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Ureteral stent versus no ureteral stent for ureteroscopy in the management of renal and ureteral calculi: A Cochrane review

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Abstract

Introduction: We aimed to assess the effects of postoperative ureteral stent placement after uncomplicated ureteroscopy.
Methods: We performed a comprehensive search with no restrictions on publication language or status up to February 1, 2019. We only included randomized trials. Two review authors independently examined full-text reports, identified relevant studies, assessed the eligibility of studies for inclusion, extracted data, and assessed risk of bias. We performed statistical analyses using a random-effects model and assessed the certainty of the evidence according to GRADE.

Results: We included 23 studies with 2656 randomized patients. Primary outcomes: It is uncertain whether stenting reduces the number of unplanned return visits (very low CoE). Pain on the day of surgery is probably similar (mean difference [MD] 0.32; 95% confidence interval (CI) -0.13–0.78; moderate CoE). Pain on postoperative days 1–3 may show little to no difference (SMD 0.25; 95% CI -0.32–0.82; low CoE). It is uncertain whether stented patients experience more pain on postoperative days 4–30 (very low CoE). Stenting may result in little to no difference in the need for secondary interventions (relative risk [RR] 1.15; 95% CI 0.39–3.33; low CoE). Secondary outcomes: We are uncertain whether stenting reduces the need for narcotics and reduces ureteral stricture rates up to 90 days (very low CoE). Rates of hospital admission may be slightly reduced (RR 0.70; 95% CI 0.32–1.55; low CoE). This review was limited to patients in whom ureteroscopy was deemed 'uncomplicated.' In addition, time intervals for the grouping for the reported degree of pain were established post hoc. The CoE for most outcomes was rated as low or very low for methodological reasons.
Conclusions: Findings of this review illustrate the tradeoffs of risks and benefits faced by urologists and their patients when it comes to decision-making about stent placement after uncomplicated ureteroscopy for stone disease.

Introduction

Ureteral stents are commonly placed after ureteroscopy and are usually indicated in the setting of ureteral injury, severe edema and concerns over infection or renal failure. An international study found that stents are placed in 60% of patients after treatment for ureteral stones and in 80% of patients after treatment for renal stones.[1] Postoperative ureteral stenting is thought to decrease the risk of obstruction due to postoperative ureteral edema or small stone fragments. It is also thought to mitigate the effects of instrumentation and the sequelae of subsequent edema and to prevent ureteral stricture formation. Stents, however, also have downsides. Side effects from ureteral stent placement including urinary frequency and urgency, hematuria, dysuria, flank pain, and pelvic pain, are the most common source of postoperative morbidity.[2] These side effects can lead to office and emergency department visits. Meanwhile, omitting a stent may lead to further interventions and additional visits as well.[3]

Several systematic reviews have summarized the body of evidence on benefits and harms of placing a ureteral stent.[4-11] However, none has adhered to the methodological standards of Cochrane, including application of GRADE and generation of a 'Summary of findings' table. In this review we therefore assessed the effects of postoperative ureteral stent placement after uncomplicated ureteroscopy to help inform clinicians and guideline developers.

Methods

Search strategy and selection criteria

This systematic review and meta-analyses were based on published protocol.[12] We performed a comprehensive search using multiple database of the Cochrane Central Register of Controlled Trials in the Cochrane Library, MEDLINE Ovid and EMBASE Ovid and Western Pacific Region Index Medicus (Supplementary Table 1). We also searched the references of full articles retrieved for our review to identify any additional studies. To identify unpublished trials or trials in progress, we searched the following sources: ClinicalTrials.gov, the World Health Organization International Clinical Trials Registry Platform Search Portal (apps.who.int/trialsearch/). We hand searched relevant conference proceedings from 2013 to 2018, for unpublished studies from annual meetings of the American Urological Association, European Association of Urology, Société Internationale d'Urologie and World Congress of Endourology. Searches were initially performed on 19 January 2017 followed by an updated search on 1 February 2019. Three review authors (MO, MB, SG) independently screened all potentially relevant records and classified studies in accordance with the criteria for each provided in the Cochrane Handbook for Systematic Reviews of Interventions.[13] We search and reviewed randomized controlled trials (RCTs) only as they are likely to provide the highest quality evidence.

Types of participants

We included participants over the age of 18 who underwent ureteroscopy for stone clearance. We excluded studies conducted in children, pregnant women, patients with systemic signs of infection, patients with a solitary kidney, patients undergoing bilateral stone procedures, patients with anatomical abnormalities, and transplant patients. We excluded studies in which ureteroscopy was complicated by perforation of the ureter or gross bleeding.

Types of intervention

We compared ureteroscopy with stent placement vs ureteroscopy with no stent placement.

Types of outcomes measured

The primary outcomes of the review were unplanned return visits to the emergency/urgent care department, postoperative discomfort and secondary interventions. Secondary outcomes were the requirement for narcotics, urinary tract infection, operating room time, ureteral stricture, quality of life and postoperative hospital admission.

Assessment of risk of bias in included studies

Three review authors (MO, MB, SG) independently assessed the risk of bias of each included study on a per outcome basis. We resolved all disagreements by discussion and consensus. We

assessed risk of bias using the Cochrane 'Risk of bias' assessment tool. We judged risk of bias domains as 'low risk', 'high risk', or 'unclear risk' and evaluated individual bias items as described in the Cochrane Handbook for Systematic Reviews of Interventions.[13]

Data collection and data extraction

Data extraction was carried out independently by three review authors (MO, MB and SG) using data extraction forms created in Microsoft Excel and followed the domain-based risk of bias evaluation as described in the Cochrane Handbook for Systematic Reviews of Interventions.[13] We attempted to obtain numbers of events and totals for population for dichotomous outcomes and means with standard deviations (SDs) or data necessary to calculate this information for continuous outcomes. We summarized data using a random-effects model. We interpreted random-effects meta-analyses with due consideration of the whole distribution of effects. We planned to assess heterogeneity statistically with the I^2 statistic. I^2 values of 25%, 50% and 75% were considered low, moderate and high, respectively.[14] Tests for funnel plot asymmetry are generally only performed when at least 10 studies are included in the meta-analysis. We used Review Manager 5 software (The Cochrane Collaboration, Copenhagen, Denmark) to perform statistical analyses.

Subgroup and sensitivity analyses

We expected the following characteristics to introduce clinical heterogeneity, and we planned to carry out subgroup analyses with investigation of interactions.

