

Retrograde Intrarenal Surgery versus Percutaneous Nephrolithotomy in the Treatment of Solitary Kidney Calculi: a Meta-Analysis

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Abstract

Background: To assess the effectiveness and safety of retrograde intrarenal surgery(RIRS) and percutaneous nephrolithotomy(PCNL) as surgical management strategies for solitary kidney calculi.

Methods: Our team searched the PubMed, Cochrane and Web of Science databases up to February 28, 2019, for relevant published studies. After data extraction and quality assessment, Review Manager 5.3.5.0 software was used to pool the data.

Results: Four studies involving 314 patients were included in our meta-analysis. The pooled data showed that the stone-free rate(SFR) was higher in the PCNL group than in the RIRS group, and the difference was significant(OR:0.36, 95% CI: 0.20 to 0.67, P =0.001). No significant differences were found in minor complications or major complications between the RIRS and PCNL groups(P > 0.05, OR:0.79, 95% CI: 0.46 to 1.35;p > 0.05, OR:2.96, 95% CI: 0.67 to 12.96, respectively).

Conclusions: Neither the minor nor the major complications of RIRS and PCNL showed any statistical differences. Additionally, PCNL provided a higher SFR than RIRS. There exists enormous heterogeneity in mean operation time. Overall, this meta-analysis may help urologists make decisions regarding interventions for solitary kidney calculi management.

Keywords: Solitary kidney, Calculi, Retrograde Intrarenal surgery, Percutaneous Nephrolithotomy, Meta-analysis

Background

Choosing the most adaptive therapeutic regimen for treating patients with solitary kidney calculi is one of the most challenging clinical difficulties for urologists. Solitary kidney calculi are common, complex, and often combined with other diseases of the urinary system, and improper treatment may lead to serious complications, such as a loss of kidney function or even death[1].The main treatment methods include conservative treatment, extracorporeal shock wave lithography (ESWL), RIRS, and PCNL. Therefore, the choice of appropriate surgical methods for patients with solitary kidney calculi has a vital role.

At present, ESWL is rarely used in the treatment of solitary kidney calculi. However, RIRS is considered to be a safe and effective method of treating kidney calculi less than 2 cm in diameter, and PCNL has also been proven to be safe and effective for kidney calculi larger than 2 cm in diameter in normal patients[2]. PCNL has the advantage of obtaining the highest SFR, but compared with other treatments, it produces the greatest damage[3].Because of the compensatory hypertrophy in the kidneys and the increased thickness of the kidney parenchyma, patients with solitary kidney calculi are more likely to bleed after PCNL than normal patients[4, 5].PCNL is associated with many serious complications, especially severe complications such as bleeding and kidney injury[6, 7].In contrast, the advantages of RIRS are preservation of the kidney parenchyma and less bleeding. With the accumulation of experience, the reconfiguring of RIRS equipment and the maturation of technology, some urologists use RIRS as an alternative to PCNL for the treatment of kidney calculi larger than 2 cm in diameter[8].

Several studies compared the clinical efficacy and safety of RIRS and PCNL in treating single kidney calculi. Thomas Knoll et al. reported a prospective study. Guohua Zeng et al. recently reported a propensity score matching study. Yue Wu et al. and Yinghao Sun et al. reported retrospective analyses. However, no meta-analysis has been conducted to compare the clinical efficacy and safety of RIRS and PCNL. Clinical creation of flexible ureteroscopic control of calculi in solitary kidneys gave a huge desire for the endourologists to make the remedy in a more secure way than ever.

To date, there are no standards or guidelines to evaluate the clinical efficacy of RIRS and PCNL in the treatment of solitary kidney calculi. Therefore, we think it is necessary to compare the clinical outcomes and safety evaluations of RIRS and PCNL by meta-analysis.

Methods

Our team searched the PubMed, Cochrane and Web of Science databases up to February 28, 2019, for relevant published studies. (Solitary kidney)AND urinary calculi)AND flexible ureteroscopy)AND FURS)AND percutaneous nephrolithotomy)AND percutaneous lithotripsy)AND PCNL)AND PNL)AND retrograde intrakidney surgery)AND RIRS)OR(solitary kidney)OR urinary calculi)OR flexible ureteroscopy)OR FURS)OR percutaneous nephrolithotomy)OR percutaneous lithotripsy)OR PCNL)OR PNL)OR retrograde intrakidney surgery)OR RIRS) was used as the search strategy. After data extraction and quality assessment, RevMan 5.3.5.0 was used to pool the data.

