

Micropercutaneous Versus Minipercutaneous for the Management of Moderately Sized Kidney Stones: A Systematic Review and Meta-Analysis

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Research article

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Abstract

Background: To assess the efficacy and safety of mini-percutaneous nephrolithotomy (Miniperc) and micropercutaneous nephrolithotomy (Microperc) for moderately sized renal stones.

Methods: Literature search of PubMed, Web of Science, and Embase was performed before January 2020. We used odds ratios (OR) and weighted mean difference (WMD) for dichotomous variables and continuous variables, respectively. Results were pooled by Review Manager version 5.3 software.

Results: A total of 4 studies involving 172 Microperc and 162 Miniperc cases were included. The overall SFR of Microperc was 86.05% (148/172), while the SFR of the Miniperc was 87.65% (142/162). Microperc was associated with lower hemoglobin drop (WMD: -0.98; P = 0.03), higher renal colic requiring D-J stent insertion (OR: 3.49; P=0.01). No significant differences exist between Microperc and Miniperc with respect to stone-free rate (SFR) (OR: 0.90; P=0.75), urinary tract infection (OR: 0.38; P=0.18), operative time (WMD: 14.73; P = 0.54) and hospital stay time (WMD: -1.04; P=0.07).

Conclusions: Our meta-analysis demonstrated that Microperc could obtain comparable SFR with Miniperc. Microperc was associated with lower hemoglobin drop, but Miniperc was associated with lower renal colic rates. In addition, the operation time and hospital stay time for these two procedures were similar.

Background

Kidney stone disease has affected humankind since antiquity, and its incidence has increased to almost 9% in the last decades[1]. Moreover, studies have shown that the recurrence risks of kidney stones can be as high as 50%[2]. Current minimally invasive treatment procedures for kidney stones include extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS), and percutaneous nephrolithotomy (PCNL)[3]. PCNL has the advantage of high stone-free rate (SFR), but its higher efficiency is accompanied by more complications[4].

To reduce complications resulting from PCNL, Miniperc (10-20F) and Microperc (4.85F) have now been implemented[5]. Miniperc, Microperc, RIRS and ESWL are the main surgical procedures for moderately sized renal stones. Although ESWL is recommended for renal stone < 2 cm, its SFR is lower than other surgical methods, especially for lower pole stones[6, 7]. Previous meta-analysis demonstrated that the SFR of Miniperc was higher than that of RIRS, and overall complications were similar between two procedures[8]. Another meta-analysis demonstrated that Microperc was also associated with a higher SFR compared with RIRS[9]. Both Miniperc and Microperc are efficient surgeries for renal stones. However, there are few studies that directly assess the efficacy of Miniperc and Microperc, so which surgery is more advantageous is still controversial. Therefore, we hope to review the previous literature, pooled the data, systematically evaluate the advantages and disadvantages of Miniperc and Microperc, and provide convincing guidance for the clinical treatment of moderately sized renal stones.

Methods

Search strategy

Literature search of PubMed, Web of Science, and Embase was performed before January 2020 according the PRISMA guidelines[10]. The following terms were used: "micro-percutaneous nephrolithotomy" or "micro-PCNL" or "micro-perc" and "Minipercutaneous" or "mini-PCNL" or "ultra-mini-PCNL" or "minimally invasive PCNL" or "minimal tract" or "miniaturized PCNL" or "miniperc" or "MPCNL" and "renal stone" or "calculi".

Inclusion criteria and exclusion criteria

All eligible researches were selected based on the following criteria: (1) patients with renal stones < 2.5 cm, (2) experimental studies comparing Microperc with Miniperc, (3) studied reported at least one of the following items: mean operative time, SFR, hospitalization time and complications (renal colic requiring D-J stent insertion, hemoglobin drop, urinary tract infection). Exclusion criteria including: (1) non-English papers, (2) conference abstract, (3) noncomparative studies (letters, comments, reviews), (4) not included in the inclusion criteria.

Quality assessment

Two authors (XSG and WW) evaluated the literature quality independently, and if there were differences, discussed with the third author to solve them. We assessed the level of evidence (LE) according to the Oxford Centre for Evidence-based Medicine[11]. We assessed the methodological quality of included studies on the basis of the Newcastle Ottawa Scale (NOS)[12].

