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Systematic review of treatment methods for recurrent varicoceles to compare post-treatment sperm parameters, pregnancy and complication rates

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Abstract

We aimed to define which method would be the best for the treatment of recurrent varicoceles. We analysed 21 studies to compare post-treatment improvement in semen parameters, spontaneous pregnancy and complication rates between the treatment methods. Overall spontaneous pregnancy rate was significantly higher in the surgical methods (44.3%) than in the radiological interventions (17.9%; $p = .007$). Post-treatment improvement rates in sperm parameters were significantly higher in the open surgical methods (77.5%) than in the radiological interventions (62.5%; $p = .032$). Post-treatment recurrence rates were 3.8% in the open surgical methods, 17.6% in the laparoscopic surgery and 3.3% in the radiological interventions. However, technical failure rate was 11.8% in the radiologic interventions. To analyse open surgical methods, recurrence rate was 0.6% in the microsurgical methods and 19% in the macroscopic methods, revealing significant difference ($p < .001$). Post-treatment testicular atrophy rate was significantly higher in the laparoscopic surgery (2.9%) than in the open surgery (0.3%; $p = .033$). In conclusion, surgical methods have higher pregnancy rates and higher improvement rate in sperm parameters than radiological interventions for the treatment of recurrent varicocele. Microsurgical redo varicocelectomy has lower recurrence and testicular atrophy rates than macroscopic varicocelectomy series. Therefore, patients with recurrent varicoceles should be informed based on these findings.

KEYWORDS

complications, methods, pregnancy, recurrence, varicocele

1 | INTRODUCTION

Although treatment of varicocele may provide improvement in semen parameters in adults and testicular catch up in adolescents, some males with varicocele might not have benefit from the treatment due to varicocele recurrence, hormonal dysfunction, genetic and molecular abnormalities or unexplained reasons (Çayan & Akbay, 2018; Çayan, Bozlu, & Akbay, 2017; Çayan et al., 2002). The incidence of recurrent varicocele after primary treatment ranges from 0% to 45% based on different treatment techniques (Çayan & Akbay, 2018; Çayan et al., 2017; Çayan, Shavakhabov, & Kadioglu, 2009; Rotker & Sigman, 2016). Therefore, a method for the treatment of varicocele should provide no or low recurrence rate.

Treatment of varicocele recurrence in infertile men has been controversial in the era of assisted reproductive technology (ART), because of increased risks of ART treatments including multifoetal gestations, lower birth weight and prematurity, perinatal and maternal morbidity

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and mortality in up to 30% of cases (Chiles & Schlegel, 2016). In addition, surgery itself can cause anaesthesia-related risks. Therefore, natural conception is preferred to decrease such risks.

Recurrent varicoceles can be treated via open redo surgical, radiologic and laparoscopic approaches (Çayan & Akbay, 2018; Chawla, Kulkarni, Kamal, & Zini, 2005; Chen, 2014; Çift & Yucel, 2018; Feneley, Pal, Nockler, & Hendry, 1997; Flati et al., 2004; Glassberg et al., 2011; Grober, Chan, Zini, & Goldstein, 2004; Guevara, El-Hilal, & Darcy, 2015; Jargiello et al., 2015; Kaufman et al., 1983; Kenawi, 1998; Kim et al., 2012; Lund & Jensen, 1997; Madjar, Moskovitz, Issaq, Weinberger, & Nativ, 1998; Mazzoni, Minucci, & Gentile, 2002; Moon, Cho, Kim, Park, & Park, 2012; Niedzielski & Paduch, 2001; Punekar, Prem, Ridhorkar, Deshmukh, & Kelkar, 1996; Sze et al., 2008; Yan, Wu, & Wang, 2017). Recurrent varicoceles have been previously treated with radiological methods, because of redo surgical complications, including testicular atrophy, hydrocele and nerve injury (Feneley et al., 1997; Guevara et al., 2015; Jargiello et al., 2015; Kaufman et al., 1983; Kim et al., 2012; Mazzoni et al., 2002; Punekar et al., 1996; Sze et al., 2008).

However, no randomised and controlled clinical study has compared various techniques for the treatment of recurrent varicocele, and it is unclear which method would be the best for the treatment of recurrent varicoceles. In this systematic review, for the first time, we aimed to define which method would be the best for the treatment of recurrent varicoceles, by comparing all techniques, published in the literature.

2 | MATERIALS AND METHODS

2.1 | Literature search and data extraction

The literature search via PubMed/MEDLINE and Web of Science databases was performed for articles published from January 1980 until August 2018, using the population, intervention, comparison, outcomes and study design (PICOS). The search was conducted with the combination of medical subject headings (MeSH) terms and frequently used key words: redo varicocele repair, infertile men, adolescents, varicocelectomy, techniques, radiologic method, intervention, pregnancy, recurrence, recurrent or persistent varicocele and hydrocele.