Inclusion And Exclusion Criteria

Inclusion criteria were as follows:

- (1)All the cases were comparative analyses of RIRS and PCNL in the treatment of solitary kidney calculi. (2)The experimental group and the control group were both treated with RIRS or PCNL.
- (3)After the first operation (RIRS or PCNL), patients were reexamined to assess whether residual calculi existed.
- (4)Clavien-Dindo scoring was performed for all patients after the first operation.
- (5)Articles included the SFR, mean operation time and Clavien-Dindo score.

Exclusion criteria were as follows:

- (1) Only RIRS or PCNL without a comparison group.
- (2) Calculi not in the kidneys.
- (3) Repetitive articles, case reports, reviews, editorial comments, meeting abstracts or articles without corresponding data.

Data Extraction

Four reviewers independently extracted all the documents to determine whether they met the above criteria, and we extracted the data for the SFR, mean operation time, and the number of patients who experienced minor complications or major complications after surgery. A flow diagram of the process for the selection of relevant studies is shown in Fig. 1.

Data analysis

We used Review Manager 5.3.5.0 software for statistical analysis and used the odds ratio (OR) and 95% confidence interval (CI) to evaluate binary data. The statistical significance level was set at 0.05. For quantitative data, we use the weighted mean difference (WMD) and 95% CI to assess continuous data. The Cochran Q test and I^2 statistics were used to detect heterogeneity. According to the existence or absence of heterogeneity, a fixed-effect model or random-effect model was adopted. Significant heterogeneity was defined as $P < 0.1$ or $I^2 > 50\%$, and the random-effect model was used for parameters with significant heterogeneity ($I^2 < 25\%$, no heterogeneity; $25\% - 50\%$ of I^2 , low heterogeneity; $50\% - 75\%$ of I^2 , medium heterogeneity; and $I^2 > 75\%$, high heterogeneity).

Retrieval Results

We searched PubMed, Cochrane and the Web of Science for articles on solitary kidney calculi up to February 2019 and obtained 291 articles. None of the articles were a meta-analysis of the treatment of solitary kidney calculi. There were 57 overlapping articles. We excluded 180 articles after reading the title. After reading the abstracts of all the remaining articles, we obtained the full text of 13 articles. Finally, after reading the full text, we obtained four articles that met the requirements for meta-analysis. The four articles comprised 314 patients and included one prospective study, one propensity score matching study and two retrospective studies. Table 1 summarizes basic characteristics of the included studies.

Table 1
Basic characteristics of the included studies

Study	RIRS		PCNL		Holmium laser		Population distribution
	Endoscope	Ureteral access sheaths	Percutaneous access	Location	Method		
Thomas Knoll et al.	FlexX ² , Karl Storz Endoscopes, Germany	12/14Fr, Flexor, Cook Medical, Ireland	18Fr, modiWed Amplatz	ultrasound and Xuoroscopy	Mini-PCNL	600 or 210 micron Wber, Auriga XL, Starmedtec, Germany	Germany
Yue Wu et al.	Karl Storz Flex-x2 Fr7.5, Germany	12/14Fr	16-18Fr	ultrasound and X-ray	Mini-PCNL	LUMENIS VersaPulse PowerSuite 60W, Israel	China
Guohua Zeng et al.	7.5-Fr flexible ureteroscope(Olympus, Japan)	12/14Fr (UAS)	18Fr	fluoroscopic or ultrasonic	Mini-PCNL	pneumatic or holmium laser lithotripter	China
Yinghao Sun et al.	7.5-Fr flexible ureteroscope (Storz FLEX-X2, Karl Storz, Tuttlingen, Germany)	12/14Fr	22-24Fr, Amplatz	ultrasonographic guidance	General PCNL	1000- μ m holmium laser fiber (VersaPulse@100 W PowerSuiteTM, Coherent Medical Group, Santa Clara, CA, USA)	China

The New-Ottawa Scale (NOS) was used to evaluate the included studies. The NOS scores were evaluated using a 9-point system. A NOS score of 7 or above indicated high quality, and a NOS score of 3 or below represented low quality. Two of us (LJQ and YLJ) evaluate the quality of the 4 studies. The quality assessment of each included study is shown in Table 2.

