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*CORRESPONDENCE Dongqing Zhang zhang68dq@163.com

[†]These authors have contributed equally to this work and share first authorship

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Safety and efficacy of extracorporeal shock wave lithotripsy vs. flexible ureteroscopy in the treatment of urinary calculi: A systematic review and meta-analysis

Guangda Lv^{1†}, Wenqiang Qi^{1†}, Han Gao¹, Yongheng Zhou¹, Minglei Zhong¹, Kai Wang², Yunxing Liu², Qiang Zhang², Changkuo Zhou¹, Yan Li¹, Lingling Zhang³ and Dongging Zhang^{1*}

¹Department of Urology, Qilu Hospital of Shandong University, Jinan, China, ²Department of Urology, The People's Hospital of Xin Tai City, Xintai, China, ³Department of Nursing, Qilu Hospital of Shandong University, Jinan, China

Objective: This study aims to compare the safety and efficacy of extracorporeal shock wave lithotripsy (SWL) and flexible ureteroscopy lithotripsy (f-URS) in treating urinary tract stones.

Methods: We systematically searched PubMed, Embase, and Cochrane for literature comparing SWL with f-URS. The primary outcomes we focused on were stone-free rate (SFR) and complications; the secondary outcomes were operation time, hospital stay, retreatment rate, number of sessions, and auxiliary procedures rate. We used ReviewManager version 5.4.1 and STATA version 14.2 for meta-analysis.

Results: Seventeen studies with a total of 2,265 patients were included in the metaanalysis, including 1,038 patients in the SWL group and 1,227 patients in the f-URS group. The meta-analysis indicated that patients in the f-URS group had higher SFR than those in the SWL group [odds ratio (OR): 2.00, 95% confidence interval (CI): 1.29–3.12, p = 0.002]. In addition, we found no significant difference in complications (OR: 1.08, 95% CI: 0.85–1.37) between the two treatments. Also, we found that the retreatment rate and the auxiliary procedure rate in the f-URS group were significantly lower than those in the SWL group (OR: 0.08, 95% CI: 0.02–0.24, p < 0.00001; OR: 0.30, 95% CI: 0.11–0.83, p = 0.02). Moreover, the number of sessions in the f-URS group was significantly lower than that in the SWL group [mean difference (MD): –1.96, 95% CI: –1.55 to –0.33, p = 0.003]. However, the operation time and hospital stay in the f-URS group were significantly longer than those in the SWL group (MD: 11.24, 95% CI: 3.51–18.56, p = 0.004; MD: 1.14, 95% CI: 0.85–1.42, p < 0.00001).

Conclusion: For 1–2-cm urinary stones, f-URS can achieve a higher SFR than SWL while having a lower retreatment rate, number of sessions, and auxiliary procedure rate. For urinary stones <1 cm, there was no significant difference in SFR between SWL and f-URS groups. The SWL group has a shorter operative time and hospital stay than the f-URS group.

KEYWORDS

extracorporeal shock wave lithotripsy, flexible ureteroscopy (f-URS), urinary calculi, systematic review, meta-analysis

Introduction

Urinary calculus is one of the most common and painful diseases in urology (1). Global warming, high-salt diet, urinary tract infection, genetic factors, and so on are common etiological factors (2). Severe urolithiasis may lead to a lot of damage to patients, such as infections and chronic kidney failure (3). Although stones can be present throughout the entire urinary tract, the most common site is the kidney (4). Kidney stones easily descend to the ureter causing severe pain (5).

Extracorporeal shock wave lithotripsy (SWL) and flexible ureteroscopy (f-URS) are the two most common treatments for kidney and upper ureteral stones smaller than 2 cm in diameter (6). SWL is a noninvasive and anesthesia-free procedure with a stone-free rate (SFR) of around 80%. However, the problems such as high retreatment rate and possible kidney damage cannot be ignored. f-URS is an invasive treatment and requires anesthesia assistance. With the development of endoscopy technology, the quality of f-URS to explore the upper urinary tract has greatly been improved. Experiences showed that f-URS might have a higher SFR and a lower risk of kidney damage and bleeding (7, 8). However, higher medical costs, greater surgical difficulty, and greater risk of ureteral injury limit surgeons' and patients' preference to use it for treatment (9). At present, guidelines no longer consider SWL as the mandatory first choice for the treatment of stones ≤ 2 cm. The prospect of using f-URS to treat stones ≤ 2 cm is promising.

The best treatment for kidney and upper ureteral stones $\leq 2 \text{ cm}$ in diameter is still controversial. Thus, the purpose of this study is to compare the efficacy and safety of SWL and f-URS for the treatment of this kind of stones.

Methods

We conducted and reported this systematic review and metaanalysis based on the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) guidelines and the PRISMA statement (10, 11). Our study has been registered at the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY; https://inplasy.com) under registration number 202240120.

Search strategy

All relevant literature on PubMed, Embase, and Cochrane library database were reviewed. The search strategy design

included studies comparing SWL and f-URS in treating renal stones ≤ 2 cm or upper ureteral stones ≤ 2 cm. The keywords used for the search were "Ureteroscopy," "Lithotripsy," "Extracorporeal Shockwave Lithotripsy," "Calculi," and "Stone." The detailed search strategies can be found in the **Supplementary material**. In addition, we manually searched the reference list of excluded publications to identify any further potential studies.

Selection criteria

Studies meeting the following criteria were included in this review: (1) studies comparing SWL and f-URS in the treatment of patients with calculi; (2) reported outcomes we were interested in SFR, operation time, complication rate, hospital stay, auxiliary procedure rate, and retreatment rate; (3) stones were less than 2 cm in the diameter; and (4) the age of patients were above 18 years.

The exclusion criteria are as follows: (1) case reports, reviews, conference abstracts, and other ineligible article types; (2) outcomes do not contain the contents of section "Effect of treatments"; and (3) not in English.

Data extraction

Two reviewers (GL and WQ) independently assessed all eligible studies. Any discrepancies were resolved by discussion with the third reviewer (HG). Each reviewer independently used well-structured and standardized proformas to extract data from all studies included in our review. The following information was extracted from each study: first author's name, year of publication, study design, stone diameter, stone location, detection of stone, evaluation of the treatments, study population, baseline demographic characteristics, and postoperative outcomes (SFR, complication rate, operation time, hospital stay, auxiliary procedure rate, and retreatment rate).

Outcomes

The main outcomes are SFR and complication rate. The secondary outcomes are operation time, hospital stay, number of sessions, auxiliary procedure rate, and retreatment rate.

Study quality assessment

We used the Cochrane Collaboration's Tool (version 5.3, The Nordic Cochrane Centre, The Cochrane Collaboration, United States) to evaluate the methodological quality of each randomized controlled trial (RCT) (12). Deviation risks were identified from seven aspects using this tool. The Newcastle–Ottawa Quality Assessment Scale (NOS) was used to evaluate the methodological quality of each included cohort studies (13). Studies with a score ≥ 6 were eligible for our meta-analysis.

Statistical analysis

We used odds ratio (OR) and 95% confidence interval (95% CI) to summarize the dichotomous variables, and we used mean difference (MD) and 95% CI to summarize continuous variables, which were presented as mean values with standard deviations (SDs).We did not incorporate the data of studies presenting continuous variables as means and range in the meta-analysis (12).

The Cochrane Q test and I^2 statistics were used to quantify the degree of heterogeneity. I^2 values of 25%, 50%, and 75% represent low, moderate, and substantial heterogeneity, respectively (14). A two-sided *p*-value of less than 0.05 was considered statistically significant. We used the random effects model to estimate pooled effect sizes to reduce possible deviations. Egger's test was used to detect potential publication bias in meta-analyses because it is more sensitive. Publication bias testing is not required when the number of included studies is <10. If Egger's *p* value is <0.05, there is substantial publication bias in meta-analyses (15).

We conducted sensitivity analysis by omitting studies one by one to examine the stability of pooled estimates. If there was no significant difference between the adjusted and primary results, our meta-analysis was stable (12).

To compare the efficacy of SWL and f-URS for stones <1 cm and stones of 1–2 cm, respectively, we performed meta-analyses on these two subgroups. If a study only described stones ≤ 2 cm, the study would not be included in either of the two subgroups. In addition to comparing the different grades of postoperative complications of the two treatments, we performed a meta-analysis on four subgroups. The complication grade was determined according to the Clavien–Dindo classification (16).

All data analysis was performed with ReviewManager software (RevMan version 5.3, The Nordic Cochrane Centre, Cochrane Collaboration, 2014) and STATA (version 14; StataCorp LLC, Texas A&M University, College Station, TX, United States).

Results

Literature search

A flow diagram outlining the literature search is shown in **Figure 1**. Our initial search identified 1,962 records. After checking for duplications and reviewing titles, abstracts, and full texts, we included 17 eligible articles (4, 8, 17–31) in the meta-analysis.

Information of included studies and patients

The baseline characteristics of the included patients are shown in **Table 1**. A total of 2,265 patients were finally enrolled in our meta-analysis, of which 1,227 (54.17%) patients were enrolled in the f-URS group and the other 1,038 (45.83%) patients were enrolled in the SWL group. There were eight RCTs (18, 22, 23, 26–29, 31) and nine cohort studies (4, 8, 17, 19–21, 24, 25, 30) included in the meta-analysis.