- Patient age (40 or younger vs over 40 years of age).
- Patient gender (male vs female).
- Ureteroscope type (flexible vs semi-rigid).
- Stone location (renal vs proximal and mid vs distal ureteral)
- Stone size (≤ 5 mm vs 5 mm to 10 mm vs > 10 mm)
- Ureteral dilation including access sheath use or balloon dilation, or both (yes vs no)

We performed sensitivity analyses to explore the influence of the following factors (when applicable) on effect sizes.

- Restricting the analysis by taking into account the risk of bias, by excluding studies at 'high risk' or 'unclear risk'.
- Restricting the analysis to studies with a minimal stent duration of three days.

Summary of findings table

We presented the overall certainty of the evidence for each outcome according to GRADE, which accounts for five criteria not only related to internal validity (study limitations, inconsistency, imprecision, publication bias) but also to external validity such as directness of results.[15]

Results

Search results

Our comprehensive literature search identified 5,529 records. After removal of duplicates, we screened the titles and abstracts of 2,631 records and excluded 2,590. We screened 41 full-text articles and excluded 16 articles. In all, 14 studies did not meet the inclusion criteria or were not relevant to the question under question.[1, 11, 16-27] We identified one ongoing trial.[28] In all, 23 studies with 24 relevant articles (abstracts or secondary publications: not listed in the references) ultimately met the inclusion criteria and were included in the qualitative synthesis of this review.[29-51] The flow of literature through this assessment process is shown in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Figure 1).

Included studies

Detailed characteristics of included studies are summarized in Supplementary Table 2. We included 2656 randomized participants, of whom 2275 completed the trials. A total of 21 studies performed ureteral stenting after ureteroscopy as an intervention and used no stent placement, with URS as a comparator. El Harrech et al[38] and Wang et al[48] compared three groups (i.e. DJ stent placement vs ureteral stent placement vs no stent placement;[38] and DJ stent placement vs no stent placement vs sham (named 'control')[48]); therefore, we selected one pair of interventions to create a single pair-wise comparison (i.e. DJ stent placement vs no stent placement). Follow-up duration ranged two weeks to one year.

Two studies reported no funding source,[30, 33] and one reported the funding source.[37] The remaining trials did not mention a funding source. Three studies reported no conflicts of interest,[30, 33, 38] and one reported a conflict of interest.[37] The remaining studies did not mention conflicts of interest.

Risk of bias in included studies

Further details on the assessment of Risk of Bias were stated in the review published in Cochrane Library. Assessments of risk of bias are summarized in Figure 3.

Summary of findings tables

We summarized the results in summary of findings tables in accordance with GRADE methodology (Table 1).

Effect of the Intervention

1. Unplanned return visit to emergency/urgent care department

We included 16 studies with 1970 participants.[30, 32-38, 41, 42, 44-46, 48, 49, 51] Stent placement may reduce the number of unplanned return visits slightly (RR 0.69, 95% CI 0.40 to 1.21; very low

CoE) but we are very uncertain of this finding. The funnel plot shows asymmetry, thereby suggesting publication bias (Figure 2).

2. Postoperative discomfort

2.1 Postoperative day 0 (the day of surgery)
We included 4 studies with 346 participants.[31, 34, 46, 47] There is probably no difference in postoperative discomfort on postoperative day 0 between stented and unstented participants (MD 0.32, 95% CI -0.13 to 0.78; moderate CoE).

2.2 Postoperative days 1 to 3
We included 8 studies with 683 participants.[32, 35, 36, 38, 46-49] There may be no difference in postoperative discomfort on postoperative days 1 to 3 between stented and unstented participants (SMD 0.25, 95% CI -0.32 to 0.82; low CoE).

2.3. Postoperative days 4 to 30
We included 8 studies with 903 participants.[30, 32, 36-38, 42, 45, 49] Postoperative discomfort on postoperative days 4 to 30 may be greater in stented participants (SMD 0.62, 95% CI 0.08 to 1.16; very low CoE), but we are very uncertain of this finding.

3. Secondary interventions
We included 10 studies with 1435 participants.[30, 35-38, 41, 45, 46, 48, 49] There may be no difference in the number of secondary interventions between stented and unstented participants (RR 1.15, 95% CI 0.39 to 3.33; low CoE). The funnel plot shows symmetry, thereby giving no indication of publication bias (Supplementary Figure 1).

4. Narcotic requirement
In contrast to our protocol,[12] we analyzed this outcome to assess the number of participants who required narcotics, rather than average narcotic requirements in morphine equivalents, which was not reported in any of the studies. We included 7 studies with 830 participants.[29, 33, 36, 44, 46, 48, 49] Stent placement may reduce the need for narcotics (RR 0.80, 95% CI 0.48 to 1.36; very low CoE), but we are very uncertain of this finding.

5. Urinary tract infections
We included 10 studies with 1207 participants.[30, 35-38, 41, 45, 46, 48, 49] There is probably no difference in the number of urinary tract infections between stented and unstented participants (RR 0.94, 95% CI 0.59 to 1.51; moderate CoE). The funnel plot shows symmetry, thereby giving no indication of publication bias (Supplementary Figure 2).

6. Operating room time
We included 17 studies with 1981 participants.[29, 30, 33, 35-38, 41-49, 51] Placement of a stent probably increases operating room time slightly (MD 3.72 minutes, 95% CI 2.30 to 5.14 minutes; moderate CoE). The funnel plot provided no indication of clinically relevant publication bias (Supplementary Figure 3).

7. Ureteral stricture
We included 14 studies with 1625 participants.[30, 32, 33, 35-38, 41, 42, 45, 47-49, 51] Placement of a stent may slightly reduce the rate of ureteral stricture up to 90 days (RR 0.58, 95% CI 0.23 to 1.47; very low CoE), but we are very uncertain of this finding. The funnel plot thereby giving no indication of publication bias (Supplementary Figure 4).

8. Quality of life
We included only one study.[45] Quality of life may be reduced in stented participants (MD 2.9, 95% CI 2.52 to 3.28; low CoE).

9. Hospital admission
We included 13 studies with 1647 participants.[30-33, 36-38, 41, 42, 45, 46, 48, 51] The risk of postoperative hospital readmission may be slightly lower in stented patients (RR 0.70, 95% CI 0.32 to 1.55; very low CoE), but we are very uncertain of this finding. The funnel plot shows symmetry, thereby giving no indication of publication bias (Supplementary Figure 5).

Subgroup and sensitivity analyses
We were unable to conduct any preplanned subgroup or sensitivity analyses due to a lack of relevant data in the included studies.

