Urologia Internationalis

Original Paper

Urol Int 2021;105:64–70
DOI: 10.1159/000506716

Received: January 19, 2020
Accepted: February 17, 2020
Published online: November 23, 2020

Comparison of Retrograde Intrarenal Surgery and Micro-Percutaneous Nephrolithotomy for Kidney Stones: A Meta-Analysis

Zhenhua Gu[a] Yucheng Yang[a] Rui Ding[a] Meili Wang[a] Jianming Pu[b] Jian Chen[a]

[a]Department of Urology, Wuxi Traditional Chinese Medicine Hospital, Wuxi, China; [b]Department of Urology, Changshu Hospital Affiliated to Nanjing University of Chinese Medicine, Changshu, China

Keywords
Micro-percutaneous nephrolithotomy · Retrograde intrarenal surgery · Kidney stones · Meta-analysis

Abstract
Background: Advances in micro-percutaneous nephrolithotomy (PCNL) for kidney stones have made it an alternative approach to the retrograde intrarenal surgery (RIRS) approach. Nevertheless, the superiority of micro-PCNL over RIRS is still under debate. The results are controversial. ***Objectives:*** The purpose of this study was to systematically evaluate the clinical results in patients presenting with kidney stones treated with micro-PCNL or RIRS. ***Methods:*** A literature search was done for electronic databases to identify researches that compared micro-PCNL and RIRS till December 2019. The clinical outcome included complications, stone-free rates (SFRs), hemoglobin reduction, length of hospital stay, and operative time. ***Results:*** Five articles were included in our study. The pooled results revealed no statistical difference in the rate of complications (OR = 0.99, 95% CI = 0.57–1.74, $p = 0.99$), length of hospital stay (MD = −0.29, 95% CI = −0.82 to 0.24, $p = 0.28$), and operative time (MD = −6.63, 95% CI = −27.34 to 14.08, $p = 0.53$) between the 2 groups. However, significant difference was present in hemoglobin reduction (MD = −0.43, 95% CI = −0.55 to 0.30, $p < 0.001$) and the SFRs (OR = 0.59, 95% CI = 0.36–0.98, $p = 0.04$) when comparing RIRS with micro-PCNL. ***Conclusions:*** Compared with micro-PCNL to treat kidney stones, RIRS is associated with better stone clearance and bearing higher hemoglobin loss. As the advantages of both technologies have been shown in some fields, the continuation of well-designed clinical trials may be necessary.

Introduction

Kidney stone diseases are one of the most common health problems with the increasing occurrence rate worldwide [1]. The therapy choices for renal calculi include shock wave lithotripsy (SWL), percutaneous nephrolithotomy (PCNL), and retrograde intrarenal surgery (RIRS) [2].

RIRS is currently accepted as the established therapy for the management of lower calyceal stones. Flexible ureterorenoscopy (F-URS), referred to as RIRS, was firstly recommended as a diagnostic modality. The develop-

karger@karger.com
www.karger.com/uin

Jian Chen
Department of Urology, Wuxi Traditional Chinese Medicine Hospital
No. 8 Zhongnan West Road, Binhu District
Wuxi 214071 (China)
chenjian2115@sina.com