Results of studies' quality assessment

The results of the quality assessment of RCTs are shown in **Figure 2**. All except one study of RCTs described specific randomization methods. Only one study described allocation concealment, and no study was double-blinded. Except for one study, others mentioned the blinding of outcome assessment. All studies reported complete outcome data. Six articles mentioned that there was no selective reporting. Other biases were low in one study, high in two studies, and unclear in others. Quality assessment of the cohort studies is presented in **Table 2**. The NOS scores were greater than or equal to 6 in all studies. There were no other risks of bias identified.

Effect of treatments

Stone-free rate

All 17 studies reported SFR in the f-URS group and SWL group. The pooled OR of all 17 studies was 2.31 (95% CI: 1.57–3.40; p < 0.0001), indicating a significantly higher SFR in the f-URS group than that in the SWL group. However, significant heterogeneity was found ($I^2 = 66\%$; p < 0.0001). In the stone 1–2 cm subgroup, we found that SFR was higher in the F-URS group than that in the SWL group (OR: 2.00, 95% CI: 1.29–3.12, p = 0.002). However, in the stone <1 cm subgroup, no significant difference was found between the two treatment groups (OR: 1.49, 95% CI: 0.80–2.77), as

shown in **Figure 3**. No publication bias was found using Egger's test (p = 0.419).

We also performed a subgroup analysis of SFR according to the cutoff time. After 3 months of the surgery, we found that SFR was higher in the f-URS group than that in the SWL group (OR: 2.15, 95% CI: 1.27–3.63, p = 0.004). However, no significant difference was found between the two treatment groups after 1 month of the surgery (OR: 1.51, 95% CI: 0.55–4.14), as shown in **Figure 4**.

Complication rate

All 17 studies reported the complication rate in the f-URS group and SWL group. We found no significant difference between the two treatments in the complication rate (OR: 1.20, 95% CI: 0.86–1.69; p = 0.28), with moderate heterogeneity ($I^2 = 39\%$, p = 0.05). The same is true for the stone 1–2 cm subgroup (OR: 1.16, 95% CI: 0.73–1.84) and the stone <1 cm subgroup (OR: 1.31, 95% CI: 0.62–2.73), as shown in **Figure 5**. No publication bias was found using Egger's test (p = 0.060).



TABLE 1 Baseli	ne characté	eristics of Study	f the inc	TABLE 1 Baseline characteristics of the included patients. Study: Country Study Stone Stone Incerion	Detection of stone	Evaluation of SFR	Endnoint of	4	2	Cender	der	RMI (La/m ²	(a/m ²	Stone size	citae
Annie	Country	otudy design	size	эгоне юсанон	Detection of stone	EVALUATION OF SFR	Endpoint of SFR	A (year, ?	Age (year, $X \pm SD$)	(female/male)	kuer e/male)	$X \pm SD$	кg/ш, SD)	score size $(\text{cm}, X \pm \text{SD})$	size ± SD)
			(cm)					f-URS	SWL	f-URS	SWL	f-URS	SWL	f-URS	SWL
Ahmed R (2012)	Egypt	RECT	1^{-2}	Lower pole stone	Ultrasound, KUB	CT	3 months	47.8 ± 10.7	45.4 ± 11.3	11/26	21/41	26.2 ± 6.8	28.2 ± 4.3	13.1 ± 2.4	13 ± 2.3
Anup Kumar (2015)	India	RCT	1-2	Lower calyceal renal calculi	Ultrasound, KUB, CT	Ultrasound, KUB, CT	3 weeks	33.4 ± 1.4	33.1 ± 1.3	23/20	21/21	23.6 ± 1.1	23.4 ± 1.2	13.1 ± 1.1	13.2 ± 1.2
Anup Kumar (2015)	India	RCT	\Diamond	Lower calyceal stones	Ultrasound, KUB, CT	Ultrasound, KUB, CT	3 weeks	35.6 ± 2.1	37.7 ± 2.4	44/46	46/44	NA	NA	12.3 ± 1.1	12.1 ± 1.2
Bhupendra Pal Singh (2014)	India	RCT	1–2	IC stones	Ultrasound, KUB, IVU, CT (when required)	Ultrasound, KUB	1 month	37.65 ± 11.8	34.5 ± 13.07	13/22	15/20	23.45 ± 3.3	22.7 ± 4.35	15.05 ± 3.56	16.45 ± 2.28
Faruk Ozgor (2018)	Turkey	RECT	1^{-2}	Lower pole stones	IVU or CT	CT, KUB	3 months	45.9 ± 14.7	48.6 ± 14.9	65/63	48/65	26.3 ± 5.1	25.6 ± 5.2	12.1 ± 5	11.3 ± 3.1
G. Bozzini (2017)) Germany	RCT	1-2	A single lower pole stone	KUB or CT	KUB at day 10 and a CT scan after 3 months	10 days and 3 months	55.8 ± 16.1	53.3 ± 14.8	106/101	26/26	NA	NA	14.82 ± 2.7	13.78 ± 3.1
H. Aboutaleb (2012)	Egypt	RECT	1-2	Lower calyceal stones	KUB	KUB	2 weeks and 3 months.	47.2 ± 15.2	53.2 ± 19	6/7	5/19	NA	NA	14.5 ± 3.2	15.6 ± 4.3
Ibrahim Kartal (2020)	Turkey	RECT	1-2	Proximal ureteral stones	KUB, ultrasound, and/or CT	KUB, ultrasound, and/ or CT	15 days and 3 months	44.5 ± 13.1	43.6 ± 12.6	49/152	35/127	25.3 ± 2.7	24.8 ± 2.1	13.6 ± 2.4	13.4 ± 2.6
Luke H. Chan (2017)	Scotland	RECT	1-2	Lower pole stones	KUB, ultrasound or CT	KUB, ultrasound or CT	1 and 3 months	62.2 ± 15	54.1 ± 13.3	10/11	54/144	NA	NA	13.1 ± 3.7	12.4 ± 2.4
Nevzat Can Sener (2014)	r Germany	RCT	$\overline{}$	Lower pole stones	KUB, ultrasound IVU、CT	KUB, ultrasound IVU, CT	3 months	45.4 ± 6.4	42.9±5.6	29/41	39/31	NA	NA	7.8 ± 1.3	8.2 ± 1.2
Nevzat Can Sener (2015)	r United States	RCT	$\overline{}$	Lower pole stones	KUB, IVU and CT	KUB, IVU, and CT	3 months	36.84 ± 11.7	34.5 ± 11.04	15/35	13/37	NA	NA	8.2 ± 1.2	7.9 ± 1.1
Okan Bas (2014)	Germany	RECT	1–2	A single renal pelvis opaque stone	KUB	KUB	1 month	47.2 ± 14.2	46.4 ± 15.1	17/30	24/28	NA	NA	14.8 ± 2.3	15.3 ± 2.1
Pearle, Margaret S (2008)	S United States	RCT	$\overline{}$	Lower pole stones	KUB, CT	KUB, CT	3 months	49.3 ± 14.2	52.5 ± 12.3	18/17	13/19	28.1 ± 6.6	26.9 ± 8.1	NA	NA
R.M. Vilches (2015)	Chile	RCT	$\langle \rangle$	Lower pole stones	fluoroscopy	CT	2 months	43.7 ± 9.2	45.6 ± 13.7	9/15	13/18	26.6 ± 1.5	27.7 ± 3.1	9.7 ± 0.5	9.6 ± 0.6
Ufuk Ozturk (2013)	Turkey	RECT	1-2	Lower pole stones	KUB, ultrasound	KUB	3 months	52	44.2	16/22	98/123	NA	NA	17.3 ± 1.45	17 ± 1.55
Vincent Koo (2011)	UK	RECT	\Diamond	Lower pole r calculi	Ultrasound/CT and/ or KUB	Ultrasound/CT and/or KUB	1 month	56.6 ± 15.9	51.2 ± 14.9	15/22	16/35	NA	NA	8.4±2.5	8.5 ± 3.5
Volkmar Tauber (2015)	Austria	RECT	\Diamond	Renal and ureter	KUB or CT	KUB or CT	2-3 weeks, another 6-12 weeks	NA	NA	60/101	60/105	NA	NA	NA	NA
RCT, randomized wave lithotripsy;	d controlled 1 NA, not avail	rial; RECT able; IC, i	Γ, retrosk nferior c	bective case trial; H alyceal; SFR, stone	RCT, randomized controlled trial: RECT, retrospective case trial: KUB, radiography of kidneys, ureter, anc wave lithotripsy; NA, not available: IC, inferior calyceal: SFR, stone-free rate; IVU, intravenous urography	RCT, randomized controlled trial; RECT, retrospective case trial; KUB, radiography of kidneys, ureter, and bladder; CT, computed tomography; BMI, body mass index; f-URS, flexible ureteroscopy; SWL, extracorporeal shock wave lithotripsy: NA, not available; IC, inferior calyceal; SFR, stone-free rate; IVU, intravenous urography.	; CT, computed t	omography;	BMI, body m	ass index	; f-URS, f	lexible urete	eroscopy; S ¹	ML, extracorp	oreal shock

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TABLE 2 Detailed quality assessment of cohort study.