Table 2
Quality of assessment of each included studies.

Study	Trial type	Selection				Comparability	Outcome			Total
		Representativeness of exposed cohort	Selective of non exposed Cohort	Ascertainment of exposure	Outcome not present at start		Assessment of outcome	Adequate follow-up length	Adequacy Of follow-up	
Guohua Zeng et al.	R	*	*	*	*	*	*	*	-	7
Thomas Knoll et al.	P	*	*	*	*	*	*	*	*	8
Yinghao Sun et al.	PSM	*	*	*	*	*	*	*	*	8
Yue Wu et al.	R	*	*	*	*	*	*	*	*	8
P Prospectively study, R Respectively study, PSM Propensity Score Matching										
The symbol "*" represents score										

SFR

Four articles including 314 patients compared the treatment of solitary kidney calculi between RIRS and PCNL groups. Heterogeneity was tested by I^2 statistics. ORs were used as an indicator of therapeutic effect detection. The results showed that $P = 0.55 (> 0.10)$ and $I^2 = 0\% (< 25\%)$, which meant that there was no heterogeneity between the two groups. The fixed-effect model was used for the meta-analysis. The results (OR = 0.36, 95% CI: 0.20–0.67, $P = 0.001$, Fig. 2) showed that compared with RIRS, PCNL significantly increased the SFR in patients with solitary kidney calculi after their first surgical treatment.

Mean operation time

Three studies reported mean operation times. The result showed that $P < 0.00001 (< 0.10)$ and $I^2 = 95\% (> 50\%)$, and the random-effect model was used for the meta-analysis. There was no statistically significant difference in the mean operation time between the RIRS group and the PCNL group. ($n = 268$, 130 patients in the RIRS group, 138 patients in the PCNL group; WMD: 5.92, 95% CI: -23.46 to 35.31; $I^2 = 95\%$; $P = 0.69$, random-effect model, Fig. 3).

Minor complications and major complications

There was no statistically significant difference in minor complications between the RIRS group and the PCNL group. ($n = 314$, 151 patients in the RIRS group, 163 patients in the PCNL group; OR: 0.79; 95% CI: 0.46 to 1.35; $I^2 = 14\%$; $P = 0.39$, fixed-effects model, Fig. 4). There was no statistically significant difference in major complications between the RIRS group and the PCNL group. ($n = 314$, 151 patients in the RIRS group, 163 patients in the PCNL group; OR: 2.96; 95% CI: 0.67 to 12.96; $I^2 = 0\%$; $P = 0.15$, fixed-effects model, Fig. 5).

Discussion

For patients with solitary kidney calculi, severe obstruction, azotemia, disturbance of water and electrolyte balances, disturbance of the acid-base balance and even acute kidney failure may occur. Therefore, PCNL is the primary treatment to remedy solitary kidney calculi especially for solitary kidney calculi larger than 2 cm. But PCNL generally has severe complications, including peripheral organ damage and bleeding, and intraoperative and postoperative hemorrhaging might also occur. Importantly, the solitary kidney functions in a compensatory state for a long time with a thick cortex, considerable blood waft, and abnormal blood vessels, and it is easy to cause bleeding after puncture dilation.

In recent years, because of the low incidence of complications, RIRS has become the preferred treatment for kidney calculi [9]. We already know that both RIRS and PCNL treatments for kidney calculi offer excellent safety [10]. However, due to the lack of RCT research, all urolithiasis guidelines have not yet clearly established treatment principles for patients with solitary kidney calculi. In recent years, several authors have compared the efficacy of PCNL and RIRS in the treatment of solitary kidney calculi [11]. Some of these authors pronounced that retrograde calculi removal may be achieved even for larger solitary kidney calculi, generally with PCNL [12–15]. So results are still inconclusive.

Hence, it is necessary to compare the treatments of RIRS and PCNL by meta-analysis. In this study, we assessed 4 scientific research studies. Through systematic evaluation and meta-analysis, this article compares the efficacies of RIRS and PCNL in the treatment of solitary kidney calculi. Our meta-analysis showed that patients with solitary kidney calculi had comparable fundamental traits. This study compared the short-term follow-up results of patients receiving RIRS with those of patients receiving PCNL.