Figure 1 shows flow diagram of comprehensive literature search for the identification and selection of the studies, using the PICOS design:

Population (P): Infertile males or adolescents with recurrent varicoceles.
Intervention (I): Surgical and radiologic interventions for recurrent or persistent varicocele.
Comparison (C): Outcome comparison between the treatment methods for recurrent varicocele.
Outcome (O): Spontaneous pregnancy, improvement in post-treatment sperm parameters and complication rates.
Study design (S): Studies on the treatment of recurrent varicocele, reporting at least one of the post-treatment sperm parameters, spontaneous pregnancy and complication rates in adults and adolescents who underwent treatment for recurrent varicocele.

2.2 | Eligibility criteria

Two independent authors (SÇ and IO) screened 745 titles and abstracts to extract data, and 314 of them were removed due to duplication. Of the 431 abstracts, 401 excluded due to title and abstract contents, and 30 studies were selected by eligibility. However, nine studies were excluded with reasons: no post-treatment outcomes or reporting pregnancy with the use of ART (n: 4), no technical detail (n: 4), review (n: 1).

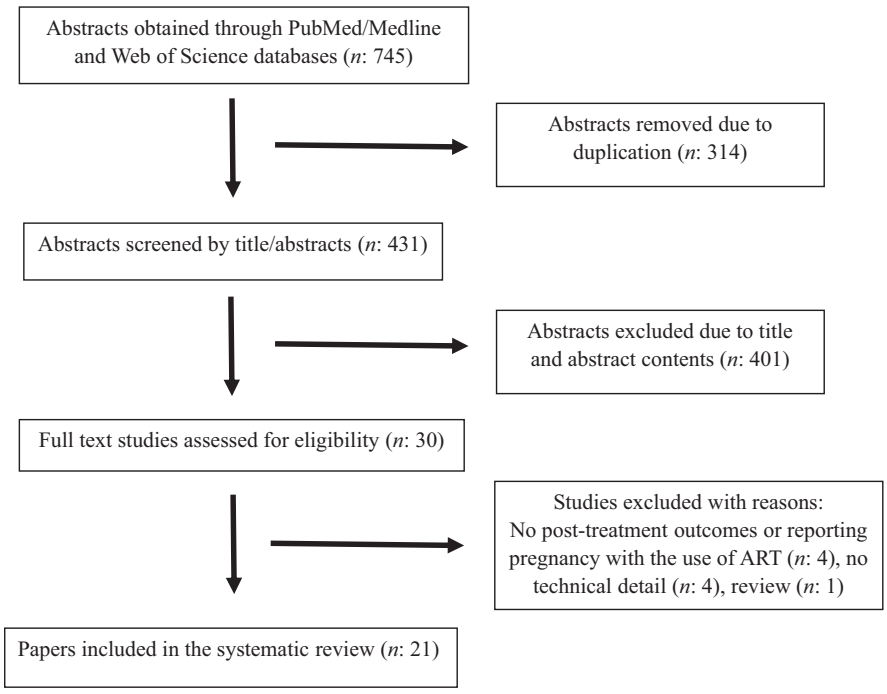

FIGURE 1 Flow diagram of comprehensive literature search for the identification and selection of the studies, using the population, intervention, comparison, outcomes and study design

TABLE 1 All studies reporting outcomes of treatment for recurrent varicoceles

Authors	Year	Level of evidence grade	# Patients	Indications for treatment	Treatment method	Type of treatment	Main outcome measures
Çayan and Akbay	2018	Level 2b	120	Infertility	Open surgery	Subinguinal microsurgical	Primary: Pregnancy, sperm parameters and serum hormone values Secondary: Complications
Grober et al.	2004	Level 3	54	Infertility	Open surgery	Subinguinal microsurgical	Primary: Pregnancy, sperm parameters, testosterone level and testis volume Secondary: Complications
Chen	2013	Level 3	38	Infertility	Open surgery	Subinguinal microsurgical	Primary: Pregnancy and sperm parameters Secondary: Predictive factors
Flati et al.	2004	Level 3	34	Infertility	Open surgery	Microsurgical shunt	Primary: Pregnancy and sperm parameters Secondary: Recurrence
Çift and Yucel	2018	Level 3	27	Orchalgia	Open surgery	Subinguinal microsurgical	Primary: Visual analog scale (VAS) Secondary: Complications
Madjar et al.	1997	Level 3	23	Subfertility/± Testicular volume loss	Open surgery	Subinguinal macroscopic	Primary: Sperm parameters Secondary: Complications
Chawla et al.	2005	Level 3	11	Orchalgia	Open surgery	Subinguinal microsurgical	Primary: Pain relief assessment Secondar: Complications
Lund and Jensen	1997	Level 4	6	No report	Open surgery	Subinguinal macroscopic	Primary: Recurrence
Kenawi	1998	Level 4	2	Subfertility/± Testicular volume loss	Open surgery	Juxtarenal macroscopic	Primary: Pain relief assessment and sperm parameters
Mazzoni et al.	2002	Level 3	53	Large varicocele/± Subfertility	Radiologic intervention	Antegrade sclerotherapy	Primary: Technical success and complications
Punekar et al.	1996	Level 3	39	Infertility	Radiologic intervention	Embolization	Primary: Technical success and sperm parameters Secondary: Pregnancy
Jargiello et al.	2015	Level 3	33	Orchalgia/± Subfertility	Radiologic intervention	Embolization	Primary: Technical success Secondary: Complications
Kim et al.	2012	Level 3	28	Orchalgia/± Subfertility	Radiologic intervention	Embolization	Primary: Technical success Secondary: Complications
Feneley et al.,	1997	Level 3	18	Orchalgia/± Subfertility	Radiologic intervention	Embolization	Primary: Technical success and complications Secondary: Satisfaction
Sze et al.	2008	Level 3	17	Orchalgia/± Subfertility	Radiologic intervention	Embolization	Primary: Technical success Secondary: Complications
Kaufman et al.	1983	Level 4	5	Orchalgia/± Subfertility	Radiologic intervention	Balloon occlusion	Primary: Technical success Secondary: Complications
Guevara et al.	2014	Level 4	1	Orchalgia	Radiologic intervention	Embolization	Primary: Technical success Secondary: Complications