Discussion
Findings of this systematic review indicate that we are very uncertain whether stenting may reduce the number of unplanned return visits to the hospital, the need for narcotics, ureteral stricture, and hospital readmission, given that these findings were based on very low CoE. Moderate to low CoE shows no difference in postoperative discomfort on the day of surgery (day 0) and in the early postoperative phase (days 1 to 3). Stented individuals may have more pain in the later postoperative phase (days 4 to 30), but we are once again very uncertain of this finding. There may also be no difference in the number of secondary interventions. With regard to other outcomes, rates of urinary tract infection are probably similar but quality of life may be better in unstented participants. Stenting probably increases operating room time slightly (by approximately 4 minutes), which appears of little clinical relevance.

Several other systematic reviews have been published on this topic. A systematic review by Tang et al which included 14 trials,[10] found that an increase in dysuria, frequency, and

hematuria in stented patients - outcomes that we did not deem of critical patient importance and that we did not investigate. However, effect estimates for the number of unplanned medical visits or hospital readmissions (risk ratio (RR) 0.60, 95% confidence interval (CI) 0.33 to 1.11) and for urinary tract infection (RR 1.20, 95% CI 0.62 to 2.32) showed similar results. Wang et al reported a systematic review of 22 RCTs but included among them three trials of shockwave lithotripsy (SWL),[11] which we perceived as sufficiently distinct as to not include in this review. This study also reported its findings as odds ratios. One of the main findings highlighted in the abstract results and conclusion was a reduced risk of unplanned readmissions (OR 0.63, 95% CI 0.41 to 0.97) in the stented group. However, these numbers do not correlate with those in the results section (OR 0.54, 95% CI 0.34 to 0.87), suggesting an error in the analysis. Moreover, our findings mainly differ in the (routine) choice of a random-effects model, which provides the more conservative effect size estimate. A fixed-effect model analysis of this outcome based on our data yields an RR of 0.60 (95% CI 0.37 to 0.96), which comes close to the reported odds ratio. In terms of the outcome of urinary tract infection, unlike our findings, they found that stenting increased urinary tract infection (OR 2.01, 95% CI 1.16 to 3.47), which may be attributable to the inclusion of two trials of SWL and one trial of patients with chronic inflammatory, bilharzial ureters.[21] Another recent review by Pais et al reported that 'unstented patients were significantly more likely to have an unplanned medical visit compared to those who received a post-ureteroscopy stent' (odds ratio (OR) 1.63, 95% CI 1.15 to 2.30).[7] These findings were based on a pooled analysis of randomized and non-randomized studies. Included observational studies favored the unstented group, whereas randomized controlled trials (RCTs) favored the stented group; the test of interaction was significant ($p = 0.04$), thereby questioning the appropriateness of pooling. However, although it did not provide a formal quality of evidence rating by outcome, as we do, this review stands out for its thoughtful and detailed discussion of biases that may have affected the included studies which are equally relevant to findings of our review. None of the existing systematic reviews provided a certainty of evidence rating, which we consider critical to any systematic review.

Our review has limitations. First, all included studies excluded participants in whom ureteroscopy was complicated in some manner, thereby compelling urologists to place a ureteral stent. The summarized body of evidence therefore applies only to 'uncomplicated' ureteroscopy; however, definitions of what that constitutes vary. Whereas post ureteroscopic lesion scales have been developed,[52, 53] they have not found widespread use. Second, included studies reported participants' degree of pain at different time points. To provide meaningful summary data that might be helpful for clinicians and patients, we grouped available data by three time periods of postoperative day 0, days 1 through 3, and days 4 through 30. These categories we established with input by expert clinicians after the protocol was written and the data were abstracted, but before any quantitative analysis was performed. Nevertheless, findings for these outcomes are

potentially sensitive to the specific time ranges we chose, and this may be viewed as a potential source of bias.

Findings of the review raise questions over the gap between current best evidence as reflected by this review and contemporary clinical practice with most patients receiving a stent. Muslumanoglu et al reported the results of the Clinical Research Office of Endourological Society (CROES) Ureteroscopy Global Study Cohort and found stenting rates of approximately 80% for renal stones and 60% for ureteral stones, with overall variation from 29% to 96% across countries.[1] Reported stenting rates in the United States were 93%.[1] There appears to be an important research need to better understand this discrepancy. Moreover, given the low-quality evidence that characterizes most of the reported analyses and the complex trade-offs involved in deciding whether or not to place a stent after uncomplicated ureteroscopy, more research on shared decision-making in this setting appears important.

Conflict of interest

Maria Ordonez; Eu Chang Hwang; Caitlin J Bakker; Shreyas Gandhi; Philipp Dahm: None
Michael Borofsky: Boston Scientific (consultant for endourology and stone management), Auris Health (consultant for robotic surgery and endourology).

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Figures and Tables

Fig, 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart.