After analyzing the data, we concluded that the SFR of the PCNL group was higher than that of the RIRS group, as we forecasted ($P < 0.05$, Fig. 2). The results showed excellent balance without excessive heterogeneity. In the four research, 16-18Fr percutaneous access was performed in PCNL in Thomas Knoll et al. and Yue Wu et al. and Guohua Zeng et al. And Yinghao Sun et al. used 22-24Fr percutaneous access in PCNL. Until now, the concept of Mini-PCNL has not been standardized, main to the truth that sheath diameters underneath 20F are defined as miniaturized. Desai and Giusti demonstrate a higher hemoglobin drop after conventional PCNL compared to Mini-PCNL [16, 17]. But, Li and colleagues prospectively evaluated the systemic reaction to PCNL (30Fr) and Mini-PCNL (14–18Fr) without noticing variations among each strategies [18]. Therefore, the benefit of Mini-PCNL remains undefined and may be problem of in addition studies. But the usage of miniaturized instruments turned into based on the assumption of a decrease morbidity because of reduced tract diameter resulting in an awful lot much less renal trauma, mainly for solitary kidney calculi. Finally, this conclusion is consistent with the conclusions of the four included articles, which means that PCNL might be the more effective way to treat patients with a solitary kidney. The mean operation time was highly heterogeneous ($I^2 = 95\%$, Fig. 3). We used Review Manager 5.3.5.0 software to analyze the sensitivity of the mean operation time. The results showed good stability but severe heterogeneity. We thought that although RIRS and PCNL technologies have been widely used in most hospitals, the heterogeneity originated in the different levels of RIRS and PCNL technology proficiency mastered by different urologists in different hospitals. At the same time, we can find that RIRS has longer mean operation time than PCNL in two studies by Guohua Zeng et al. and Yue Wu et al. respectively with Mini-PCNL. But the mean operation time of PCNL in the study by Yinghao Sun et al. who used general PCNL was longer than RIRS instead. For Solitary Kidney Calculi patients, shorter operation time may has better safety.

There were no statistical differences in minor or major complications among the patients treated with RIRS and those treated with PCNL ($P > 0.05$, Fig. 4; $P > 0.05$, Fig. 5). Minor complications were defined as Clavien I–II, and major complications were defined as Clavien III–V [19]. In the four articles analyzed, none of the postoperative patients developed Clavien V complications. Similarly, Thomas Knoll et al. and Guohua Zeng et al. reported that the complications of patients in their RIRS groups were identical to those of the patients in their PCNL groups, but the complications were not the same as those observed by Yue Wu et al. and Yinghao Sun et al. [10, 11, 19, 20]. In surgery, PCNL still has a high risk of complications including massive hemorrhage, perforation, urine leakage, pleural injury, pleural effusion, intestinal injury and so on. Although the improvement in the PCNL era, which includes minimally invasive percutaneous nephrolithotomy, has considerably decreased the chance of bleeding, the solitary kidney with thick cortex, rich blood flow, abnormal blood vessels which is in the compensatory state for a long term is easily bleeds after puncture and expansion. But, it is reported PCNL has a better SFR without reoperation and the chance of infectious fever and sepsis after RIRS become larger than after PCNL. So it is also necessary to compare the intraoperative complications of PCNL and RIRS in patients with solitary kidney. In a word, for the patients who need to decide between RIRS and PCNL for solitary kidney calculi treatment, RIRS may not be a more safer way than PCNL. Of course, owing to the small number of articles included in this meta-analysis and the lack of RCTs, the accuracy of the conclusions of this article need further research to be verified.

There are a few limitations: (1) there were no randomized controlled trials, and the sample size was relatively small. (2) The basic characteristics of the included patients were not completely uniform. For example, the influencing factors (age, sex, etc.) were different, which may affect the results of the meta-analysis. (3) We cannot eliminate all sources of heterogeneity. (4) Publication and selection biases should also be considered to explain the results.

Conclusion

Based on the meta-analysis of the four included articles, PCNL has a higher SFR without increasing the incidence of minor or major complications. And more true comparisons between RIRS and Mini-PCNL originating from prospective randomized trials are highly necessary.