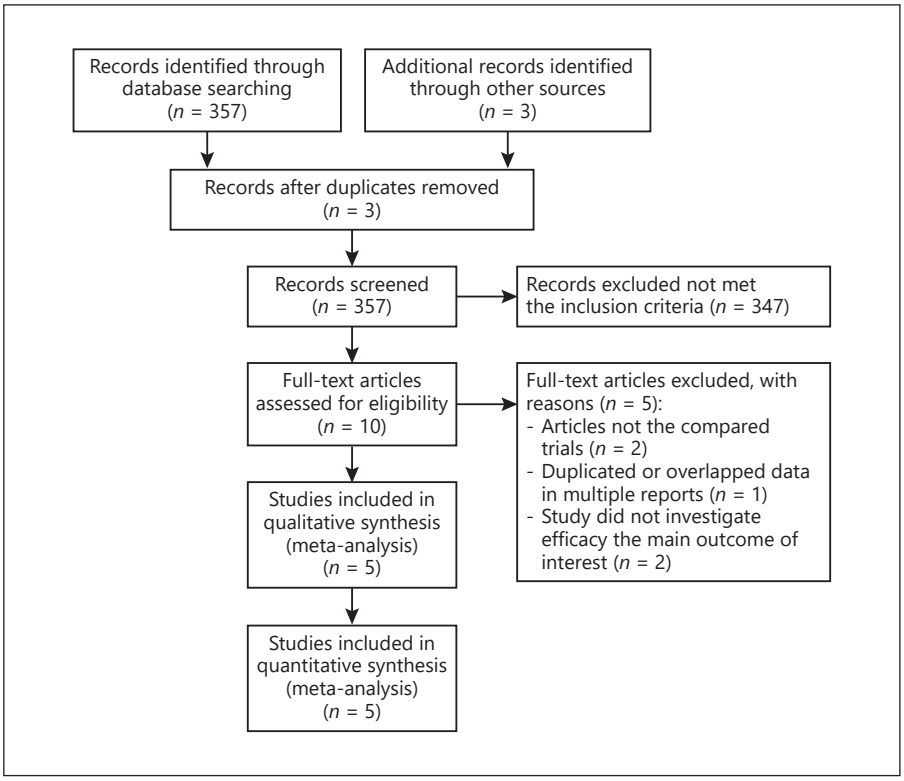

Fig. 1. The PRISMA flowchart of the selection process to identify studies eligible for pooling.

ments in optical systems and availability of the Ho/YAG laser are increasing, which have rendered F-URS an acceptable treatment of choice for kidney stones [3]. Meanwhile, each technique has its advantages and disadvantages. For lower calyceal stones, deflection problems are encountered when inserting the endoscope into the lower calyx, which may have influence on the utility of F-URS [4].

The first pediatric PNL procedure was performed by Fernstrom and Johansson in 1976 [5]. By now, this technique has become a standard therapy for upper urinary calculi with a diameter >2 cm or refractory to SWL [6]. The most important step of PCNL procedure, which has association with the complication rates, is performing a best access to the collection system [7]. Recently, the introduction of the new microperc technique to PCNL has minimized tract size and improved both the optical system and the instrumentation [8].

Although RIRS has a superior stone-free rate (SFR), the rate is lower than that of PCNL [9]; however, PCNL is related to a high risk of morbidity [10]. Previous trials have been conducted to assess stone clearance rate and safety for treatment of lower calyceal stones by micro-PCNL and RIRS. The main limitations of these previous studies were the smaller sample size, the various classifications of targeted stone size, and the definition of success [11, 12]. Therefore, the purpose of our study was to conduct a meta-analysis to assess the true benefits of RIRS versus micro-PCNL for kidney stones.

Methods

Search Strategy

PubMed and Embase databases were searched to identify studies. Two interviewers separately conducted the systematic search up to December 2019. The process was established to find all articles with the keywords and Medical Subject Heading (MeSH) terms: "micro-percutaneous nephrolithotomy" "retrograde intrarenal surgery" "flexible ureterorenoscopy" and "kidney stones." The references of eligible studies were checked for additional studies, which were found in the literature search.

Eligibility Criteria

The following inclusion criteria should be met: (1) the studies comparing micro-PCNL versus RIRS; (2) studies of patients with kidney stones, who underwent treatment; (3) the reported data included surgery-related outcomes and postoperative specimens for both 2 groups; and (4) the original studies and the full-text literature with most complete information provide complete data were only included.