Items of NOS				St	udies				
	Ahmed R	Faruk Ozgor	H. Aboutaleb	Ibrahim Kartal	Luke H. Chan	Okan Bas	Ufuk Ozturk	Vincent Koo	Volkmar Tauber
Selection									
Representativeness of the exposed cohort	*		*	*	*		*	*	*
Selection of the nonexposed cohort	*	*	*	*		*	*	*	
Ascertainment of exposure		*			*		*		*
Demonstration that outcome of interest was not present at the start of the study	*	*	*	*		*		*	*
Comparability									
Comparability of cohorts on basis of the design or analysis	**	*	*	*	*	*	*	*	
Total	8	6	7	6	6	6	7	6	6

NOS, Newcastle-Ottawa Quality Assessment Scale. One * means one point.

Retreatment rate

Twelve studies reported the retreatment rate in the f-URS group and SWL group. We found that the retreatment rate was significantly lower in the f-URS group than that in the

SWL group (OR: 0.08, 95% CI: 0.02–0.24, p < 0.00001), with high heterogeneity ($I^2 = 91\%$, p < 0.00001). The same is true for the stone 1–2 cm subgroup (OR: 0.04, 95% CI: 0.02–0.08, p < 0.00001) and the stone <1 cm subgroup (OR: 0.09,

A	f-URS		ESWL			Odds Ratio	Odds Ratio
Study or Subgroup	Events		Events			M-H, Random, 95% Cl	M-H, Random, 95% Cl
Ahmed R 2012	32	37	42	62	5.6%	3.05 [1.03, 9.00]	
Anup Kumar1 2015	37	43	31	42	5.5%	2.19 [0.73, 6.60]	
Anup Kumar2 2015	78	90	74	90	7.0%	1.41 [0.62, 3.17]	
Bhupendra Pal Singh 2014	29	35	17	35	5.5%	5.12 [1.70, 15.39]	
Faruk Ozgor 2018	114	128	88	113	7.5%	2.31 [1.14, 4.71]	
G. Bozzini 2017	170	207 13	120 15	194 24	8.8%	2.83 [1.79, 4.48]	
H. Aboutaleb 2012	11 195	201			3.4%	3.30 [0.59, 18.40]	
Ibrahim Kartal 2020 Luke H. Chan 2017	195	201	128 124	162 198	6.5% 6.2%	8.63 [3.52, 21.15] 1.19 [0.46, 3.09]	
Nevzat Can Sener 2014	70	70	64	70	1.5%	14.21 [0.78, 257.26]	
Nevzat Can Sener 2014	46	50	46	50	4.2%	1.00 [0.24, 4.24]	
Okan Bas 2014	40	47	40	52	4.2%	1.67 [0.46, 6.12]	
Pearle, Margaret S 2008	23	35	17	32	6.1%	1.69 [0.63, 4.53]	
R.M. Vilches 2015	17	24	15	31	5.4%	2.59 [0.84, 8.00]	
Ufuk Ozturk 2013	28	38	168	221	7.1%	0.88 [0.40, 1.94]	
Vincent Koo 2011	24	37	38	51	6.4%	0.63 [0.25, 1.59]	
Volkmar Tauber 2015	134	161	71	165	8.5%	6.57 [3.92, 11.00]	
	101			100	0.070		
Total (95% CI)		1237		1592	100.0%	2.31 [1.57, 3.40]	•
Total events	1065		1103				
Heterogeneity: Tau ² = 0.39;	Chi ² = 46.5	7. df =		0001):	$ ^2 = 66\%$		
Test for overall effect: Z = 4.				1.			0.01 0.1 1 10 100 Favours [experimental] Favours [control]
Study or Subgroup 1.1.1 1-2cm	Experime Events		Contr Events		Weight	Odds Ratio M-H, Random, 95% C	Odds Ratio I M-H, Random, 95% Cl
Ahmed R 2012	32	37	42	62	5.2%	3.05 [1.03, 9.00]	
Anup Kumar1 2015	37	43	31	42	5.1%	2.19 [0.73, 6.60]	
Anup Kumar2.1 2015	35	39	29	35	4.2%	1.81 [0.47, 7.04]	
Bhupendra Pal Singh 2014	170	207	120	194	7.9%	2.83 [1.79, 4.48]	_
Faruk Ozgor 2018	11	13	15	24	3.2%	3.30 [0.59, 18.40]	
G. Bozzini 2017	195	201	128	162	6.0%	8.63 [3.52, 21.15]	
H. Aboutaleb 2012	14	21	124	198	5.7%	1.19 [0.46, 3.09]	
Ibrahim Kartal 2020	43	47	45	52	4.4%	1.67 [0.46, 6.12]	
Luke H. Chan 2017	28	38	168	221	6.5%	0.88 [0.40, 1.94]	
	10	47	45	52	4.4%	1.67 [0.46, 6.12]	
Okan Bas 2014	43	47					
Ufuk Ozturk 2013	43 28	38	168	221	6.5%	0.88 [0.40, 1.94]	
Ufuk Ozturk 2013 Subtotal (95% Cl)	28			221 1263	6.5% 58.8%	0.88 [0.40, 1.94] 2.00 [1.29, 3.12]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events	28 636	38 731	915	1263	58.8%		
Ufuk Ozturk 2013 Subtotal (95% Cl)	28 636 Chi² = 23.03	38 731 3, df = 1	915	1263	58.8%		•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.0 1.1.2 <1cm	28 636 Chi² = 23.03 08 (P = 0.00	38 731 3, df = 1 02)	915 0 (P = 0.0	1263)1); I² =	58.8% = 57%	2.00 [1.29, 3.12]	•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.0 1.1.2 <1cm Anup Kumar2.2 2015	28 636 Chi ² = 23.03 08 (P = 0.00 43	38 731 3, df = 1 02) 51	915 0 (P = 0.0 45	1263 01); I ² = 55	58.8% 57% 5.4%	2.00 [1.29, 3.12] 1.19 [0.43, 3.31]	•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.0 1.1.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014	28 636 Chi ² = 23.03 08 (P = 0.00 43 70	38 731 3, df = 1 02) 51 70	915 0 (P = 0.0 45 64	1263 01); l² = 55 70	58.8% = 57% 5.4% 1.4%	2.00 [1.29, 3.12] 1.19 [0.43, 3.31] 14.21 [0.78, 257.26]	•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.0 1.1.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015	28 636 Chi ² = 23.03 08 (P = 0.00 43 70 46	38 731 3, df = 1 02) 51 70 50	915 0 (P = 0.0 45 64 46	1263 01); l ² = 55 70 50	58.8% 57% 5.4% 1.4% 3.9%	2.00 [1.29, 3.12] 1.19 [0.43, 3.31] 14.21 [0.78, 257.26] 1.00 [0.24, 4.24]	•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.0 1.1.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI)	28 636 Chi ² = 23.03 08 (P = 0.00 43 70 46 23	38 731 3, df = 1 02) 51 70	915 0 (P = 0.0 45 64 46 17	1263 01); l² = 55 70	58.8% 57% 5.4% 1.4% 3.9% 5.6%	2.00 [1.29, 3.12] 1.19 [0.43, 3.31] 14.21 [0.78, 257.26]	•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.(1.1.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Total events	28 636 Chi ² = 23.03 08 (P = 0.00 43 70 46 23 182	38 731 3, df = 1 02) 51 70 50 35 206	915 0 (P = 0.0 45 64 46 17 172	1263 01); ² = 55 70 50 32 207	58.8% 57% 5.4% 1.4% 3.9% 5.6% 16.4%	2.00 [1.29, 3.12] 1.19 [0.43, 3.31] 14.21 [0.78, 257.26] 1.00 [0.24, 4.24] 1.69 [0.63, 4.53]	•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.0 1.1.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI)	28 636 Chi ² = 23.03 08 (P = 0.00 43 70 46 23 182 Chi ² = 3.01,	38 731 3, df = 1 02) 51 70 50 35 206 , df = 3	915 0 (P = 0.0 45 64 46 17 172	1263 01); ² = 55 70 50 32 207	58.8% 57% 5.4% 1.4% 3.9% 5.6% 16.4%	2.00 [1.29, 3.12] 1.19 [0.43, 3.31] 14.21 [0.78, 257.26] 1.00 [0.24, 4.24] 1.69 [0.63, 4.53]	•
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.29; (Test for overall effect: Z = 3.0 1.1.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2015 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.00; (28 636 Chi ² = 23.03 08 (P = 0.00 43 70 46 23 182 Chi ² = 3.01,	38 731 3, df = 1 02) 51 70 50 35 206 , df = 3	915 0 (P = 0.0 45 64 46 17 172	1263 01); ² = 55 70 50 32 207	58.8% 57% 5.4% 1.4% 3.9% 5.6% 16.4%	2.00 [1.29, 3.12] 1.19 [0.43, 3.31] 14.21 [0.78, 257.26] 1.00 [0.24, 4.24] 1.69 [0.63, 4.53]	•

95% CI: 0.02–0.37, p = 0.0008). As shown in **Figure 6**, no publication bias was found using Egger's test (p = 0.321).

Auxiliary procedure rate

Twelve studies reported the auxiliary procedure rate in the f-URS group and SWL group. We found that the auxiliary procedure rate was significantly lower in the f-URS group than that in the SWL group (OR: 0.30, 95% CI: 0.11–0.83, p = 0.02), with high heterogeneity ($I^2 = 88\%$, p < 0.00001). The same is true for the stone of 1–2 cm subgroup (OR: 0.23, 95% CI: 0.07–0.74, p = 0.01). However, we did not find significant differences between the two groups in the stone <1 cm subgroup (OR: 0.42, 95% CI: 0.13–1.35, p = 0.15), as shown in **Figure 7**. No publication bias was found using Egger's test (p = 0.275).