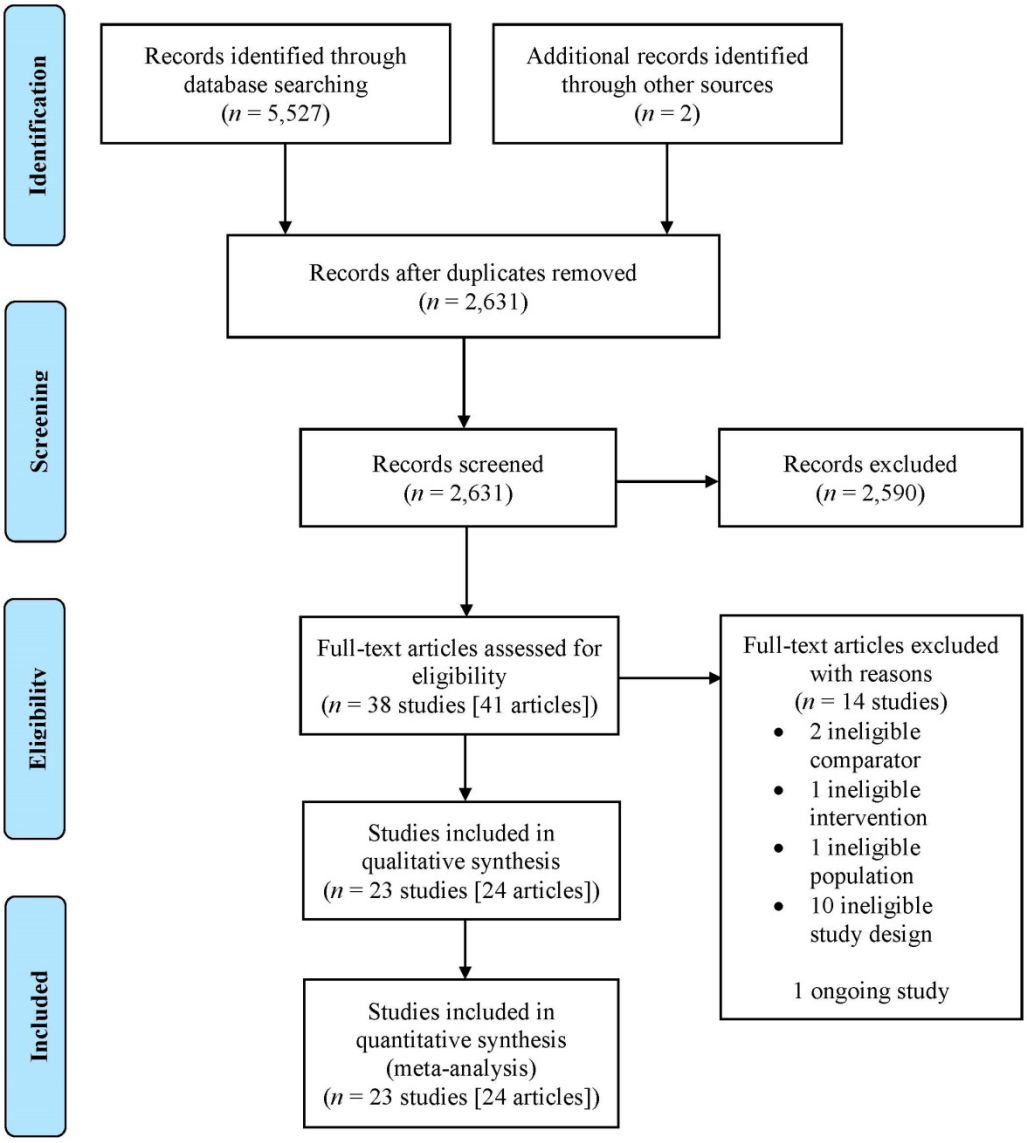


Fig. 2. Funnel plot of unplanned return visit to emergency/urgent care department.

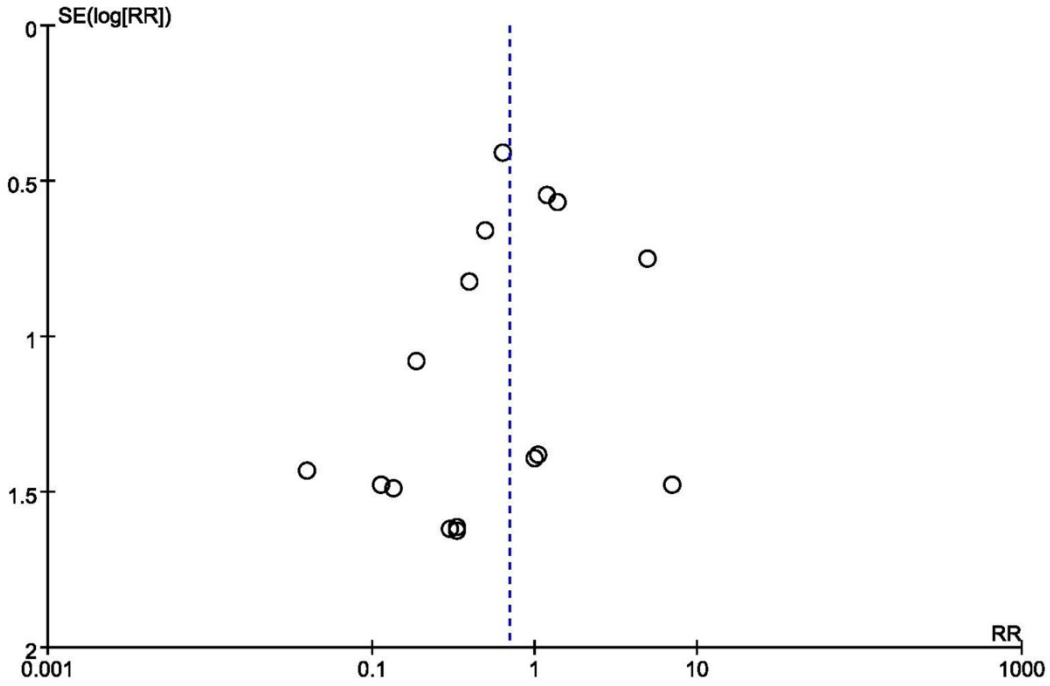


Fig. 3. Summary of risk of bias assessment.

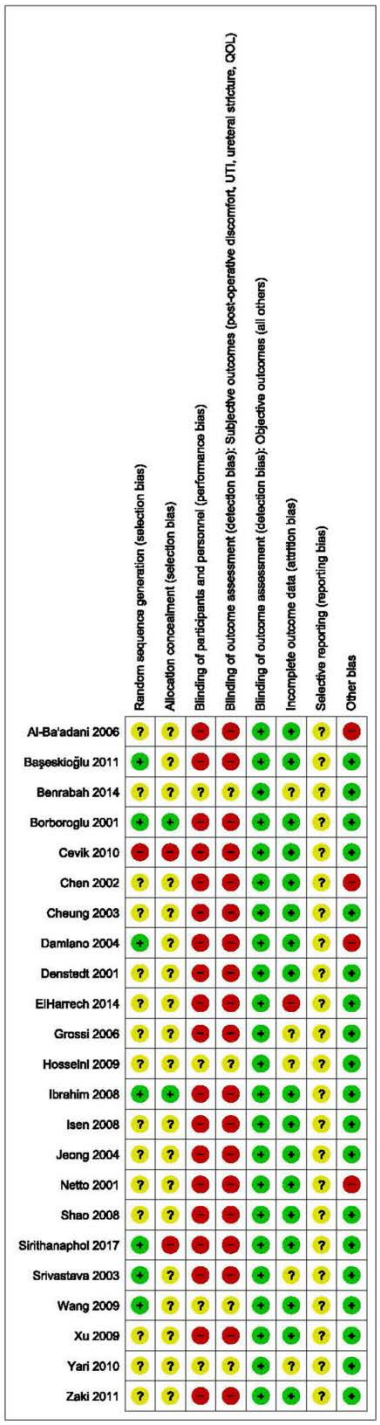


Table 1. Stent vs no stent for ureteroscopy in the management of renal and ureteral calculi.