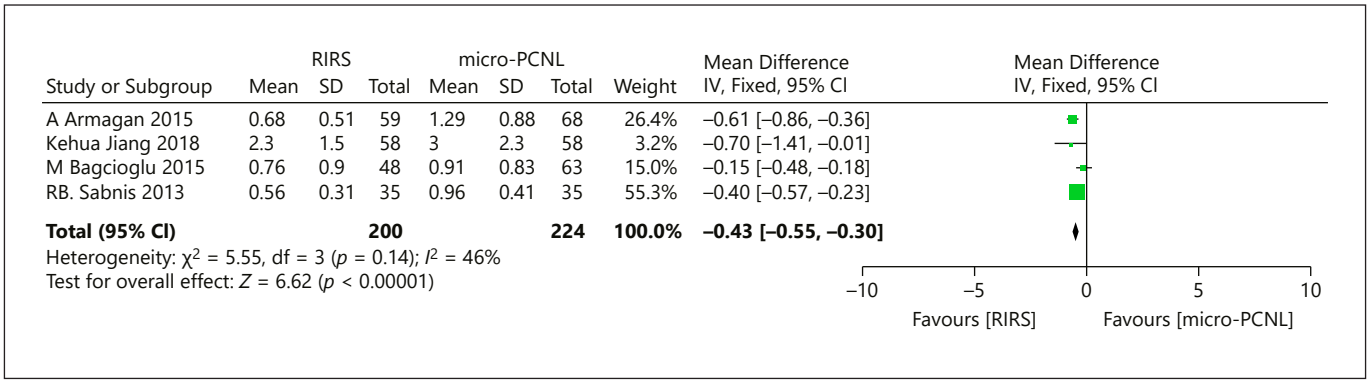

Fig. 2. Pooled analysis of hemoglobin reduction. RIRS, retrograde intrarenal surgery; micro-PCNL, micro-percutaneous nephrolithotomy.

Table 1. Baseline data for included studies

Study	Publication year	Sample size		Age		Mean stone size, mm	
		RIRS	micro-PCNL	RIRS	micro-PCNL	RIRS	micro-PCNL
Sabnis et al. [15]	2013	35	35	43.7	38.6	10.4	11
Armagan et al. [16]	2015	58	68	49.3	43.6	14.4	13.7
Bagcioglu et al. [17]	2015	48	63	38.5	41.5	14.6	17.7
Bas et al. [18]	2016	36	45	8.39	5.62	12.8	13.97
Jiang et al. [19]	2018	58	58	45.4	43.4	15.2	16.1

RIRS, retrograde intrarenal surgery; micro-PCNL, micro-percutaneous nephrolithotomy.

Quality Assessment

Two authors independently rated the quality of the included articles. The Newcastle-Ottawa Quality assessment scale was used to study the quality of the articles.

Data Extraction

Two investigators independently extracted main categories. A third researcher was asked to help resolve disagreement through discussion. The contents include first author, the year of publication, number of recruited participants, mean age, mean stone size (mm), and the endpoints of interested outcomes.

Statistical Analysis

The Review Manager version 5.3 software (RevMan; The Cochrane Collaboration, Oxford, UK) was conducted for statistical analysis. Heterogeneity across articles was examined using the I^2 statistic [13]. Articles with an $I^2 \geq 50\%$ was considered to have moderate and high degree of heterogeneity, and $I^2 < 50\%$ was considered to indicate low heterogeneity [14]. The random-effects model was used if $I^2 > 50\%$; otherwise, the fixed-effect model was adopted. $p < 0.05$ was considered as statistically significantly different.

Results

Study Selection

Totally, 357 articles were initially searched out after primary selection. Relying on the criteria described in the Methods, 5 studies were assessed for eligibility in this meta-analysis [15–19]. The selection process for identifying eligible studies is shown in Figure 1, and Table 1 shows the statistical baseline data.

Synthesis of Outcomes

Pooled Analysis of Hemoglobin Reduction

The pooled data showed that RIRS was associated with a higher hemoglobin loss (MD = −0.43, 95% CI = −0.55 to 0.30, $p < 0.001$) than the micro-PCNL group (Fig. 2).

Pooled Analysis of SFR

The pooled data revealed that the RIRS group did achieve advantage in terms of SFR (OR = 0.59, 95% CI = 0.36–0.98, $p = 0.04$) (Fig. 3).