Data extraction

We read the full text of the included articles and extracted following items: author, publication date, patients country, study type, access sheath size of Miniperc, inclusion criteria, follow-up imaging and duration, number of patients, gender, age, stone side, operation time, stone-free rate, hospital stay, complications (D-J stent insertion, hemoglobin drop, urinary tract infection).

Statistical analysis

All meta-analyses were performed using Review Manager version 5.3 software. For the dichotomous variables, odds ratios (OR) and 95% confidence interval (CI) were used. For continuous variables, weighted mean difference (WMD) and 95% CI were used. We assessed the heterogeneity of the included studies by Cochrane Chi-square test and I^2 test. The fixed-effects model was used for low heterogeneity among studies ($P > 0.1$, $I^2 < 50\%$); Otherwise, the random-effects model was used when there was evidence of high heterogeneity ($p < 0.1$, $I^2 > 50\%$). Pooled effects were calculated by the Z-test, and $P < 0.05$ was considered

statistically significant. Sensitivity analysis was conducted using a single-item removal method. The funnel plot was used to assess the potential publication bias.

Results

Studies characteristics and quality assessment

The literature search protocol is presented in Figure 1. Following our search strategy, we initially retrieved 148 articles. Finally, 4 studies including 172 Microperc and 162 Miniperc cases were included in our meta-analysis. All included four studies were retrospective case controls trails. They compared the advantages and disadvantages of two surgical methods for moderately sized kidney stones. These four studies included adult kidney stones in 2 studies[13, 14] and pediatric kidney stones in 2 studies[15, 16]. LE of 4 included studies was 3b, and the NOS score of these studies were 6 or 7 scores. The characteristics of these studies were listed in Table 1.

Stone-free rate

All 4 studies compared SFR between Microperc group and Miniperc group. The stone-free criterion was defined as either no residual stone or fragment < 4mm in diameter. Reexamination by computed tomography (CT), Kidney-Ureter-Bladder or Ultrasound within one month after the operation. In Microperc group, the overall SFR was 86.05% (148/172). The SFR of the Miniperc was 87.65% (142/162). As the heterogeneity was low among these studies ($P = 0.83$, $I^2 = 0\%$), fixed-effect model indicated that Microperc and Miniperc were statistically similar concerning SFR. (OR: 0.90; 95% CI: 0.47, 1.71; $P = 0.75$) (Figure 2). In subgroup analyses, we divided the meta-analysis into adult kidney stones and pediatric kidney stones. The SFR of Microperc and Miniperc were similar for pediatric kidney stones (OR: 0.73; 95% CI: 0.29, 1.84; $P = 0.50$) (Figure 2). For adult kidney stones, there were also no significant differences (OR: 1.09; 95% CI: 0.45, 2.65; $P = 0.85$) (Figure 2).

Operative time

The operative time of Microperc versus Miniperc for renal stones was assessed in 4 studies. The pooled result showed that the heterogeneity was high among these studies ($P < 0.00001$, $I^2 = 97\%$), and the random-effect model indicated that the two techniques were statistically similar concerning operative time (WMD: -4.94; 95% CI: -34.96, 25.08; $P = 0.75$) (Figure 3). In a subgroup analyse, our pooled results showed that the operative time of Microperc was shorter for pediatric kidney stones (WMD: -24.72; 95% CI: -49.30, -0.13; $P = 0.05$) (Figure 3). For adult kidney stones, Microperc and Miniperc had no significant differences (WMD: 14.73; 95% CI: -32.53, 61.99; $P = 0.54$) (Figure 3).

Hospital stay

The hospital stay time of Microperc versus Miniperc was measured in 4 studies. As the heterogeneity was high ($P < 0.00001$, $I^2 = 98\%$), random effect model was used. Results found that the hospital stay time was shorter in the Microperc group (WMD: -1.04; 95% CI: -2.15, 0.07; $P = 0.07$) (Figure 4), but the differences between the two procedures were not statistically significant.

Hemoglobin drop

The hemoglobin drop of Microperc versus Miniperc for renal stones was measured in 3 studies[14-16], the heterogeneity was high ($P = 0.007$, $I^2 = 80\%$), and the random-effect model indicated that Miniperc was associated with larger hemoglobin drop (WMD: -0.98; 95% CI: -1.84, -0.12; $P = 0.03$) (Figure 5).

