsis. Finally, clinicians should be aware that empirical therapy for stent-associated infections should cover common colonisers like *E. coli* and

P. aeruginosa, and be guided by local resistance patterns. With the rising incidence of antimicrobial resistance in India, the present study findings underscore the importance of judicious stent management and tailored antimicrobial strategies to improve patient outcomes.

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