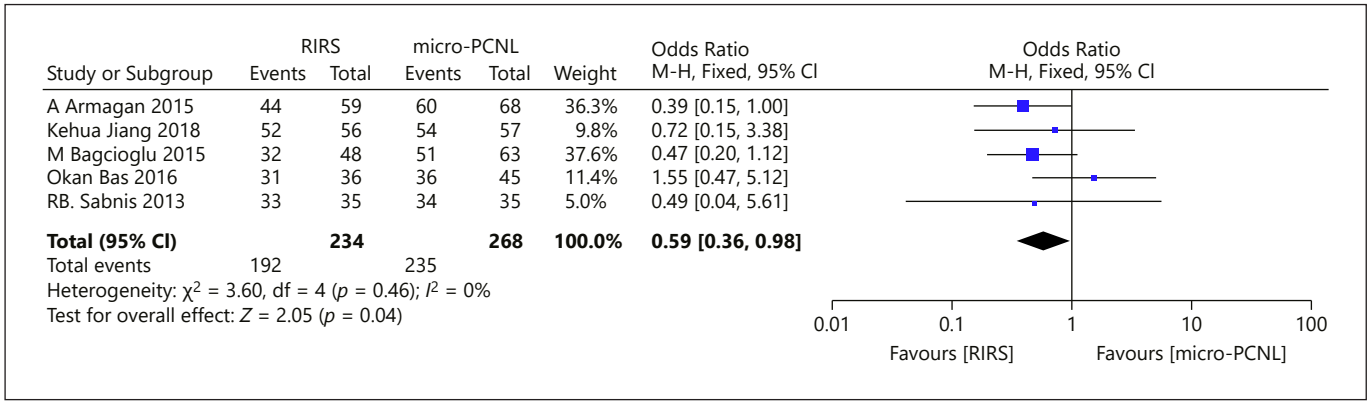

Fig. 3. Pooled analysis of stone-free rate. RIRS, retrograde intrarenal surgery; micro-PCNL, micro-percutaneous nephrolithotomy.

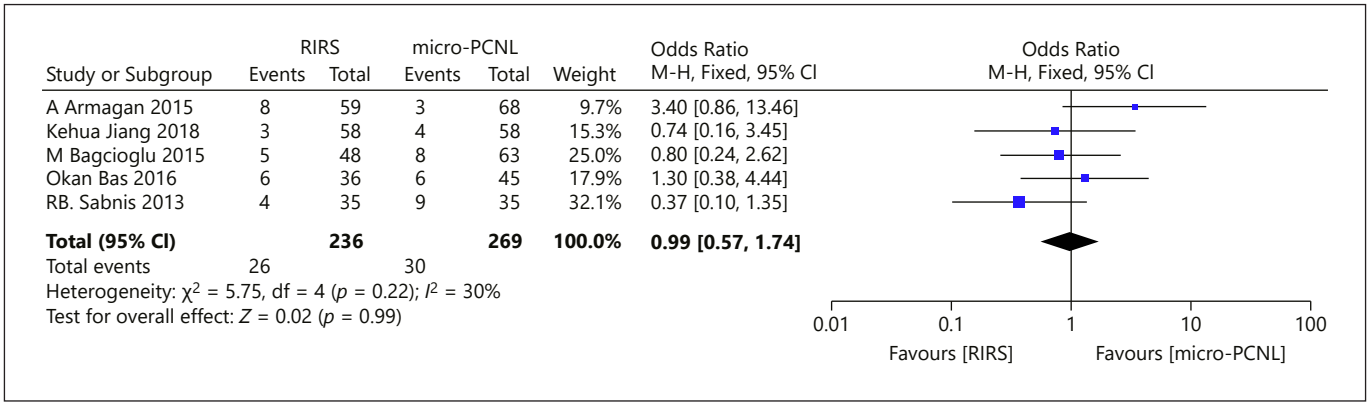

Fig. 4. Pooled analysis of complications. RIRS, retrograde intrarenal surgery; micro-PCNL, micro-percutaneous nephrolithotomy.

Pooled Analysis of the Complications

The pooled data showed that RIRS had similar complications rates (OR = 0.99, 95% CI = 0.57–1.74, $p = 0.99$) to the micro-PCNL group, and no statistically significant difference was found (Fig. 4).

Pooled Analysis of the Length of Hospital Stay

There was no difference in the length of hospital stay between RIRS and the micro-PCNL groups (MD = −0.29, 95% CI = −0.82 to 0.24, $p = 0.28$) (Fig. 5).

Pooled Analysis of the Operative Time

The pooled results showed that the difference in operative time between the 2 groups was not statistically significant (MD = −6.63, 95% CI = −27.34 to 14.08, $p = 0.53$) (Fig. 6).