Renal colic requiring D-J stent insertion

Some patients requiring D-J stent insertion because of larger fragments in the ureter and caused renal colic. The heterogeneity was low among 4 included studies ($P = 0.20$, $I^2 = 35\%$), and the fixed-effect model indicated that D-J stent insertion in Microperc group was higher than Miniperc group (OR: 3.49; 95% CI: 1.30, 9.38; $P = 0.01$) (Figure 6 A).

Urinary tract infection

The urinary tract infection of was assessed in 3 studies[13, 14, 16]. Urinary tract infection was defined as positive urine culture and given the appropriate antibiotic treatment. As the heterogeneity was low among these studies ($P = 0.95$, $I^2 = 0\%$), and fixed-effect model indicated that the two techniques were statistically similar concerning urinary infection (OR: 0.38; 95% CI: 0.09, 1.56; $P = 0.18$) (Figure 6 B).

Sensitivity analysis and publication bias

We removed the single study one by one and found no source of heterogeneity. A funnel plot was used to assess the potential publication bias, and there was no publication bias in this meta-analysis (Supplementary figure 1).

Discussion

PCNL has been widely used for renal stones since 1970[17]. Its high SFR is accompanied by more complications, such as blood loss and pain, which can be reduced by reducing the diameter of the percutaneous tract[18–20]. Miniperc and Microperc have both been used effectively for treating kidney stones with no clearly which one is better. Our meta-analysis showed that Microperc could obtain comparable SFR with Miniperc, but the complications such as hemoglobin drop and urinary infection associated with Microperc was lower. Besides, we found that Microperc needs shorter hospital stay time and operative time

compared to Miniperc, although this difference was not statistically significant. The advantage of Miniperc compared to Microperc is that flexible or rigid nephroscope can be moved through the sheath, and lithotripsy can be continued when fragments move into other calyces[19]. To our knowledge, this is the first meta-analysis comparing the safety and effectiveness of Microperc versus Miniperc.

Miniperc was initially used for pediatric urinary stones in 1997[21]. Then Jackman et al. developed it for adults[22]. Miniperc usually refers to a percutaneous nephroscope with a nephrostomy tract less than 20 F[5]. Previous studies confirmed that complications of PCNL could reduce by reducing the diameter of the percutaneous tract[23]. Miniperc can obtain comparable SFR with standard PCNL, but complications such as blood loss and pain are reduced[19, 20]. Retrograde intrarenal surgery (RIRS) is another procedure for the treatment of upper urinary calculi. A high-quality meta-analysis showed that Miniperc provided significantly higher SFR compared with RIRS; however, Miniperc was accompanied with a higher incidence of postoperative complications[24].

In 2011, Desai et al. firstly used Microperc to fragment stones[25]. The tract of Microperc is smaller than Miniperc and standard PCNL, and the puncture and lithotripsy were completed in one step[25]. The see-through needle helps the surgeon puncture into the desired calyx. Microperc is widely used for medium-sized renal stones, which can get a SFR of 93%[26]. For lower-pole stones, the SFR of Microperc also can reach 85.7%[27]. Microperc can get as high SFR as Miniperc; however, Microperc is accompanied with lower blood loss and hospitalization time[14]. Compared with RIRS, Microperc provided significantly higher SFR; however, it is accompanied with a more significant drop in hemoglobin and more extended hospital stay[28]. For pediatric renal stones, the SFR of Microperc is 93.8%, hemoglobin drop is 0.79 ± 0.49 g/dL, no patient needs blood transfusion[15]. This indicated that Microperc can be used in children with kidney stones. The disadvantage of Microperc is the need to pay attention to the large intrapelvic pressure. In addition, micro can't exclude fragments, so it is necessary to ensure that the stones are dusted rather than fragmented[19].

SFR is a key indicator to evaluate the effectiveness of lithotripsy. Different studies have different standards for the definition of clear stone. The imaging follow-up methods are different after surgery. Three studies were followed by Kidney-Ureter-Bladder or Ultrasound[14–16], and one study was reexamination by CT[13]. The review time was one month after surgery, and one study conducted a review 48 hours after surgery[15]. The standard for SFR is no residual stone or asymptomatic fragments < 4 mm. Our pooled results showed that Microperc and Miniperc were statistically similar concerning SFR. This result indicates that Microperc does not reduce SFR when the tract size is reduced. In subgroup analyses, we divided the meta-analysis into adult kidney stones and pediatric kidney stones. The SFR of Microperc is similar to Miniperc in both adult and pediatric group. These demonstrated there is no difference between the two surgical methods in children and adults stones. We found the overall SFR of Microperc is 86.05% (148/172), and the SFR of Miniperc is 87.65% (142/162). These results show that both Microperc and Miniperc are very effective in treating moderately sized kidney stones. For lower pole stones, the SFR of Miniperc and Microperc were also similar[14].