Patient or population: participants underwent ureteroscopy due to renal and ureteral calculi
Setting: inpatient or outpatient
Intervention: stent placement
Comparison: no stent placement

Outcomes	**No. of participants (studies)**	**Certainty of the evidence (GRADE)**	**Relative effect (95% CI)**	**Anticipated absolute effects***	
				Risk with URS with no stent placement	**Risk difference with URS with stent placement**
Unplanned return visit to emergency/urgent care department Followup: 2 weeks to 49 months	1970 (16 RCTs)	⊕◯◯◯ Very low[a,b,c]	RR 0.69 (0.40–1.21)	67 per 1000	21 fewer per 1000 (40 fewer to 14 more)
Postoperative pain day 0 Assessed with visual analogue scale (range 0–10): 4 studies	346 (4 RCTs)	⊕⊕⊕◯ Moderate[a]	-	The mean postoperative pain day 0 ranged from 2.3–4.82	MD 0.32 higher (0.13 lower to 0.78 higher)
Postoperative pain day 1 to day 3 Assessed with visual analogue scale (range 0–10): 7 studies; pain questionnaire (range 0–100): 1 study	683 (8 RCTs)	⊕⊕◯◯ Low[a,d,e]	-	-	SMD 0.25 SD higher (0.32 lower to 0.82 higher)
Postoperative pain day 4 to day 30 Assessed with visual analogue scale (range 0–10): 5 studies; pain questionnaire (range 0–100): 1 study; other: 2 studies	903 (8 RCTs)	⊕◯◯◯ Very low[a,b,d]	-	-	SMD 0.62 SD higher (0.08 higher to 1.16 higher)

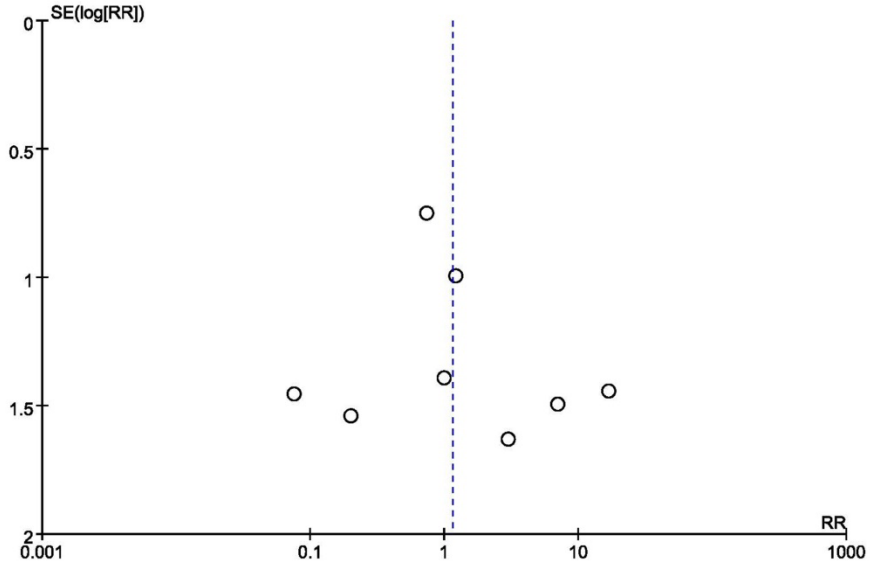
Secondary interventions Follow up: 1 month to 49 months	1435 (10 RCTs)	⊕⊕◯◯ Low[a,f]	RR 1.15 (0.39–3.33)	21 per 1000	3 more per 1000 (13 fewer to 48 more)
Narcotic requirement Follow up: 2 weeks to 6 months	830 (7 RCTs)	⊕◯◯◯ Very low[a,d,f]	RR 0.80 (0.48–1.36)	207 per 1000	41 fewer per 1000 (108 fewer to 75 more)
UTI (positive urine culture as well as symptoms) up to 90 days	1207 (10 RCTs)	⊕⊕⊕◯ Moderate[a]	RR 0.94 (0.59–1.51)	57 per 1,000	3 fewer per 1,000 (23 fewer to 29 more)
Ureteral stricture up to 90 days	1625 (14 RCTs)	⊕◯◯◯ Very low [a,b]	RR 0.58 (0.23–1.47)	15 per 1000	6 fewer per 1000 (11 fewer to 7 more)
Hospital admission Follow up: 2 weeks to 49 months	1647 (13 RCTs)	⊕◯◯◯ Very low [a,b]	RR 0.70 (0.32–1.55)	49 per 1000	15 fewer per 1000 (33 fewer to 27 more)
GRADE Working Group grades of evidence High certainty: We are very confident that the true effect lies close to that of the estimate of the effect Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect					

[a]Downgraded by one level for study limitations mainly due to concerns about performance bias across studies. [b]Downgraded by two levels for imprecision: wide confidence interval. [c]Downgraded by one level for publication bias: funnel plot asymmetry. [d]Downgraded by one level for inconsistency: clinically relevant heterogeneity. [e]We did not downgrade for imprecision, because it resulted from inconsistency. [f]Downgraded by one level for imprecision: confidence interval crosses the line of no difference and the assumed threshold of a clinically important difference. [*]The risk in the intervention group (and its 95% confidence interval) is

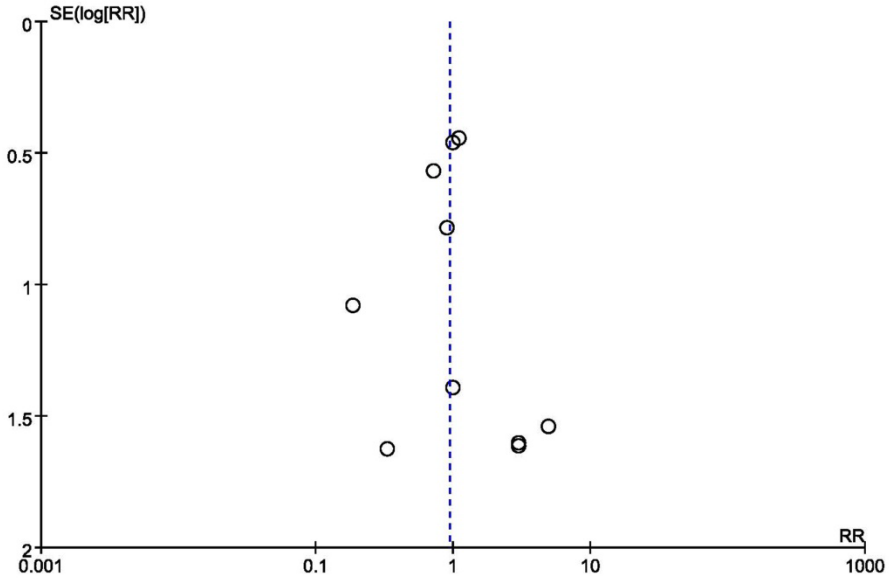
based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI). CI: confidence interval; MD: mean difference; RCTs: randomized controlled trials; RR: risk ratio; SMD: standardized mean difference.