Discussion

Recently, the surgical choices have been revised consistent with the increasing occurrence rate of kidney stone disease [20]. Developments in optic puncture systems and equipment have led to an advance in the minimally invasive therapy approaches. The high rate of recurrence and re-operation in patients made it necessary to select an appropriate surgical option to provide a maximum stone clearance rate with a minimum morbidity. The alternative treatments of F-URS and PCNL have been increasingly demonstrated to be efficient for improving success rates and reducing morbidities in recent years [21–23].

The F-URS is related to a lower SFR when compared to SWL, and a lower disintegration rate and an inability

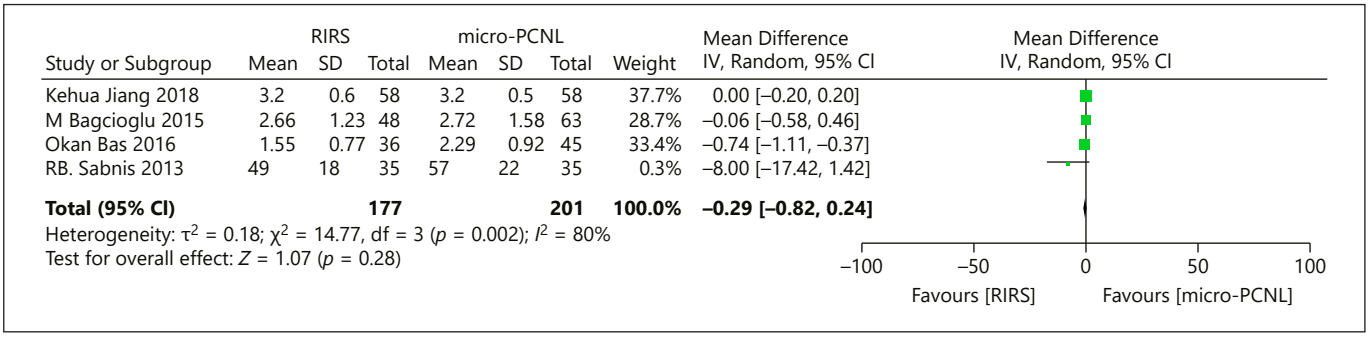

Fig. 5. Pooled analysis of length of hospital stay. RIRS, retrograde intrarenal surgery; micro-PCNL, micro-percutaneous nephrolithotomy.

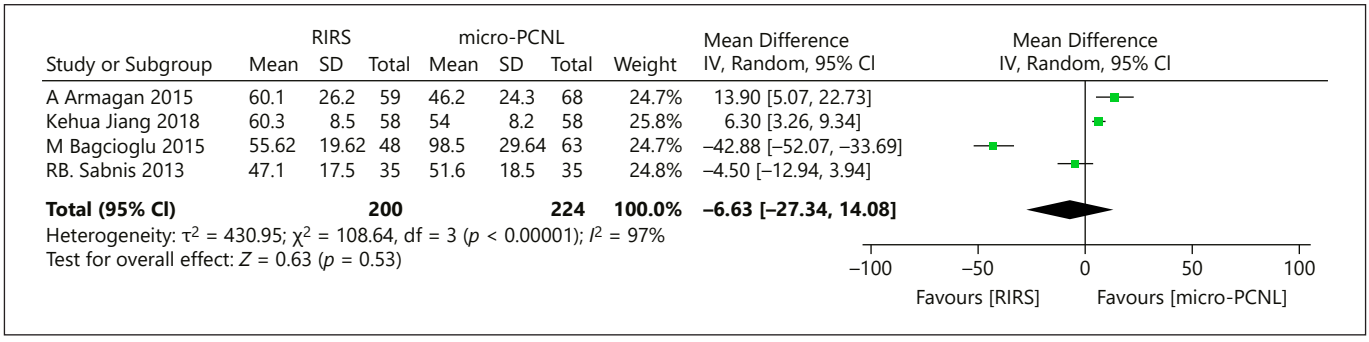

Fig. 6. Pooled analysis of operative time. RIRS, retrograde intrarenal surgery; micro-PCNL, micro-percutaneous nephrolithotomy.

to suck up all debris compared with PCNL [7, 24, 25]. The disadvantages of F-URS include expensive instruments, the need for staged procedures, and severe injuries of the ureter [26, 27].