Three studies showed that Microperc was accompanied with shorter operative time[14–16], but one study demonstrated a opposite result[13]. Our pooled result showed that Microperc and Miniperc were statistically similar concerning operative time. In subgroup analyses, our pooled results also showed that Microperc was accompanied with shorter operative time for pediatric kidney stones. This shows that Microperc is more efficient, especially for pediatric stones. Different definitions of operative time resulted in greater heterogeneity among the studies. The variations among studies during the operation such as energy source (laser or ultrasonic lithotripsy), diameter of the laser fiber, the optics (flexible), irrigation through the pump, ureteral double J stent inserted, and nephrostomy catheter placement also cause the different operation time among studies[19].

Complications are important indicators to evaluate the safety of a surgery. Our pooled results indicated that the two techniques were statistically similar concerning urinary infection (OR: 0.38; P = 0.18). However, we found that D-J stent insertion ratio is higher in Microperc. (OR: 3.49; P = 0.01). It can be explained that Microperc is done to dust the stone and leave the fragments to be spontaneously passed, and stones fragments are generally removed in Miniperc. So, Microperc needs more D-J stent insertion.

The tract size of PCNL is significantly associated with blood loss[23]. Our pooled results showed that hemoglobin drop is larger in Miniperc group (WMD: -0.98; P = 0.03). The reason may be that the enlargement of the nephrostomy tract increases the damage to the renal parenchyma and renal vascular system[20]. In the four studies we included, all patients in the Microperc group did not require blood transfusions. However, in the Miniperc group, Karatag et al. found 7.9% (5/63) patients needed blood transfusions[16]. Dundar et al. also calculated 7.4% (2/27) patients needed blood transfusions[15].

We demonstrated that the hospital stay time of Microperc is shorter, although not statistically significant. The possible reason is that Microperc has less damage and less postoperative discomfort[24]. Besides, it carries a lower urinary tract infection rate and hemoglobin drop. Furthermore, Microperc is more likely not to use percutaneous nephrostomy tube.

There are several limitations in our meta-analysis. Above all, only four retrospective case controls trails were included and analyzed, and the quality of the literature is relatively low. In addition, the heterogeneity is high among the important indicators such as operation time, hospital stay time, and hemoglobin drop. Although the random effect model is used, the results may be biased. Besides, the definition of SFR and the follow-up time are different in different studies. Moreover, many studies do not specify specific complications. Finally, the limited studies included and the limited number of patients in the study may lead to reduced confidence in the results.

Conclusion

Our meta-analysis demonstrated that Microperc could obtain comparable SFR with Miniperc. Microperc was associated with lower hemoglobin drop, but Miniperc was associated with lower renal colic rates. In addition, the operation time and hospital stay time for these two procedures were similar.

Abbreviations

Miniperc

mini-percutaneous nephrolithotomy, Microperc: micro-percutaneous nephrolithotomy, ESWL: extracorporeal shock wave lithotripsy, RIRS: retrograde intrarenal surgery, PCNL: percutaneous nephrolithotomy, SFR: stone-free rate, CCT: case control trials, OR: odds ratios, WMD: weighted mean difference, NOS: Newcastle Ottawa Scale, KUB: X-ray of kidney ureter bladder, CT: computerized tomography, USG: ultrasonography.

Declarations

Ethics approval and consent to participate

All analyses were based on previous published studies. Thus, no ethical approval and patient consent are required

Consent for publication

All authors have read the final version and agreed to authorship and order of authorship for this manuscript.

Availability of data and materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Author contributions

GXS wrote the manuscript writing. ZL collected and analyzed the data. WW and DXP analyzed the data. JX, LH and XKW helped review and revise the manuscript. WKJ helped design the study and revise article. All authors have read and approved the manuscript.

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Not applicable

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Tables

Table 1. Basic characteristics and data of included articles.