Supplementary Figures and Tables

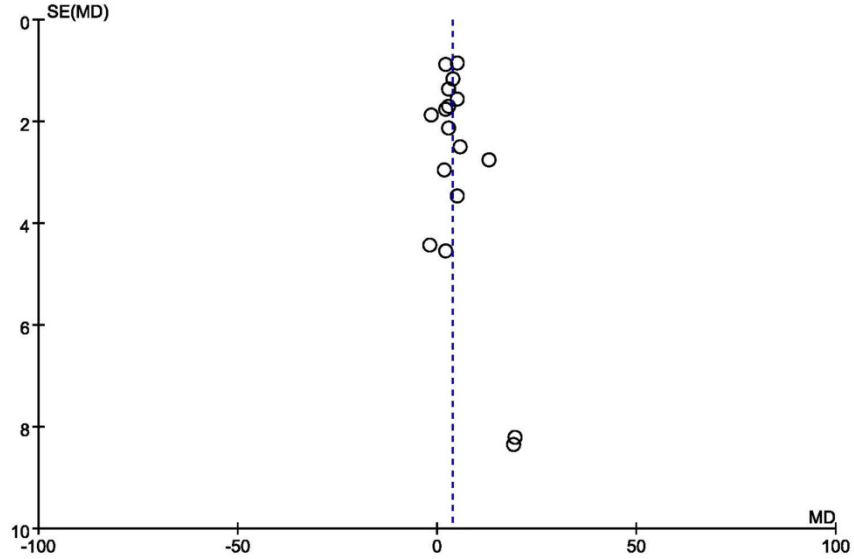
Supplementary Fig. 1. Funnel plot of secondary interventions.



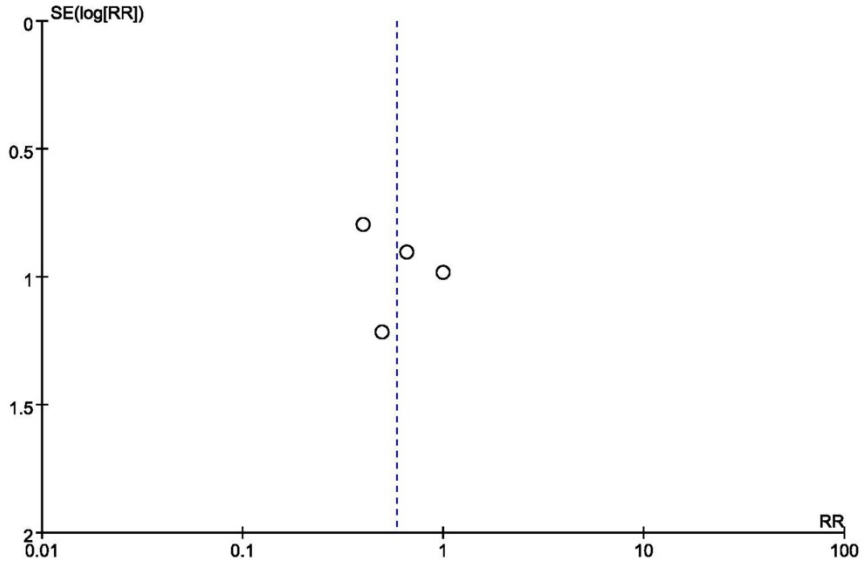
Supplementary Fig. 2. Funnel plot of urinary tract infection.



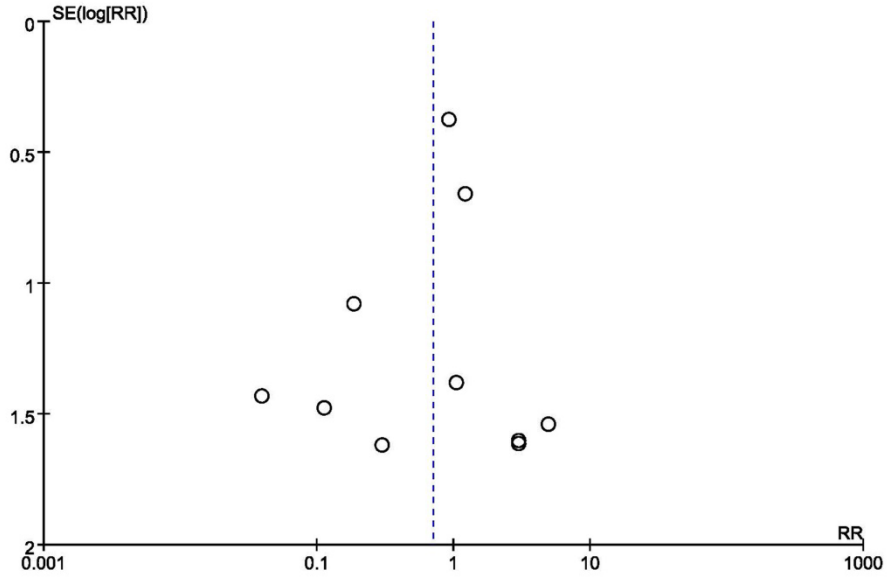
Supplementary Fig. 3. Funnel plot of operating room time.



Supplementary Fig. 4. Funnel plot of ureteral stricture.



Supplementary Fig. 5. Funnel plot of hospital admission.



Supplementary Table 1. Search strategies	
Database	**Search terms**
Cochrane Library via Wiley	1. MeSH descriptor: [Nephrolithiasis] explode all trees 2. MeSH descriptor: [Kidney Calculi] explode all trees 3. MeSH descriptor: [Ureterolithiasis] explode all trees 4. MeSH descriptor: [Urolithiasis] explode all trees 5. MeSH descriptor: [Ureteral Calculi] explode all trees 6. MeSH descriptor: [Urinary Calculi] explode all trees 7. ("Kidney Calculi" or "Kidney Calculus" or "Kidney Stones" or "Kidney Stone" or "Renal Calculus" or "Renal Calculi" or Nephrolith or Nephrolithasis or "Staghorn Calculi" or "Staghorn Calculus" or "Ureteral Calculus" or "Ureteral Calculi" or "Urinary Calculi" or "Urinary Calculus" or "Urinary Lithiasis" or "Calyceal calculi" or calyces or "ureteric calculi" or "ureteric calculus" or "bladder stone" or "bladder stones" or "ureter stone" or "ureter stones" or ureterolithiasis or urolithiasis):ti,ab,kw (Word variations have been searched) 8. #1 or #2 or #3 or #4 or #5 or #6 or #7 9. MeSH descriptor: [Ureteroscopy] explode all trees 10. (Ureteroscop* or "Ureteroscopic Surgical Procedure*" or "Ureteroscopic Surgery" or "Ureteroscopic Surgeries" or pyeloureteroscopy or ureteropyeloscopy):ti,ab,kw (Word variations have been searched) 11. #9 or #10 12. MeSH descriptor: [Stents] explode all trees 13. (stent* or "non-stent*" or unstent* or nonstent*):ti,ab,kw (Word variations have been searched) 14. #12 or #13