Recently, the newly developed method "micro-PCNL" with the use of the "all-seeing needle" optical puncture system appears to shorten the duration of surgery, reduce exposure to radiation, and decrease the complications related to tract dilation [8, 28]. However, micro-PCNL still has its own limitations.

Apart from studies reporting the importance of spatial anatomical measurements, several studies compared F-URS and PCNL. Sabnis et al. [29] were the first to retrospectively compare the outcomes of micro-PCNL and F-URS to treat 70 patients with renal calculi <15 mm in diameter. Similar results were found in terms of SFR and complication rates in the 2 arms. Moreover, the decrease in hemoglobin level was greater in the micro-PCNL group, as well as increased pain and more need for analgesics, whereas F-URS is associated with a higher rate of JJ stenting. Nevertheless, our results differ, relying on our assessment of the pooled meta-analysis with the 5 trials.

In our study, RIRS has a higher stone clearance rate but at the cost of higher hemoglobin drop when compared with micro-PCNL. For most urologists, the spatial anatomy of the inferior calyceal system is associated with the difficulties during RIRS. Previous studies have reported the importance of lower-pole spatial anatomical features in the context of SFR [30, 31].

Resorlu et al. [21] showed that pelvicalyceal anatomy, which plays an important role in patient selection, had an impact on the effectiveness of RIRS used to treat LPS. They measured spatial anatomical features on preoperative images (intravenous urograms), which revealed that lower-pole anatomy had significant effect on SFRs, as did stone size after F-URS. Meanwhile, in the study by Jacquemet et al. [32], no relationship was found between LPS location and the morbidity associated with F-URS. Nevertheless, it was reported that multiple stones and a stone >10 mm seemed to significantly reduce stone clearance rates without increasing morbidity.

In the current analysis, not all studies have measured anatomical lengths prior to surgery. Therefore, no subgroup analysis was performed. Nevertheless, we suspect that anatomy may be an important factor in selecting patients for a particular therapeutic modality.

With respect to decrease in hemoglobin, even after the technique of RIRS is mastered, the maneuverability of the flexible and long instrument is definitely limited as compared to the rigid and short instruments used in micro-PCNL [15]. These findings can be viewed with caution: micro-PCNL is superior as it is a single-step procedure access with a small-caliber needle and the tract dilatation need is not extensive as mentioned above. Thus, since the sheaths are used in conventional PNL, major hemorrhage seems to be rare.

Furthermore, although micro-PCNL, as a relatively new procedure, can be easily performed by any urologist trained in PCNL, there is no difference in terms of complication rates, and the mean duration of surgery and stay of the hospital were also similar between the 2 groups in our study.

Our results are based on a well-maintained and updated database. However, bias still exists, which may influence the outcomes of operative parameters. Meanwhile, considering the significant difference in the preferred surgical procedure among surgeons and the serious ethical need to concerned, it is very hard to conduct a randomized controlled clinical trial to compare the operative parameters of RIRS and micro-PCNL for kidney stones. Moreover, our study did not evaluate cost efficiency between the 2 arms. The cost-effectiveness should also be taken into account when adopting this new technology.

Conclusions

RIRS has a higher SFR and a greater level of hemoglobin loss than micro-PCNL. However, no differences were found in hospitalization, fluoroscopy durations, and complication. Both micro-PCNL and RIRS have several shortcomings that are unique to each procedure, and each procedure has specific advantage over the other in specific situations. In future, available treatment options should be chosen individually by taking efficacy and safety into consideration.

Statement of Ethics

Ethics approval was waived because this study does not involve any human participants or animals.

Conflict of Interest Statement

The authors declare there is no conflict of interest.

Funding Sources

No funding was received for this study.

Author Contributions

Z.G. and J.C. have made substantial contributions to conception and design of the study and written the manuscript; Y.Y., M.W., and R.D. searched literature, extracted data from the collected literature, and analyzed the data; and J.P. revised the manuscript. All authors approved the final version of the manuscript.

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