Study	Country	Study design	LE	Tract size of Miniperc	Inclusion criteria	Surgery	Number	Sex		Side		Age mean±SD (years)	Stone Size mean±SD (mm)	Follow-up imaging and duration (month)
								M	F	L	R			
Dundar, 2016	Turkey	CCT	3b	12-20F	≤2 cm, any location	Microperc	16	8	8	8	8	7.9±3.6	12.1±4.3	KUB/USG, 1-2 day
						Miniperc	27	13	14	14	13	9.5±5.4	13.4±4.8	
Karakan, 2017	Turkey	CCT	3b	14F	≤2.5 cm, any location	Microperc	42	24	18	22	20	40±13.2	17±3.2	CT,1
						Miniperc	32	18	14	16	16	42±14.1	16.4±3.7	
Karatag, 2015	Turkey	CCT	3b	18 or 20F	1-2cm, any location	Microperc	56	31	25	N	N	7.63± 5.04	13.4±3.4	KUB/USG,1
						Miniperc	63	26	37	N	N	9.32 ± 4.98	14.8±3.7	
Tok,2015	Turkey	CCT	3b	12-20F	1-2cm, lower pole	Microperc	58	34	24	34	24	45.90±14.44	13.97±3.62	KUB/USG, 1
						Miniperc	40	24	16	22	18	43.08±12.31	16.13±6.97	

Miniperc=mini-percutaneous nephrolithotomy, Microperc=micro-percutaneous nephrolithotomy, CCT=case control trials, N=Not available, M=Male, F=Female, L=Left, R=Right, KUB=X-ray of kidney ureter bladder, CT=computerized tomography, USG=ultrasonography, N=not available.

Figures

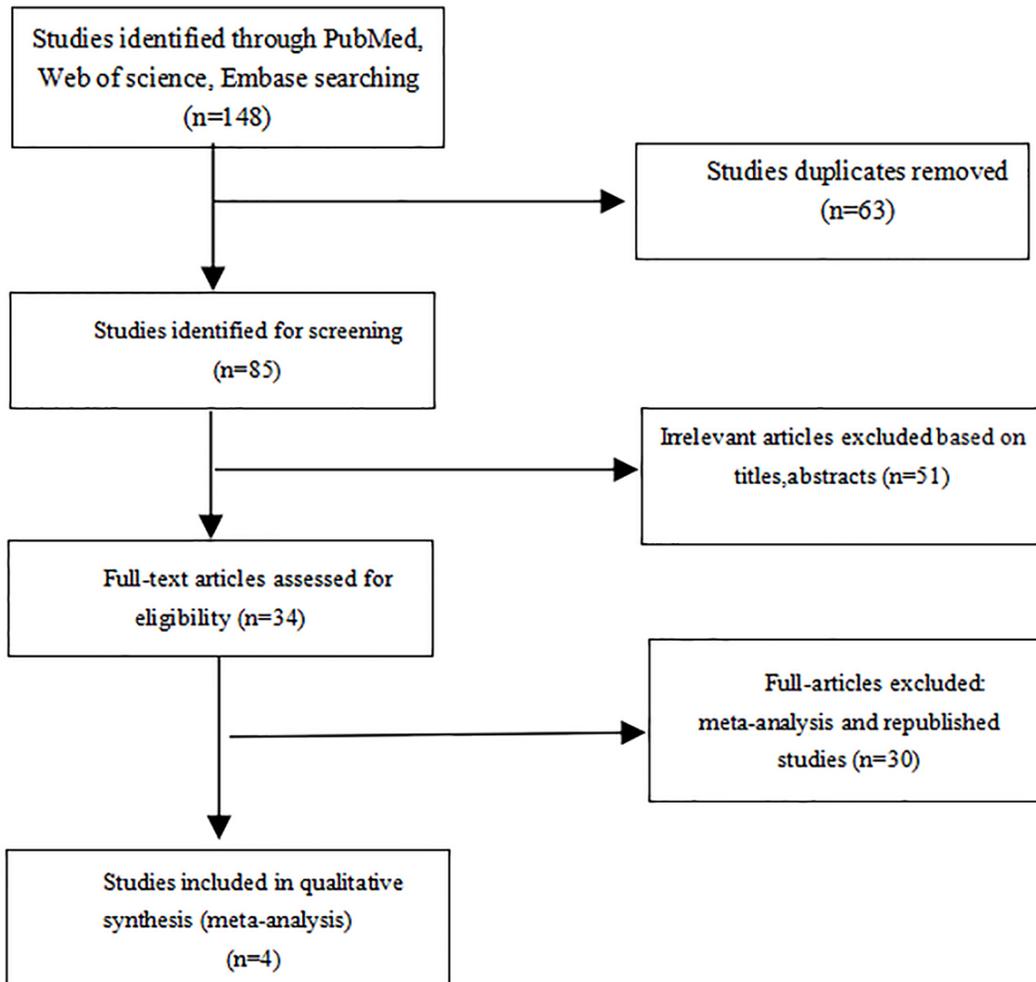


Figure 1

The flowchart showing study search and selection process.