	15. #8 and #11 and #14 16. MeSH descriptor: [Adult] explode all trees 17. MeSH descriptor: [Child] explode all trees 18. MeSH descriptor: [Adolescent] explode all trees 19. MeSH descriptor: [Infant] explode all trees 20. #17 OR #18 OR #19 21. #20 NOT #16 22. #15 NOT #21 23. MeSH descriptor: [Animals] explode all trees 24. MeSH descriptor: [Humans] explode all trees 25. #23 NOT #24 26. #22 NOT #25
MEDLINE (via OVID) search strategy	1. exp Nephrolithiasis/ 2. exp Kidney Calculi/ 3. exp Ureterolithiasis/ 4. exp Urolithiasis/ 5. exp Ureteral Calculi/ 6. exp Urinary Calculi/ 7. ("Kidney Calculi" or "Kidney Calculus" or "Kidney Stones" or "Kidney Stone" or "Renal Calculus" or "Renal Calculi" or Nephrolith or Nephrolithasis or "Staghorn Calculi" or "Staghorn Calculus" or "Ureteral Calculus" or "Ureteral Calculi" or "Urinary Calculi" or "Urinary Calculus" or "Urinary Lithiasis" or "Calyceal calculi" or calyces or "ureteric calculi" or "ureteric calculus" or "bladder stone" OR "bladder stones" OR "ureter stone" OR "ureter stones" OR ureterolithiasis OR urolithiasis).tw 8. OR/1-7 9. exp Ureteroscopy/ 10. (Ureteroscop* or "Ureteroscopic Surgical Procedure*" or "Ureteroscopic Surgery" or "Ureteroscopic Surgeries" OR

	pyeloureteroscopy OR ureteropyeloscopy).tw 11. OR/9-10 12. exp Stents/ 13. (stent* or "non-stent*" or unstent* or nonstent*).tw. 14. OR/12-13 15. 8 AND 11 AND 14 16. exp Adult/ 17. exp Child/ 18. Adolescent/ 19. exp Infant/ 20. OR/17-19 21. 20 NOT 16 22. 15 NOT 21 23. exp Animals/ 24. Humans/ 25. 23 NOT 24 26. 22 NOT 25
Embase (via OVID)	1. exp urolithiasis/ 2. ("Kidney Calculi" or "Kidney Calculus" or "Kidney Stones" or "Kidney Stone" or "Renal Calculus" or "Renal Calculi" or Nephrolith or Nephrolithasis or "Staghorn Calculi" or "Staghorn Calculus" or "Ureteral Calculus" or "Ureteral Calculi" or "Urinary Calculi" or "Urinary Calculus" or "Urinary Lithiasis" or "Calyceal calculi" or calyces or "ureteric calculi" or "ureteric calculus" or "bladder stone" OR "bladder stones" OR "ureter stone" OR "ureter stones" OR ureterolithiasis OR urolithiasis).tw 3. OR/1-2 4. exp Ureteroscopy/ 5. (Ureteroscop* or "Ureteroscopic Surgical Procedure*" or "Ureteroscopic Surgery" or "Ureteroscopic Surgeries" OR

	pyeloureteroscopy OR ureteropyeloscopy).tw 6. OR/4-5 7. exp stent/ 8. exp urologic stent/ 9. exp ureter stent/ 10. (stent* or "non-stent*" or unstent* or nonstent*).tw 11. OR/7-10 12. 3 AND 6 AND 11 13. exp adult/ 14. exp child/ 15. exp adolescent/ 16. OR/14-15 17. 16 NOT 13 18. 12 NOT 17 19. exp animals/ 20. exp humans/ 21. 19 NOT 20 22. 18 NOT 21

Supplementary Table 2. Baseline characteristics of the included studies

Study name	Trial period (year to year)	Setting/ Country	Description of participants	Stent type	Intervention(s) and comparator(s)	Duration of follow-up	Age (years)	Stone location (N)	Mean stone size (mm, mean ± SD)
Al Ba'dani et al[29]	2004–2005	Single-center/ Yemen	Participants with ureteral calculi	Ureteral stent (n=30), DJ stent (n=10); all: 6 Fr stent (length: NR)	Stent placement	(likely) 4 weeks	34.4± 13.4	Upper 0/mid 10/distal 30	9.9±3.2
					No stent placement		34.4± 15.5	Upper 1/mid 4/distal 30	8.4±3.1
Başeskioğlu et al[30]	2005–2010	Single-center/ Turkey	Adult participants undergoing ureteroscopy for ureteral calculi requiring ureteral dilation	NR	Stent placement	1 year	45.4± 15.9	Upper 6/mid 30/distal108	12.2±4.9
					No stent placement		45.2± 16.49	Upper 10/mid 23/distal 109	11.4±3.75

Benrabah[31]	NR	Single-center/ Algeria	Participants successfully treated with ureteroscopy for distal ureteral calculi	DJ sent, NR Fr (length: NR)	Stent placement	NR	NR	Distal 100	NR
					No stent placement		NR	Distal 100	NR
Borboroglu et al[32]	1998–2001	Multi-center/ USA	18 years or older and had distal ureteral calculi amenable to ureteroscopic management	(likely) DJ stent, 6 Fr stent (length determined by the surgeon)	Stent placement	4 weeks	39.8± 13.7	NR	6.5±1.5
					No stent placement		42.5± 14.6	NR	6.6±1.8
Cevik et al[33]	2005–2007	Multi-center/ Turkey	Participants with impacted ureteral stones	DJ stent, 4.8 Fr stent (length: NR)	Stent placement	3 months	44.1± 15.2	Mid 8/distal 22	9.1±4.5
					No stent placement		46.5± 12.5	Mid 7/distal 23	7.5±2.1