	Experim		Contr			Odds Ratio	Odds I		
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% C	I M-H, Rando	om, 95% Cl	
1.1 3 months									
Ahmed R 2012	32	37	42	62	6.1%	3.05 [1.03, 9.00]	F		
Anup Kumar1 2015	37	43	31	42	6.0%	2.19 [0.73, 6.60]	+		
Anup Kumar2 2015	78	90	74	90	7.3%	1.41 [0.62, 3.17]	-+	-	
Faruk Ozgor 2018	11	13	15	24	3.9%	3.30 [0.59, 18.40]	-+		
G. Bozzini 2017	195	201	128	162	7.0%	8.63 [3.52, 21.15]			
I. Aboutaleb 2012	14	21	124	198	6.7%	1.19 [0.46, 3.09]			
brahim Kartal 2020	43	47	45	52	5.2%	1.67 [0.46, 6.12]			
uke H. Chan 2017.	28	38	168	221	7.5%	0.88 [0.40, 1.94]			
Vevzat Can Sener 2014	70	70	64	70	1.8%	14.21 [0.78, 257.26]	+		
Vevzat Can Sener 2015	46	50	46	50	4.7%	1.00 [0.24, 4.24]			
Pearle, Margaret S 2008	23	35	17	32	6.6%	1.69 [0.63, 4.53]	-+		
Jfuk Ozturk 2013	28	38	168	221	7.5%	0.88 [0.40, 1.94]			
/olkmar Tauber 2015	134	161	71	165	8.7%	6.57 [3.92, 11.00]		• <u> </u>	
Subtotal (95% CI)		844		1389	79.0%	2.15 [1.27, 3.63]		•	
otal events	739		993						
Test for overall effect: Z = 2.		,							
3hupendra Pal Singh 2014	170	207	120	194	8.9%	2.83 [1.79, 4.48]			
0kan Bas 2014	43	47	45	52	5.2%	1.67 [0.46, 6.12]			
/incent Koo 2011	24	37	38	51	6.8%	0.63 [0.25, 1.59]		_	
Subtotal (95% CI)		291		297	21.0%	1.51 [0.55, 4.14]			
otal events	237		203						
leterogeneity: Tau ² = 0.58; est for overall effect: Z = 0.			P = 0.02)	; l² = 76	5%				
otal (95% Cl)		1135		1686	100.0%	2.00 [1.29, 3.08]		•	
otal events	976		1196						
leterogeneity: Tau ² = 0.49;			5 (P < 0.0	00001);	l² = 71%		0.01 0.1 1	10	100
est for overall effect: Z = 3. Test for subaroup difference	``	,	1 (P = 0.5	i4). I² =	0%		Favours [experimental]		100
E 4									
	of shows	fue e uni	to for (A)	7 mo	nthe ofte	r the current and (P)	subgroups of the stope fr	a rata of 1 month	oftor
st plot and meta-analysis	of stone-	Iree ra	LE IOI IAI	5 110	nuns ane			Se rate of T month	

Operation time

Eleven studies reported operation time in the f-URS group and SWL group. We found that the operation time was significantly longer in the f-URS group than that in the SWL group (MD: 11.24, 95% CI: 3.51-18.96, p = 0.004), with significant heterogeneity ($I^2 = 100\%$, p < 0.00001). However, we did not find significant differences between the two groups in the stone <1 cm subgroup (MD: 6.95, 95% CI: -1.89 to 15.79, p = 0.12) and the stone 1-2 cm subgroup (MD: 5.94, 95% CI: -28.98 to 40.86, p = 0.74), as shown in **Figure 8**. No publication bias was found using Egger's test (p = 0.167).

Hospital stay

Seven studies reported the length of hospitalization stay in the f-URS and the ESWL group. We found that the hospital stay was significantly longer in the F-URS group than that in the SWL group (MD: 1.14, 95% CI: 0.85-1.42, p < 0.00001),

with a significant heterogeneity ($I^2 = 93\%$, p < 0.00001), as shown in Figure 9.

Number of sessions

Eight studies reported the number of sessions in the f-URS group and SWL group. We found that the number of sessions in the f-URS group was significantly less than that in the SWL group (MD: -1.15, 95% CI: -1.54 to -0.77, p < 0.00001), with a significant heterogeneity ($I^2 = 98\%$, p < 0.00001), as shown in **Figure 10**. The same is true in the stone <1 cm subgroup (MD: -1.17, 95% CI: -1.64 to -0.71, p < 0.00001), but we did not find significant differences between the two groups in the stone 1–2 cm subgroup (MD: -1.09, 95% CI: -2.29 to 0.10, p = 0.07).

Subgroup analysis

To compare the incidence of complications of different grades between the two groups, we graded postoperative