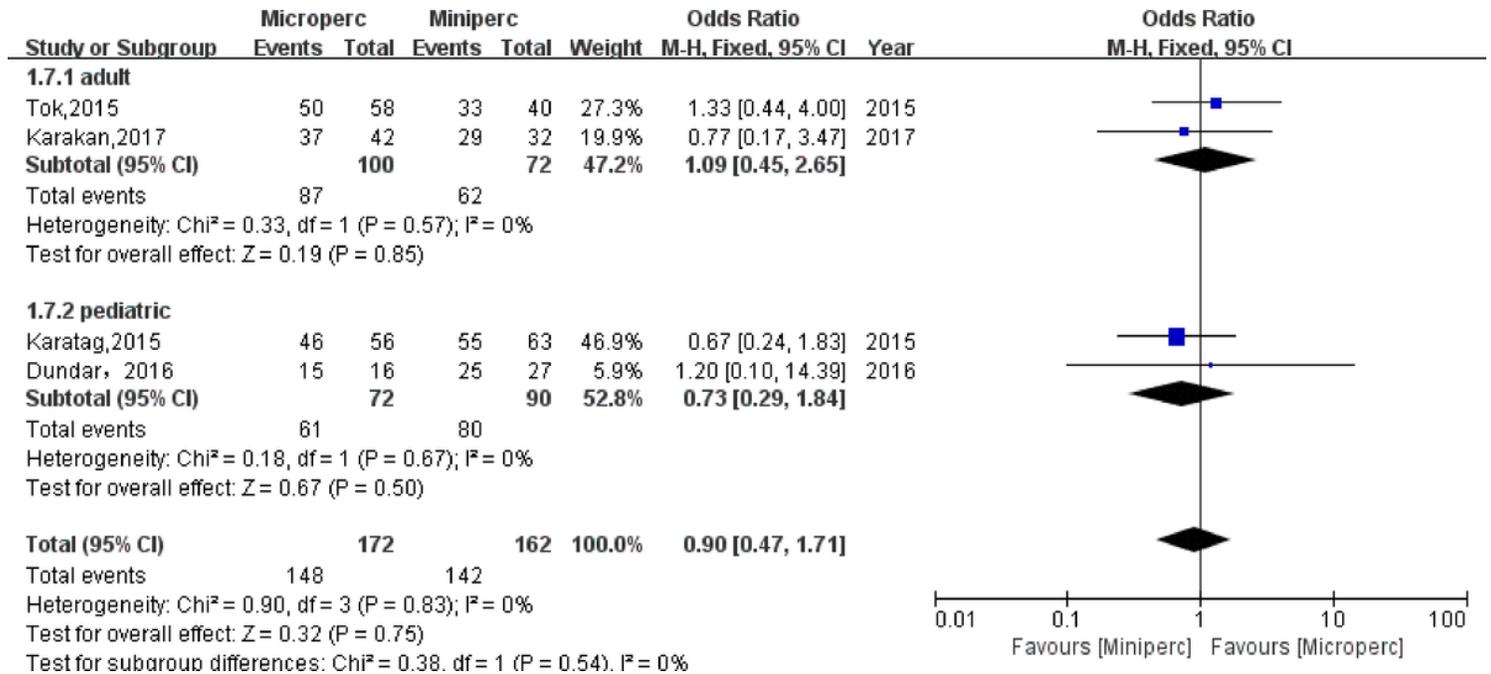


Figure 2

Forest plot for the SFR

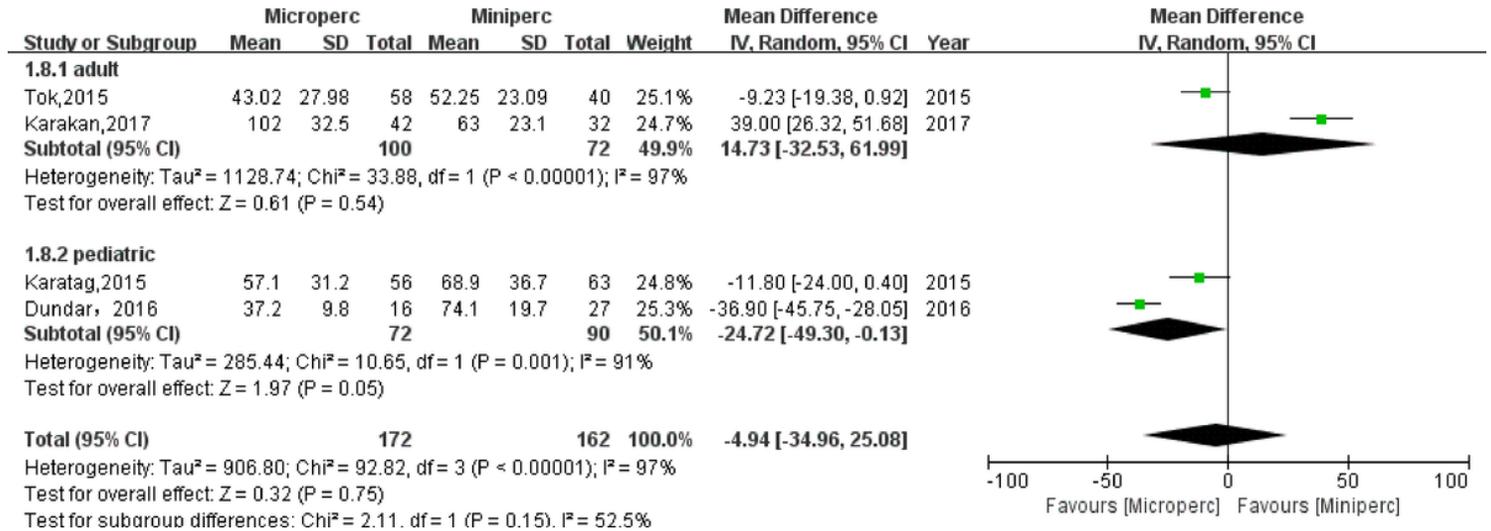


Figure 3

Forest plot for the operation time

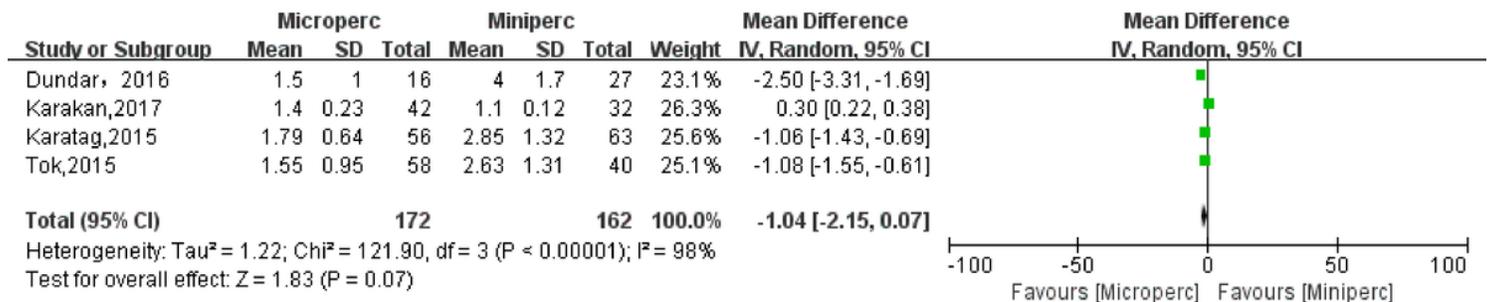