Abbreviations

PCNL: Percutaneous nephrolithotomy; RIRS: Retrograde intrarenal surgery; ESWL: Extracorporeal shock wave lithotripsy; SFR: Stone-free rate; OR: Odds ratio; CI: Confidence interval; WMD: Weighted mean difference

Declarations

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Not applicable.

Authors' contributions

LJQ and YLJ designed the study. LJQ wrote the manuscript. LJQ and JYL and ZPJ analyzed the data. YJL and JNX searched the articles. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

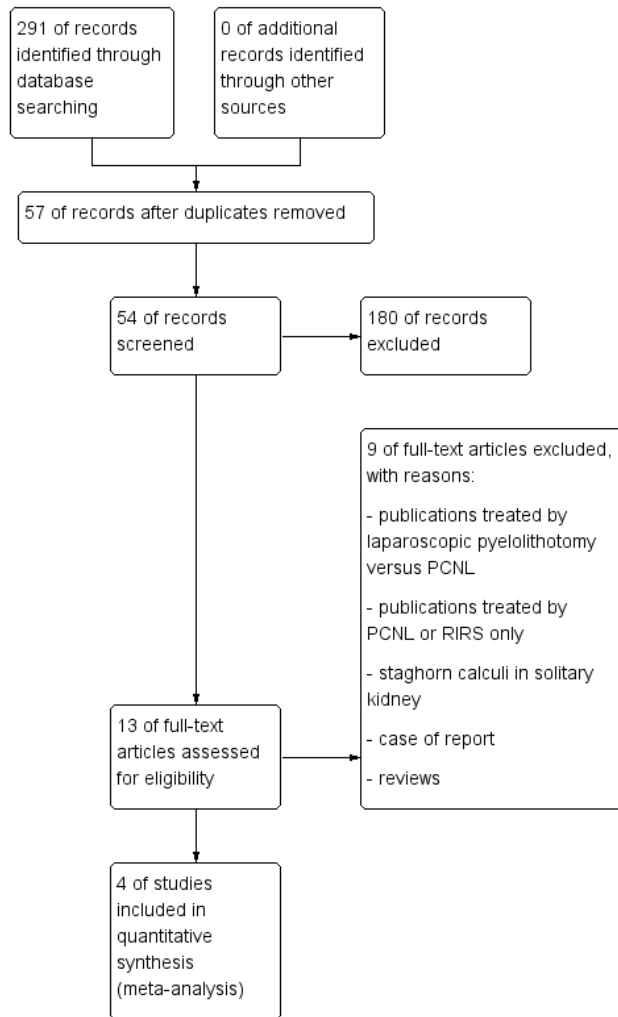


Figure 1

Flow diagram of the process for the selection of relevant studies

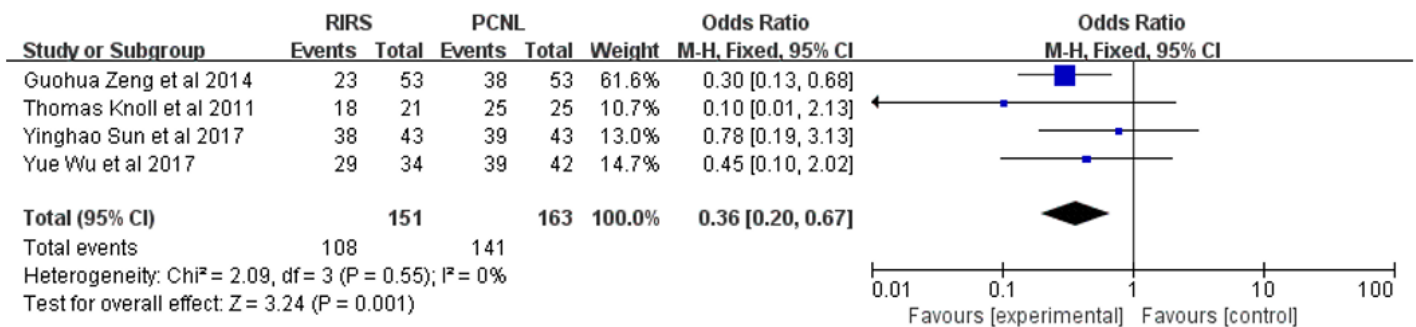


Figure 2

Forest plot comparison between RIRS and PCNL stone-free rate in solitary kidney calculi.