	f-UR		ESWI			Odds Ratio	Odds Ratio
Study or Subgroup	Events					M-H, Random, 95% CI	M-H, Random, 95% Cl
Ahmed R 2012	5	37	3	62	3.9%	3.07 [0.69, 13.70]	
Anup Kumar1 2015	4	43	3	42	3.7%	1.33 [0.28, 6.35]	
Anup Kumar2 2015	10	90	6	90	6.4%	1.75 [0.61, 5.04]	
Bhupendra Pal Singh 2014	11	35	17	35	7.0%	0.49 [0.18, 1.29]	
Faruk Ozgor 2018	20	128	17	113	9.7%	1.05 [0.52, 2.11]	
G. Bozzini 2017	30	207	13	194	10.0%	2.36 [1.19, 4.67]	
H. Aboutaleb 2012	6	13	10	24	4.5%	1.20 [0.31, 4.67]	
brahim Kartal 2020	27	201	40	162	11.7%	0.47 [0.28, 0.81]	
Luke H. Chan 2017	2	21	6	198	3.3%	3.37 [0.64, 17.86]	
Nevzat Can Sener 2014	3	70	4	70	3.8%	0.74 [0.16, 3.43]	
Nevzat Can Sener 2015	7	50	3	50	4.3%	2.55 [0.62, 10.49]	
Okan Bas 2014	3	47	4	52	3.7%	0.82 [0.17, 3.86]	
Pearle, Margaret S 2008	7	35	7	32	5.5%	0.89 [0.27, 2.90]	
R.M. Vilches 2015	9	24	5	31	5.0%	3.12 [0.88, 11.05]	
Jfuk Ozturk 2013	2	38	7	221	3.5%	1.70 [0.34, 8.50]	
Vincent Koo 2011	4	37	4	51	4.1%	1.42 [0.33, 6.11]	
/olkmar Tauber 2015	17	161	19	165	9.8%	0.91 [0.45, 1.82]	
Fotal (95% CI)		1237		1592	100.0%	1.20 [0.86, 1.69]	•
Total events	167		168				
Test for overall effect: Z = 1.	07 (P = 0.2	28)					0.01 0.1 1 10 100 Favours [experimental] Favours [control]
	07 (P = 0.2	28)					
		,	Cont	rol		Odds Ratio	
3	07 (P = 0.2 Experim Events	ental	Cont		Weight	Odds Ratio M-H. Random, 95% C	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup	Experim	ental			Weight		Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup	Experim	ental		Total			Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup I.2.1 1-2cm Ahmed R 2012	Experim Events	iental Total	Events	Total	3.6%	M-H. Random, 95% C 3.07 [0.69, 13.70]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup I.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015	Experim Events	iental <u>Total</u> 37	Events 3	<u>Total</u> 62 42	3.6% 3.3%	M-H, Random, 95% C	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015	Experim Events 5 4	iental <u>Total</u> 37 43	Events 3 3	<u>Total</u> 62 42	3.6% 3.3% 4.7%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014	Experim Events 5 4 7	iental Total 37 43 39	Events 3 3 5	Total 62 42 35	3.6% 3.3% 4.7% 6.6%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018	Experim Events 5 4 7 11	eental Total 37 43 39 35	Events 3 3 5 17	Total 62 42 35 35 113	3.6% 3.3% 4.7% 6.6% 9.3%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar2.1 2015 Anup Kumar2.1 2015 Shupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017	Experim Events 5 4 7 11 20	ental Total 37 43 39 35 128	Events 3 3 5 17 17	Total 62 42 35 35 113 194	3.6% 3.3% 4.7% 6.6% 9.3% 9.6%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 3. Bozzini 2017 H. Aboutaleb 2012	Experim Events 5 4 7 11 20 30	ental Total 37 43 39 35 128 207	Events 3 3 5 17 17 13	Total 62 42 35 35 113 194 24	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017 1. Aboutaleb 2012 brahim Kartal 2020	Experim Events 5 4 7 11 20 30 6	ental <u>Total</u> 37 43 39 35 128 207 13	Events 3 3 5 17 17 13 10	Total 62 42 35 35 113 194 24 162	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017 H. Aboutaleb 2012 brahim Kartal 2020 Luke H. Chan 2017	Experim Events 5 4 7 11 20 30 6 27	ental Total 37 43 39 35 128 207 13 201	Events 3 3 5 17 17 17 13 10 40	Total 62 42 35 113 194 24 162 198	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5% 3.0%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67] 0.47 [0.28, 0.81]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017 H. Aboutaleb 2012 Ibrahim Kartal 2020 Luke H. Chan 2017 Okan Bas 2014	Experim Events 5 4 7 11 20 30 6 27 2	rental Total 37 43 39 35 128 207 13 201 21	Events 3 5 17 17 13 10 40 6	Total 62 42 35 113 194 24 162 198 52	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5% 3.0%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67] 0.47 [0.28, 0.81] 3.37 [0.64, 17.86]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 3. Bozzini 2017 H. Aboutaleb 2012 brahim Kartal 2020 Luke H. Chan 2017 Dkan Bas 2014 Jfuk Ozturk 2013	Experim Events 5 4 7 11 20 30 6 6 27 2 2 3	rental Total 37 43 39 35 128 207 13 201 21 47	Events 3 3 5 17 17 13 10 40 6 4	Total 62 42 35 113 194 24 162 198 52	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5% 3.0% 3.4% 3.2%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67] 0.47 [0.28, 0.81] 3.37 [0.64, 17.86] 0.82 [0.17, 3.86]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017 H. Aboutaleb 2012 brahim Kartal 2020 Luke H. Chan 2017 Dkan Bas 2014 Juk Ozturk 2013 Subtotal (95% CI)	Experim Events 5 4 7 11 20 30 6 6 27 2 2 3	eental Total 37 43 39 35 128 207 13 201 21 21 47 38	Events 3 3 5 17 17 13 10 40 6 4	Total 62 42 35 35 113 194 24 162 198 52 221	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5% 3.0% 3.4% 3.2%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67] 0.47 [0.28, 0.81] 3.37 [0.64, 17.86] 0.82 [0.17, 3.86] 1.70 [0.34, 8.50]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017 H. Aboutaleb 2012 Ibrahim Kartal 2020 Luke H. Chan 2017 Okan Bas 2014 Ufuk Ozturk 2013 Subtotal (95% CI) Total events	Experim Events 5 4 7 11 20 30 6 27 2 3 2 3 2 117	eental Total 37 43 39 35 128 207 13 201 21 47 38 809	Events 3 3 5 17 17 17 13 10 40 6 44 7 125	Total 62 42 35 35 113 194 24 162 198 52 221 1138	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5% 3.0% 3.4% 3.2% 62.2%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67] 0.47 [0.28, 0.81] 3.37 [0.64, 17.86] 0.82 [0.17, 3.86] 1.70 [0.34, 8.50]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017 H. Aboutaleb 2012 Ibrahim Kartal 2020 Luke H. Chan 2017 Okan Bas 2014 Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.28; 4	Experim Events 5 4 7 11 20 30 6 27 2 3 2 2 117 Chi ² = 20.6	ental Total 37 43 39 35 128 207 13 201 21 47 380 809 3, df =	Events 3 3 5 17 17 17 13 10 40 6 44 7 125	Total 62 42 35 35 113 194 24 162 198 52 221 1138	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5% 3.0% 3.4% 3.2% 62.2%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67] 0.47 [0.28, 0.81] 3.37 [0.64, 17.86] 0.82 [0.17, 3.86] 1.70 [0.34, 8.50]	Favours [experimental] Favours [control] Odds Ratio
Study or Subgroup 1.2.1 1-2cm Ahmed R 2012 Anup Kumar1 2015 Anup Kumar2.1 2015 Bhupendra Pal Singh 2014 Faruk Ozgor 2018 G. Bozzini 2017 H. Aboutaleb 2012 Ibrahim Kartal 2020 Luke H. Chan 2017 Okan Bas 2014 Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.28; + Test for overall effect: Z = 0.4 1.2.2 <1cm	Experim Events 5 4 7 11 20 30 6 27 2 3 2 2 117 Chi ² = 20.6	ental Total 37 43 39 35 128 207 13 201 21 47 380 809 3, df =	Events 3 3 5 17 17 17 13 10 40 6 44 7 125	Total 62 42 35 35 113 194 24 162 198 52 221 1138	3.6% 3.3% 4.7% 6.6% 9.3% 9.6% 4.1% 11.5% 3.0% 3.4% 3.2% 62.2%	M-H, Random, 95% C 3.07 [0.69, 13.70] 1.33 [0.28, 6.35] 1.31 [0.38, 4.59] 0.49 [0.18, 1.29] 1.05 [0.52, 2.11] 2.36 [1.19, 4.67] 1.20 [0.31, 4.67] 0.47 [0.28, 0.81] 3.37 [0.64, 17.86] 0.82 [0.17, 3.86] 1.70 [0.34, 8.50]	Favours [experimental] Favours [control] Odds Ratio

Anup Kumar2.2 2015 1.7% 3.38 [0.34, 33.54] 3 51 1 55 Nevzat Can Sener 2014 3 70 4 70 3.4% 0.74 [0.16, 3.43] Nevzat Can Sener 2015 7 50 3 50 3.9% 2.55 [0.62, 10.49] Pearle, Margaret S 2008 35 7 32 5.1% 0.89 [0.27, 2.90] Subtotal (95% CI) 206 207 14.1% 1.31 [0.62, 2.73] Total events 20 15 Heterogeneity: Tau² = 0.00; Chi² = 2.45, df = 3 (P = 0.48); l² = 0% Test for overall effect: Z = 0.71 (P = 0.48) FIGURE 5 Forest plot and meta-analysis of complications rate for (A) all studies and (B) subgroups of stone length 1–2 cm and <1 cm for f-URS and SWL.

complications to grades 1, 2, 3, and 4 according to the Clavien-Dindo classification and performed a subgroup analysis (16). We found that there was no significant difference between the two groups in grade 1, 3, and 4 subgroups (OR: 1.16, 95% CI: 0.76–1.75; OR: 1.04, 95% CI: 0.53–2.03; OR: 8.34, 95% CI: 0.69–100.83), but the grade 2 complication rate in the f-URS was higher than that in the SWL group (OR: 2.11, 95% CI: 1.22–3.64), as shown in **Figure 11**.

Sensitivity analysis

Sensitivity analysis was conducted by omitting studies one by one. The pooled ORs based on the remaining studies in every group of meta-analysis were not out of the estimated range, as shown in **Figure 12**. No substantial variation was found between the adjusted and primary pooled estimates. Therefore, the strong robustness of our meta-analysis was confirmed.



Discussion

The incidence of urolithiasis is increasing yearly worldwide, and its treatment methods and equipment are also constantly developing (32). The EAU guidelines point out that SWL and f-URS are optional treatments for nephrolithiasis $\leq 2 \text{ cm}$ (33), and both treatments can achieve good SFR in the treatment of noninferior calyceal calculi $\leq 2 \text{ cm}$. In the management of ureteral stones, the SFR of SWL and f-URS is similar; however, it is easier to remove stones at one time with f-URS, but it has more complications (34).

Herout et al. found that, in Germany, although the incidence of urolithiasis has increased year by year and the number of surgeries to treat urolithiasis has also increased,

the overall number of SWL has decreased and the proportion of SWL as an outpatient surgery has gradually increased. In contrast, the number of f-URS has increased significantly (35). The meta-analysis results of Mi et al. also found that for 1–2 cm urinary calculi, f-URS had higher SFR, lower auxiliary procedure rate, and lower retreatment rate than SWL (36). It seems that SWL has fallen behind f-URS in terms of safety and efficacy. However, the meta-analysis by Mi et al. was performed a long time ago, during which new studies on SWL and f-URS were published. Our work is to discuss the current safety and efficacy comparison between SWL and f-URS by collecting studies comparing SWL and f-URS in treating urolithiasis in recent years.