Chen et al[34]	2000	Single-center/ Taiwan	Participants scheduled for ureteroscopic lithotripsy with stone 6–10 mm, absence of polyp or stricture in the ureter, and no mucosal injury or perforation during operation	DJ stent, 7 Fr (length: NR)	Stent placement	4 weeks	44.6± 10.5	Upper 4/mid 2/distal 24	6.26±1.39
					No stent placement		38.8±1.8	Upper 4/mid 2/distal 24	6.17±1.44
Cheung et al[35]	2001–2002	Single-center/ Hong Kong	Participants with unilateral ureteral stones, irrespective of stone burden, location and severity of obstruction	DJ stent, 6 Fr (24 or 26 cm)	Stent placement	3 months	51.2 ± 15.3	Upper 6/mid 2/distal 21	9.8 ± 3.7
					No stent placement		53.1± 13.0	Upper 12/mid 5/distal 12	9.6±4.7
Damiano et al[36]	2000–2002	Multi-center/ Italy	Ureteroscopy for treatment of ureteral lithiasis,	DJ stent, 4.8 Fr to 6 Fr (length:	Stent placement	6 months	44±16	Upper 7/mid 14/distal 31	11±0.9

			absence of polyp suggestive of urothelial cancer, no evidence of stricture, no mucosal perforation during the operation	NR)	No stent placement		43±14	Upper 9/mid 15/distal 28	10±1.2
Denstedt et al[37]	NR	Multi-center/ Canada	Adults 18 years or older scheduled for ureteroscopy for ureteral calculus	DJ stent, NR Fr (length: NR)	Stent placement	12 weeks	49±15	Upper 4/mid 5/distal 20	NR
					No stent placement		54±15	Upper 3/mid 3/distal 23	NR
El Harrech et al[38]	2009–2011	Single-center/ Morocco	Participants treated with successful ureteroscopy for distal ureteral stones	Ureteral stent (n=37), DJ stent (n=42); all: 7 Fr (length: NR)	Double J stent placement	Minimum 3 months (mean 12 months)	44.1± 12.5	NR	8.6±3.4
					Ureteral stent placement		39.6± 11.3	NR	10.1±2.7

					No stent placement		43.2±14	NR	9.6±3.4
Grossi et al[39]	2000–2001	Multi-center/ Italy	Participants with ureteral stones amenable to endoscopic treatment by ureterorenoscopy	DJ stent, 6 Fr (length: NR)	Stent placement	6 months	48±12 (total)	Total only; upper 8/mid 21/distal 27	9.17 x 6.91 (total)
					No stent placement				
Hosseini et al[40]	NR	Single-center/ Iran	20–54 years old with mid/distal ureteral calculi ≤10 mm	Ureteral stent 5 Fr (length: NR)	Stent placement	NR	NR	NR	NR
					No stent placement		NR	NR	NR
Ibrahim et al[41]	2004–2006	Multi-center/ Kuwait and Egypt	Distal ureteric stone (defined as below iliac vessels on	(likely) DJ stent; 6 Fr (length	Stent placement	49 months	39±11	NR	12.4±2.9

			imaging) amenable to ureteroscopic management - age over 18	determined by the surgeon)	No stent placement		36±9	NR	13.3±3.3
Isen et al[42]	2004–2007	Single-center/ Turkey	Lower ureteral stone larger than 1 cm who underwent ureteroscopic lithotripsy (stone was localized below the inferior part of the sacroiliac joint)	DJ stent, 4.8 Fr (length: NR)	Stent placement	3 months	35.28± 9.0	NR	13.28±2.5
					No stent placement		36.09± 9.7	NR	12.90±2.4
Jeong et al[43]	2000–2001	Single-center/ South Korea	Participants with ureteric calculi treated by ureteroscopic lithotripsy	DJ stent, 7 Fr (length: NR)	Stent placement	4 weeks	50.5± 12.6	Upper 4/mid 2/distal 17	7.1±2.9
					No stent placement		42.9± 12.6	Upper 1/mid 0/distal 21	5.3±2.9

Netto et al[44]	1997–2000	Single-center/ Brazil	Participants underwent rigid ureteroscopy for ureteral calculi	NR	Stent placement	Minimum 3 months (median 12 months)	65±9.5	Upper 10/mid 20/distal 103	8.4±3.5
					No stent placement		39±9.6	Upper 8/mid 20/distal 134	10.3±9.4
Shao et al[45]	2005–2006	Single-center/ China	Participants with distal or middle ureteral calculi smaller than 2 cm were performed by ureteroscopic holmium laser lithotripsy	DJ stent, 4.8 Fr (26 cm)	Stent placement	12 weeks	47.0± 10.9	Mid 16/distal 42	9.5±2.5
					No stent placement		45.3± 13.2	Mid 12/distal 45	9.3±2.4
Sirithanaphol et al[46]	2014	Single-center/ Thailand	18 years or older, flexible ureteroscopy to do retrograde intrarenal stone surgery (RIRS), to do ureterolithotri	(likely) DJ stent, NR Fr (length: NR)	Stent placement	(likely) 2 weeks	45.8± 12.2	NR	NR
					No stent placement		50.1± 10.3	NR	NR

			psy in upper ureter (URSL), and to manage upper urinary tract tumour						
Srivastava et al[47]	2000–2002	Single-centre/ India	Participants were scheduled for ureteroscopy for distal ureteral stone (below the sacroiliac joint)	DJ stent, 6 Fr (26 cm)	Stent placement	3 months	36.12± 10.66	NR	7.58±1.92
					No stent placement		32.05± 8.49	NR	7.82±1.53
Wang et al[48]	2004–2007	Single-center/ Taiwan	Adult patients were included if they were scheduled for ureteroscopy for ureteral stones	DJ stent, 7 Fr (length used by body height)	Stent placement	12 weeks	54.3± 8.3	Upper 9/mid 26/distal 36	10.1
					No stent placement		54.6± 13.5	Upper 6/mid 22/distal 39	9.9
					Control		59.7± 10.3	Upper 8/mid 30/distal 52	10.1

Xu et al[49]	2005–2006	Single-center/ China	Adults, 18 years or older, were considered eligible for the study if they were scheduled for ureteroscopy for distal and middle ureteral calculi	DJ stent, 4.8 Fr (26 cm)	Stent placement	3 months	38.69± 6.00	Mid 9 distal 46	11.19±2.11
					No stent placement		40.04± 5.15	Mid 11 distal 44	11.46±2.24
Yari et al[50]	2006–2007	Single-center/Iran	Participants with distal ureteral calculi amenable to ureteroscopic stone removal	NR	Stent placement	NR	NR	NR	NR
					No stent placement		NR	NR	NR
Zaki et al[51]	2008–2010	Single-center/ Pakistan	Participants underwent uncomplicated	DJ stent, 6 Fr (25 cm)	Stent placement	3 months	41±7.8	NR	9±1.3

			ureteroscopic stone disintegration in ureteric stones irrespective of size and site		No stent placement		45±7.3	NR	10±1.6

DJ: double J; Fr: 1 French (Fr), equivalent to 0.33 mm of diameter; NR: not reported.