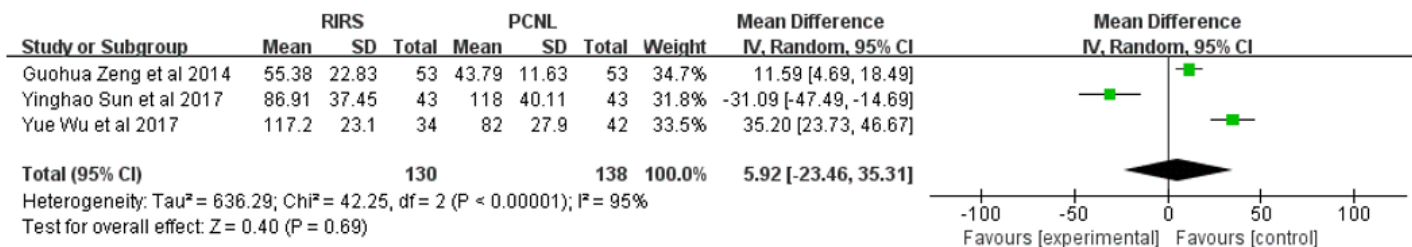


Figure 3

Forest plot comparison between RIRS and PCNL mean operation time in solitary kidney calculi.

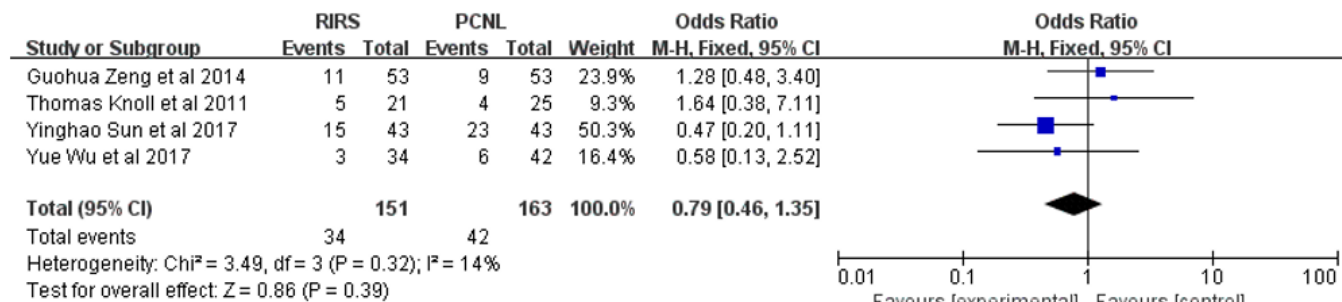


Figure 4

Forest plot comparison between RIRS and PCNL minor complications in solitary kidney calculi.

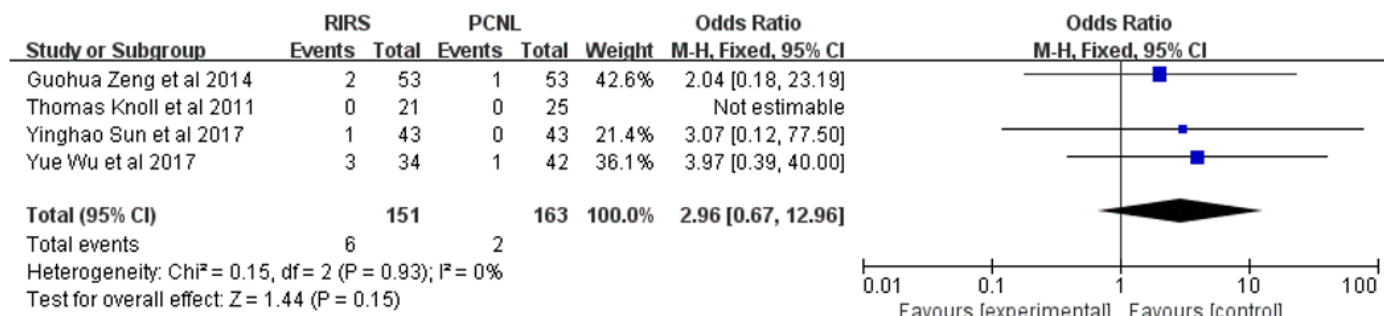


Figure 5

Forest plot comparison between RIRS and PCNL major complications in solitary kidney calculi.

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