4	f-URS		ESWI			Odds Ratio	Odds Ratio
Study or Subgroup	Events					M-H, Random, 95% Cl	M-H, Random, 95% Cl
Ahmed R 2012	4	37	10	62	9.1%	0.63 [0.18, 2.18]	
Anup Kumar1 2015	4	43	8	42	9.0%	0.44 [0.12, 1.58]	
Anup Kumar2 2015	16	90	19	90	9.9%	0.81 [0.39, 1.69]	
Bhupendra Pal Singh 2014	3	35	16	35	8.9%	0.11 [0.03, 0.43]	
G. Bozzini 2017	18	207	151	194	10.1%	0.03 [0.02, 0.05]	
brahim Kartal 2020	9	201	42	162	9.9%	0.13 [0.06, 0.29]	
Luke H. Chan 2017	2	21	16	198	8.5%	1.20 [0.26, 5.61]	
Nevzat Can Sener 2014	0	70	6	70	5.7%	0.07 [0.00, 1.27]	<hr/>
Nevzat Can Sener 2015	4	50	3	50	8.5%	1.36 [0.29, 6.43]	
Pearle, Margaret S 2008	0	35	3	32	5.5%	0.12 [0.01, 2.39]	· · · · · · · · · · · · · · · · · · ·
Ufuk Ozturk 2013	0	38	53	221	5.9%	0.04 [0.00, 0.68]	·
Vincent Koo 2011	8	37	4	51	9.0%	3.24 [0.90, 11.73]	
Total (95% CI)		864		1207	100.0%	0.30 [0.11, 0.83]	
Total events	68		331				
Heterogeneity: Tau ² = 2.61;		6. df = 1		00001	; l ² = 88%		
Test for overall effect: Z = 2.				,			0.01 0.1 1 10 100
							Favours [experimental] Favours [control]
3	Experime	ental	Cont	rol		Odds Ratio	Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% Cl	M-H, Random, 95% Cl
1.4.1 1-2cm							
Ahmed R 2012	4	37	10	62	7.7%	0.63 [0.18, 2.18]	
Anup Kumar1 2015	4	43	8	42	7.6%	0.44 [0.12, 1.58]	
Anup Kumar2.1 2015	12	39	10	35	8.1%	1.11 [0.41, 3.02]	
Bhupendra Pal Singh 2014	3	35	16	35	7.5%	0.11 [0.03, 0.43]	
G. Bozzini 2017	18	207	151	194	8.6%	0.03 [0.02, 0.05]	
Ibrahim Kartal 2020	9	201	42	162		0.13 [0.06, 0.29]	
	2	21	16	198	7.1%	1.20 [0.26, 5.61]	
				221	4.8%	0.04 [0.00, 0.68]	
		38					
Luke H. Chan 2017 Ufuk Ozturk 2013 Subtotal (95% CI)	0	38 621	53				
Ufuk Ozturk 2013 Subtotal (95% Cl)	0	38 621		949	59.9%	0.23 [0.07, 0.74]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events	0 52	621	306	949	59.9%		
Ufuk Ozturk 2013 Subtotal (95% Cl) Total events Heterogeneity: Tau ² = 2.33; (0 52 Chi² = 63.07	621 7, df = 7	306	949	59.9%		
Ufuk Ozturk 2013 Subtotal (95% CI) Total events	0 52 Chi² = 63.07	621 7, df = 7	306	949	59.9%		
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4	0 52 Chi² = 63.07	621 7, df = 7	306	949	59.9%		
Ufuk Ozturk 2013 Subtotal (95% Cl) Total events Heterogeneity: Tau ² = 2.33; (0 52 Chi² = 63.07	621 7, df = 7	306	949	59.9%	0.23 [0.07, 0.74]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm	0 52 Chi² = 63.07 47 (P = 0.01	621 7, df = 7	306 (P < 0.00	949 0001);	59.9%	0.23 [0.07, 0.74]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014	0 52 Chi² = 63.07 47 (P = 0.01 4	621 7, df = 7) 51	306 (P < 0.00	949 0001); I 55	59.9% 1 ² = 89% 7.7%	0.23 [0.07, 0.74]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015	0 52 Chi ² = 63.07 47 (P = 0.01 4 0	621 7, df = 7 1) 51 70	306 (P < 0.00 9 6	949 0001); 55 70	59.9% ¹² = 89% 7.7% 4.7%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015	0 52 Chi ² = 63.07 47 (P = 0.01 4 0 4	621 7, df = 7 1) 51 70 50	306 (P < 0.00 9 6 3	949 0001); 55 70 50	59.9% ¹² = 89% 7.7% 4.7% 7.1%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27] 1.36 [0.29, 6.43]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015 Pearle, Margaret S 2008	0 52 Chi ² = 63.07 47 (P = 0.01 4 0 4	621 7, df = 7 1) 51 70 50 35	306 (P < 0.00 9 6 3	949 0001); 1 55 70 50 32	59.9% ² = 89% 7.7% 4.7% 7.1% 4.5%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27] 1.36 [0.29, 6.43] 0.12 [0.01, 2.39]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Total events	0 52 Chi ² = 63.07 47 (P = 0.01 4 0 4 0 8	621 7, df = 7 1) 51 70 50 35 206	306 (P < 0.00 9 6 3 3 21	949 0001); 1 55 70 50 32 207	59.9% ¹² = 89% 7.7% 4.7% 7.1% 4.5% 24.0%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27] 1.36 [0.29, 6.43] 0.12 [0.01, 2.39]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2015 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.47; (0 52 Chi ² = 63.07 47 (P = 0.01 4 0 4 0 8 Chi ² = 4.47,	621 7, df = 7 1) 51 70 50 35 206 df = 3 (306 (P < 0.00 9 6 3 3 21	949 0001); 1 55 70 50 32 207	59.9% ¹² = 89% 7.7% 4.7% 7.1% 4.5% 24.0%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27] 1.36 [0.29, 6.43] 0.12 [0.01, 2.39]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2014 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Total events	0 52 Chi ² = 63.07 47 (P = 0.01 4 0 4 0 8 Chi ² = 4.47,	621 7, df = 7 1) 51 70 50 35 206 df = 3 (306 (P < 0.00 9 6 3 3 21	949 0001); 1 55 70 50 32 207	59.9% ¹² = 89% 7.7% 4.7% 7.1% 4.5% 24.0%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27] 1.36 [0.29, 6.43] 0.12 [0.01, 2.39]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2015 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.47; (0 52 Chi ² = 63.07 47 (P = 0.01 4 0 4 0 8 Chi ² = 4.47,	621 7, df = 7 1) 51 70 50 35 206 df = 3 (306 (P < 0.00 9 6 3 3 21	949 0001); 1 55 70 50 32 207	59.9% ¹² = 89% 7.7% 4.7% 7.1% 4.5% 24.0%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27] 1.36 [0.29, 6.43] 0.12 [0.01, 2.39]	
Ufuk Ozturk 2013 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 2.33; (Test for overall effect: Z = 2.4 1.4.2 <1cm Anup Kumar2.2 2015 Nevzat Can Sener 2015 Nevzat Can Sener 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Total events Heterogeneity: Tau ² = 0.47; (0 52 Chi ² = 63.07 47 (P = 0.01 4 0 4 0 8 Chi ² = 4.47,	621 7, df = 7 1) 51 70 50 35 206 df = 3 (306 (P < 0.00 9 6 3 3 21	949 0001); 1 55 70 50 32 207	59.9% ¹² = 89% 7.7% 4.7% 7.1% 4.5% 24.0%	0.23 [0.07, 0.74] 0.43 [0.13, 1.51] 0.07 [0.00, 1.27] 1.36 [0.29, 6.43] 0.12 [0.01, 2.39]	

In our included studies, some provided more precise descriptions of stone length (the largest diameter of the stone), so we performed a subgroup analysis of these studies. Our study found that SWL compared with f-URS in the treatment of 1-2 cm stones had lower SFR, shorter hospitalization time, higher retreatment rate, higher number of sessions, and higher auxiliary procedures rate, which was similar to a previous study (36). However, in our subgroup analysis of <1 cm kidney stones, there was no significant difference in SFR between the two surgical modalities because when we extracted data from the study of Sener et al., its SFR was the statistical free rate after the same operation and the total clearance rate of other operations was added after the end of the study (27); this is the reason why our results were different from those of the study in 2016. There was no difference in operation time, complications rate, and the need for auxiliary procedures between SWL and f-URS. It shows that for kidney stones smaller than 1 cm, both SWL and f-URS can achieve similar SFR, and SWL may be a better choice because of its shorter hospitalization time and less impact on patients' daily work and life (37).

The assessment of endpoint of SFR and the examined varied across studies. In most studies, the endpoint was three months after the surgery, and in Kumar et al.'s study, SFR was assessed 3 weeks after surgery using ultrasonography (22, 38). In the studies by Singh et al. and Bas et al., the SFR was assessed 1 month after each procedure (4, 29) and 2 months in the study by Vilches et al. Generally speaking, the longer the time from surgery,