Figure 4

Forest plot for the hospital stay time

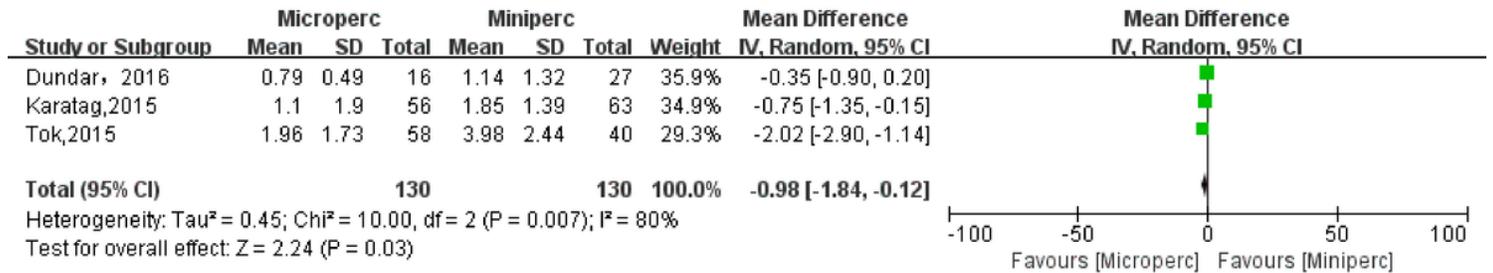


Figure 5

Forest plot for the hemoglobin drop

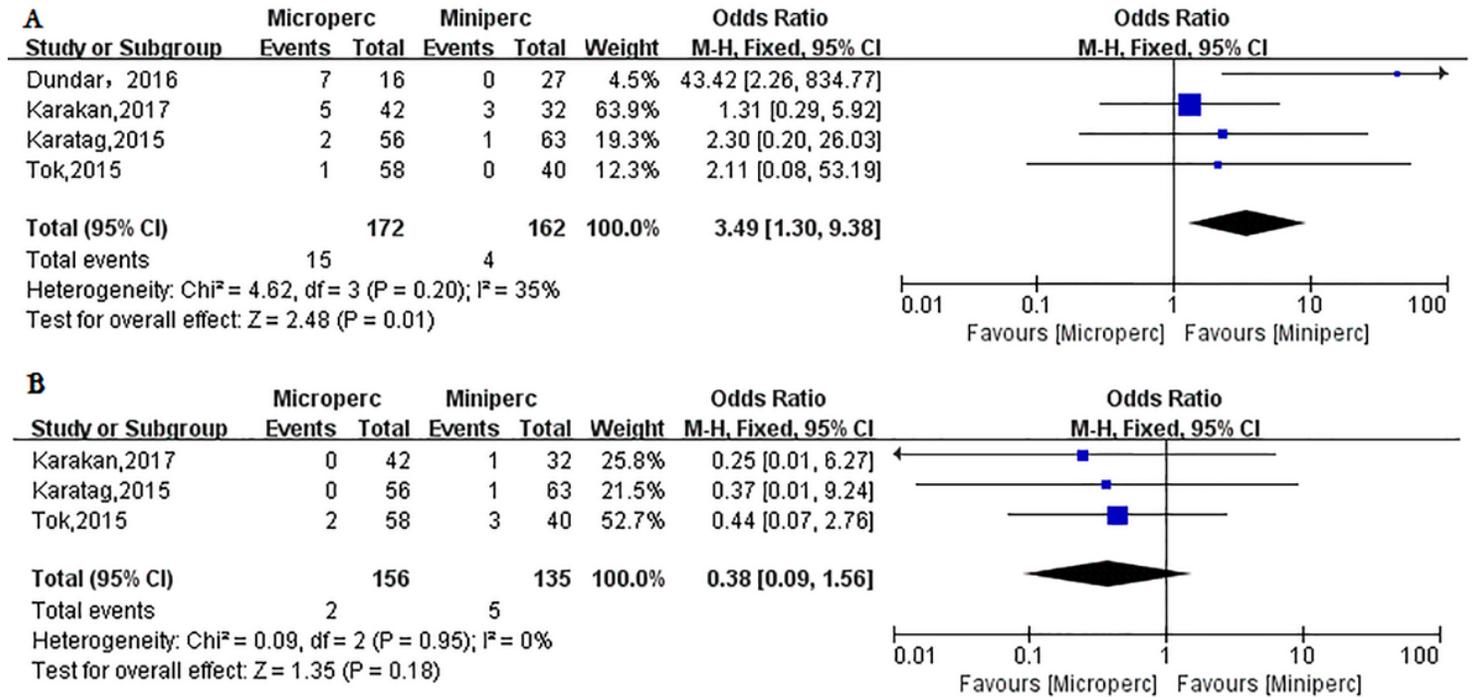


Figure 6

Forest plot for the renal colic requiring D-J stent insertion and urinary tract infection

Supplementary Files

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