4		f-URS			ESWL			Mean Difference	Mean Difference
Study or Subgroup	Mean			Mean				IV, Random, 95% Cl	IV, Random, 95% Cl
Ahmed R 2012	73	29	37	92	41	62		-19.00 [-32.84, -5.16]	
Anup Kumar1 2015	47.5	1.1	43	43.6	1.4	42	10.6%	3.90 [3.36, 4.44]	
Anup Kumar2 2015	35.5	1.9	90	45.3	2.1	90	10.6%	-9.80 [-10.39, -9.21]	
Bhupendra Pal Singh 2014		20.03	35	86	21.21	35	9.1%	-7.30 [-16.96, 2.36]	
Faruk Ozgor 2018	52.3	16.2	128	25.9	2.5	113	10.4%	26.40 [23.56, 29.24]	-
G. Bozzini 2017	55.8	11.4	207	40.9	7.7	194	10.5%	14.90 [13.01, 16.79]	
H. Aboutaleb 2012	76	34	13	48.3	16.7	24	6.3%	27.70 [8.05, 47.35]	
Ibrahim Kartal 2020	50.2	10.9	201	30.9	3.9	162	10.5%	19.30 [17.68, 20.92]	*
Pearle, Margaret S 2008	90.4	43.8	35	65.5	27.9	32	6.9%	24.90 [7.46, 42.34]	
R.M. Vilches 2015	59.6	16.5	24	42.7	12.2	31	9.5%	16.90 [9.02, 24.78]	
Vincent Koo 2011	76.5	41.9	37	42.9	16.3	51	7.8%	33.60 [19.38, 47.82]	
Total (95% CI)			850			836	100.0%	11.24 [3.51, 18.96]	◆
Heterogeneity: Tau ² = 146.92	2; Chi² =	2457.7	4, df =	10 (P <	0.0000	1); l ² = 1	100%		
Test for overall effect: Z = 2.8				,					-50 -25 0 25 50 Favours [experimental] Favours [control]
В	Ехр	eriment	al	с	ontrol			Mean Difference	Mean Difference
Study or Subaroup	Mean			Mean		Total	Weight	IV, Random, 95% CI	IV. Random, 95% CI
1.5.1 1-2cm							221		
Ahmed R 2012	73	29	37	92	41	62	6.1%	-19.00 [-32.84, -5.16]	
Anup Kumar1 2015	47.5	1.1	43	43.6	1.4	42	9.0%	3.90 [3.36, 4.44]	
Anup Kumar2.1 2015	39.1	1.5	39	49.2	1.7	35	9.0%	-10.10 [-10.83, -9.37]	
Bhupendra Pal Singh 2014		20.03	35		21.21	35	7.3%	-7.30 [-16.96, 2.36]	
Faruk Ozgor 2018	52.3	16.2	128	25.9	2.5	113	8.9%	26.40 [23.56, 29.24]	*
G. Bozzini 2017	55.8	11.4	207	40.9	7.7	194	9.0%	14.90 [13.01, 16.79]	*
H. Aboutaleb 2012	76	34	13	48.3	16.7	24	4.6%	27.70 [8.05, 47.35]	
Ibrahim Kartal 2020	50.2	10.9	201	30.9	3.9	162	9.0%	19.30 [17.68, 20.92]	*
Subtotal (95% CI)			703		0.0	667	63.0%	6.95 [-1.89, 15.79]	◆
Heterogeneity: Tau ² = 145.89	Chi ² =	2004 10	df = 7	7(P < 0)	00001)	$l^2 = 10$			
			.,		,				
Test for overall effect: $Z = 1.5$									
							0 00%	-10.80 [-11.38, -10.22]	
Test for overall effect: Z = 1.5	30.3	1.2	51	41.1	1.8	55	9.0 %		
Test for overall effect: Z = 1.5 1.5.2 <1cm Anup Kumar2.2 2015 Pearle, Margaret S 2008	30.3 90.4	1.2 43.8	35	41.1 65.5	1.8 27.9	32	5.1%	24.90 [7.46, 42.34]	
Test for overall effect: Z = 1.5 1.5.2 <1cm Anup Kumar2.2 2015									
Test for overall effect: Z = 1.5 1.5.2 <1cm Anup Kumar2.2 2015 Pearle, Margaret S 2008	90.4	43.8	35 86	65.5	27.9	32 87	5.1%	24.90 [7.46, 42.34]	
Test for overall effect: Z = 1.5 1.5.2 <1cm Anup Kumar2.2 2015 Pearle, Margaret S 2008 Subtotal (95% CI)	90.4 3; Chi² =	43.8 16.09, d	35 86	65.5	27.9	32 87	5.1%	24.90 [7.46, 42.34]	
Test for overall effect: Z = 1.5 1.5.2 <1cm Anup Kumar2.2 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Heterogeneity: Tau ² = 597.63	90.4 3; Chi² =	43.8 16.09, d	35 86	65.5	27.9	32 87	5.1%	24.90 [7.46, 42.34]	
Test for overall effect: Z = 1.5 1.5.2 <1cm Anup Kumar2.2 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Heterogeneity: Tau ² = 597.63	90.4 3; Chi² =	43.8 16.09, d	35 86	65.5	27.9	32 87	5.1%	24.90 [7.46, 42.34]	
Test for overall effect: Z = 1.5 1.5.2 <1cm Anup Kumar2.2 2015 Pearle, Margaret S 2008 Subtotal (95% CI) Heterogeneity: Tau ² = 597.63 Test for overall effect: Z = 0.3 RE 8	90.4 3; Chi² = 33 (P = 0	43.8 16.09, c 0.74)	35 86 df = 1 (l	65.5 P < 0.00	27.9 01); I² =	32 87 = 94%	5.1% 14.2%	24.90 [7.46, 42.34] 5.94 [-28.98, 40.86]	ngth 1–2 cm and <1 cm for f-URS and SWL.

	f	-URS		1	ESWL			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Bhupendra Pal Singh 2014	2	0.64	35	0.51	0.215	35	17.4%	1.49 [1.27, 1.71]	
Faruk Ozgor 2018	0.88	0.69	128	0.09	0.04	113	18.8%	0.79 [0.67, 0.91]	+
G. Bozzini 2017	1.3	0.4	207	0.12	0.1	194	19.3%	1.18 [1.12, 1.24]	
H. Aboutaleb 2012	1	0.56	13	0.73	0.21	24	15.8%	0.27 [-0.05, 0.59]	
Ibrahim Kartal 2020	1.3	1.1	201	0.3	1.1	162	17.4%	1.00 [0.77, 1.23]	
Luke H. Chan 2017	2.4	3.5	21	0	0.4	198	3.1%	2.40 [0.90, 3.90]	· · · · · · · · · · · · · · · · · · ·
Vincent Koo 2011	2.8	2.3	37	0.25	0.7	51	8.2%	2.55 [1.78, 3.32]	
Total (95% CI)			642			777	100.0%	1.14 [0.85, 1.42]	•
Heterogeneity: Tau ² = 0.11;	Chi ² = 88	8.97, df	= 6 (P	< 0.000	001); l ² :	= 93%			
Test for overall effect: Z = 7.2	74 (P < 0	0.0000	1)						Favours [experimental] Favours [control]
GURE 9									
	6.1			<		C) A (I			
rest plot and meta-analysi	s ot ho	spital	stay fo	or t-Uł	KS and	SVVL.			

the easier it is for the residual stone to pass out, and the higher the SFR. When we extracted the data, the evaluation of SFR was performed after the same operation, which might include multiple sessions, but it was limited to the same operation and did not include other auxiliary operations. Different definitions of SFR and endpoint assessment among studies might have contributed to the biasedness. So, we performed a subgroup analysis according to the endpoint of SFR. After 3 months of the surgery, we found that SFR was higher in the F-URS group than that in the SWL group. However, no significant difference was found between the two treatment groups after 1 month of the surgery.

	f	-URS		E	SWL			Mean Difference	Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% Cl	
Ahmed R 2012		0.34	37	2.2	1.19	62	11.8%	-1.10 [-1.42, -0.78]		
Faruk Ozgor 2018		0.22	128	2.8	1.1	113	12.4%	-1.75 [-1.96, -1.54]		
Ibrahim Kartal 2020	1.2		201	1.9	1	162	12.6%	-0.70 [-0.86, -0.54]		
Luke H. Chan 2017	1.1	0.3	21	1.4	0.7	198	12.6%	-0.30 [-0.46, -0.14]		
Nevzat Can Sener 2014		0.01	70	2.7	0.4	70	12.8%	-1.70 [-1.79, -1.61]	-	
Nevzat Can Sener 2015	1	0.01	50	1.48		50	12.5%	-0.48 [-0.66, -0.30]		
Okan Bas 2014		0.01	47		0.49	52	12.7%	-1.60 [-1.73, -1.47]		
Ufuk Ozturk 2013	1	0.01	38	2.59	0.61	221	12.8%	-1.59 [-1.67, -1.51]	-	
Total (95% CI)			592			928	100.0%	-1.15 [-1.54, -0.77]		
Heterogeneity: Tau ² = 0.3	0; Chi² =	431.0	1, df =	7 (P < 0	.0000	1); l² = 9	98%	-	-2 -1 0 1	+2
Test for overall effect: Z =	5.89 (P	< 0.00	001)						Favours [experimental] Favours [control]	2
3	Eve	erimen	tol	~	ontro			Mean Difference	Mean Difference	
Study or Subgroup							Woight	Nean Difference	IV. Random, 95% Cl	
1.7.1 1-2cm	mean	30	Total	wean	30	Total	weight	IV, Random, 95% CI		
Ahmed R 2012	1.1	0.34	37	2.2	1.19	62	11.8%	-1.10 [-1.42, -0.78]		
Faruk Ozgor 2018		0.34	128	2.2	1.19	113	12.4%	-1.75 [-1.96, -1.54]		
Ibrahim Kartal 2020	1.05	0.22	201	2.8	1.1	162	12.4%	-0.70 [-0.86, -0.54]		
Luke H. Chan 2017	1.2	0.4	201	1.9	0.7	198	12.6%	-0.30 [-0.46, -0.14]		
Okan Bas 2014	1.1	0.01	47		0.49	52	12.0%	-0.30 [-0.46, -0.14] -1.60 [-1.73, -1.47]		
Ufuk Ozturk 2013	1	0.01	38		0.49	221	12.7%	-1.59 [-1.67, -1.51]	-	
Subtotal (95% CI)	1	0.01	472	2.09	0.01	808	74.8%	-1.17 [-1.64, -0.71]		
Heterogeneity: Tau ² = 0.3	3. Chi ² =	287 7		5 (P < 0	0000				-	
Test for overall effect: Z =				J (F < U	.0000	1), 1 – 3	/0			
1.7.2 <1cm										
Nevzat Can Sener 2014	1	0.01	70	2.7	0.4	70	12.8%	-1.70 [-1.79, -1.61]	-	
Nevzat Can Sener 2015		0.01	50	1.48	0.65	50	12.5%	-0.48 [-0.66, -0.30]		
Nevzal Gan Sener 2015			120			120	25.2%	-1.09 [-2.29, 0.10]		
Subtotal (95% CI)		138.6	0, df =	1 (P < 0	.0000	1); l ² = 9	99%	22 E		
	4; Chi ² =									
Subtotal (95% CI)		= 0.07)							
Subtotal (95% CI) Heterogeneity: Tau ² = 0.7		= 0.07)						I	
Subtotal (95% CI) Heterogeneity: Tau ² = 0.7		= 0.07).						l l	
Subtotal (95% Cl) Heterogeneity: Tau ² = 0.7 Test for overall effect: Z = RE 10	1.79 (P								' f stone length 1–2 cm and <1 cm for f-URS an	

There was no statistical difference in the total complication rate of the two surgical procedures, and there was no statistical difference between the stone length subgroups, indicating that SWL and f-URS had similar complications in the treatment of ≤ 2 cm urinary calculi. After analyzing the complication classification, we found that SWL has fewer grade 2 complications than f-URS, which may be related to SWL, as, being a noninvasive procedure, it is less likely to cause complications such as urinary tract infection and sepsis; however, further research is needed to prove it. Notably, two studies reported two extremely severe grade 4 complications in patients receiving f-URS. Although serious complications of f-URS are rare with the development of technology and equipment, life-threatening complications still occur. SWL had fewer complications overall, but it was not statistically significant.

SWL showed a higher retreatment rate than f-URS, both overall and in subgroups, but with higher heterogeneity. The number of procedures associated with ESWL and the auxiliary procedure rate were also significantly higher than those of f-URS, which was similar to previous studies (33, 36). It showed that SWL needed to perform more times than f-URS to achieve full SFR.

The conclusions of each study showed great heterogeneity, which might be related to factors such as equipment used by different medical institutions in different countries and regions and the proficiency of technicians. There are many confounding factors, but, in general, most studies reported that SWL requires less operative time than f-URS, although operative time is defined by adding up the time spent in each session, which means that although SWL requires more treatments than f-URS, the overall time spent on surgery of SWL is still shorter than that of f-URS. A similar phenomenon occurred in the length of hospital stay, which is also the sum of the length of hospital stay for each operation. Although SWL costs more operations, the overall length of stay was still shorter than that of f-URS.

As more and more medical institutions perform SWL as an outpatient procedure, the advantages of SWL having less impact on the quality of life of patients are becoming much prominent (39). Although some medical institutions have also begun to try to perform f-URS as an outpatient procedure, characteristics of f-URS as an invasive procedure requiring anesthetic drugs limit its development (40). The evaluation of the impact of the two surgical methods on the quality of life of patients may

Study or Subgroup	f-URS Events		ESW Events		Weight	Odds Ratio M-H. Random, 95% Cl	Odds Ratio I M-H. Random. 95% Cl
3.1.1 Grade 1							
Anup Kumar2 2015	10	90	6	90	12.9%	1.75 [0.61, 5.04]	
Bhupendra Pal Singh 2014	9	35	13	35	13.7%	0.59 [0.21, 1.63]	
Faruk Ozgor 2018	12	128	15	113	19.9%	0.68 [0.30, 1.51]	
G. Bozzini 2017	8	207	0	194	2.0%	16.57 [0.95, 289.12]	
Ibrahim Kartal 2020	11	201	9	162	16.6%	0.98 [0.40, 2.44]	
Luke H. Chan 2017	0	21	4	198	1.9%	1.01 [0.05, 19.31]	
Nevzat Can Sener 2014	3	70	3	70	5.9%	1.00 [0.19, 5.13]	
Nevzat Can Sener 2015	4	50	1	50	3.3%	4.26 [0.46, 39.54]	
Okan Bas 2014	2	47	2	52	4.1%	1.11 [0.15, 8.22]	
Pearle, Margaret S 2008	6	35	6	32	9.7%	0.90 [0.26, 3.13]	
R.M. Vilches 2015	7	24	3	31	7.1%	3.84 [0.87, 16.89]	
Ufuk Ozturk 2013	1	38	2	221	2.8%	2.96 [0.26, 33.47]	
Subtotal (95% CI)		946		1248	100.0%	1.16 [0.76, 1.75]	•
Total events	73		64				
Heterogeneity: Tau ² = 0.05; 0 Test for overall effect: Z = 0.0			11 (P = 0	0.34); l²	= 10%		
3.1.2 Grade 2					o		
Ahmed R 2012	4	37	2	62	9.7%	3.64 [0.63, 20.92]	
Anup Kumar1 2015	2	43	1	42	5.0%	2.00 [0.17, 22.93]	
Bhupendra Pal Singh 2014	1	35	2	35	5.0%	0.49 [0.04, 5.61]	
Faruk Ozgor 2018	5	128	1	113	6.4%	4.55 [0.52, 39.57]	
G. Bozzini 2017	18	207	4	194	24.5%	4.52 [1.50, 13.62]	
Ibrahim Kartal 2020	6	201	4	162	18.1%	1.22 [0.34, 4.38]	
Luke H. Chan 2017	1 0	21 47	1	198 52	3.8%	9.85 [0.59, 163.56]	
Okan Bas 2014 R.M. Vilches 2015	2	47 24	2	52 31	2.9% 7.2%	0.36 [0.01, 9.09]	
Ufuk Ozturk 2013	2	24 38	2	221	3.3%	1.32 [0.17, 10.11] 0.81 [0.04, 16.01]	
Vincent Koo 2011	4	37	4	51	14.1%	1.42 [0.33, 6.11]	
Subtotal (95% CI)	-	818	-	1161	100.0%	2.11 [1.22, 3.64]	•
Total events	43		25			,	
Heterogeneity: $Tau^2 = 0.00$; 0 Test for overall effect: Z = 2.6			0 (P = 0.0	63); I² =	• 0%		
3.1.3 Grade 3 Ahmed R 2012	1	37	1	62	5.8%	1 60 [0 10 27 02]	
Bhupendra Pal Singh 2014	1	35	2	35	7.6%	1.69 [0.10, 27.93] 0.49 [0.04, 5.61]	
Faruk Ozgor 2018	3	128	1	113	8.7%	2.69 [0.28, 26.21]	
G. Bozzini 2017	4	207	9	194	31.7%	0.41 [0.12, 1.34]	
Ibrahim Kartal 2020	4	201	2	162	15.5%	1.62 [0.29, 8.98]	
Luke H. Chan 2017	0	21	1	198	4.3%	3.06 [0.12, 77.52]	
Nevzat Can Sener 2014	0	70	1	70	4.4%	0.33 [0.01, 8.21]	
Nevzat Can Sener 2015	3	50	1	50	8.6%	3.13 [0.31, 31.14]	
Okan Bas 2014	1	47	1	52	5.8%	1.11 [0.07, 18.24]	
Ufuk Ozturk 2013	1	38	2	221	7.7%	2.96 [0.26, 33.47]	
Subtotal (95% CI)		834		1157	100.0%	1.04 [0.53, 2.03]	•
Total events	18		21				
Heterogeneity: Tau ² = 0.00; (Test for overall effect: Z = 0.1) (P = 0.7	1); I² =	0%		
3.1.4 Grade 4							
Ibrahim Kartal 2020	1	201	0	162	50.3%	2.43 [0.10, 60.09]	
Luke H. Chan 2017	. 1	21	0	198	49.7%	29.05 [1.15, 736.36]	_
Subtotal (95% CI)		222			100.0%	8.34 [0.69, 100.83]	
	2		0				
Total events			(P = 0.2	7); I² =	17%		
Total events Heterogeneity: Tau² = 0.54; 0 Test for overall effect: Z = 1.6	67 (P = 0.1	0)					1
Heterogeneity: Tau ² = 0.54; 0	67 (P = 0.1	0)					0.01 0.1 1 10 100
Heterogeneity: Tau ² = 0.54; 0	67 (P = 0.1	0)					0.01 0.1 1 10 100 Favours [experimental] Favours [control]

become the next focus. Although some studies have reported the impact of the two surgical methods on the quality of life of patients in recent years (37, 39, 41), the forms and methods of questionnaires used by the research institutes were quite

different and the conclusions they drew were also different. At present, a unified, standardized, and quantifiable method is urgently needed to evaluate the two surgical methods, and further research is needed for evaluation in the future.



This study still has some limitations. First, as noted above, studies have inconsistent cutoff times for SFR assessments and different definitions of SFR, which may create a range of biases. Second, there are few studies comparing the safety and efficacy of SWL and f-URS in recent years, so the included literature has not been significantly improved in quantity and quality compared with the previous meta-analysis. Finally, the differences in medical technology and systems in various countries and regions will also cause certain biases accordingly.

Conclusion

For 1–2 cm urinary stones, f-URS can achieve a higher SFR than SWL while having a lower retreatment rate, number of sessions, and auxiliary procedure rate. For urinary stones <1 cm, there is no discernible difference in SFR between SWL and f-URS. While SWL is mostly performed as an outpatient procedure, f-URS mostly requires hospitalization. SWL has a shorter total operative time and total hospital stay than f-URS, regardless of the length of urinary stone treatment. After 1 month of the surgery, the SFR between f-URS and SWL showed no difference. However, after 3 months, f-URS showed higher SFR than SWL.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection, and data analysis were performed by GL, WQ, and HG. The first draft of the manuscript was written by GL and WQ, and all authors had commented on previous versions of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsurg. 2022.925481/full#supplementary-material.

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