(Continues)

TABLE 1 (Continued)

Authors	Year	Level of evidence grade	# Patients	Indications for treatment	Treatment method	Type of treatment	Main outcome measures
Yan et al.	2017	Level 3	30 34	Infertility	Open surgery Laparoscopic surgery	High ligation Single-port varicocelectomy	Primary: Operative time and complications Secondary: Pregnancy
Glassberg et al.	2011	Level 3	19 2	Testicular volume loss/± Orchalgia	Open surgery Radiologic intervention	Inguinal microsurgical Embolization	Primary: Complications Secondary: Testis volume
Moon et al.	2012	Level 3	8 7	Subfertility/± Testicular volume loss	Open surgery Radiologic intervention	Subinguinal microsurgical Embolization	Primary: Complications Secondary: Technical success
Niedzielski and Paduch	2001	Level 4	2 1	Orchalgia/± Testicular volume loss	Open surgery Radiologic intervention	Subinguinal macroscopic Antegrade sclerotherapy	Primary: Complications

The articles included were original regarding surgical and radiologic interventions for recurrent or persistent varicocele in the English language. All studies related to treatment of recurrent varicoceles in infertile males or adolescents for different indications (infertility, scrotal pain, testicular hypotrophy) were included in this review. All authors reviewed the full text of those references to determine eligibility.

2.3 | Inclusion and exclusion criterion

The outcome measures were spontaneous pregnancy, improvement in sperm parameters and complications (recurrence, hydrocele, testicular atrophy and infection–haematoma). As shown in Table 1, of the studies reporting treatment of recurrent varicocele, 21 (612 subjects) met the inclusion criterion, reporting at least one of the post-treatment sperm parameters, spontaneous pregnancy and complication rates in adults and adolescents who underwent treatment for recurrent varicocele (Çayan & Akbay, 2018; Chawla et al., 2005; Chen, 2014; Çift & Yucel, 2018; Feneley et al., 1997; Flati et al., 2004; Glassberg et al., 2011; Grober et al., 2004; Guevara et al., 2015; Jargiello et al., 2015; Kaufman et al., 1983; Kenawi, 1998; Kim et al., 2012; Lund & Jensen, 1997; Madjar et al., 1998; Mazzoni et al., 2002; Moon et al., 2012; Niedzielski et al., 2001; Punekar et al., 1996; Sze et al., 2008; Yan et al., 2017). Interventions were divided into surgical (open or laparoscopic) and radiological (sclerotherapy or embolisation) groups. The surgical interventions were also divided into open (via a macroscopic or microscopic approach at the all levels) and laparoscopic groups. The studies were analysed as open surgery in nine (microscopic: six and macroscopic: three), radiologic intervention in eight (embolisation: six, sclerotherapy: one and balloon occlusion: one), open (microscopic: two and macroscopic: one) versus radiologic intervention in three (embolisation: two and sclerotherapy: one) and open macroscopic surgery versus laparoscopic surgery in one (Table 1; Çayan & Akbay, 2018; Chawla et al., 2005; Chen, 2014; Çift & Yucel, 2018; Feneley et al., 1997; Flati et al., 2004; Glassberg et al., 2011; Grober et al., 2004; Guevara et al., 2015; Jargiello et al., 2015; Kaufman et al., 1983; Kenawi, 1998; Kim et al., 2012; Lund & Jensen, 1997; Madjar et al., 1998; Mazzoni et al., 2002; Moon et al., 2012; Niedzielski et al., 2001; Punekar et al., 1996; Sze et al., 2008; Yan et al., 2017).

The risk of bias of the studies was also assessed, related to the following issues: only studies reporting spontaneous pregnancy after treatment of varicocele were included in the outcomes, because pregnancies with the use of ART would affect the outcomes of the treatment. Regarding the semen parameters, some studies have reported improvement as percentage, and some studies reported an increase or decrease in semen parameters from the mean value. Therefore, comparison of each sperm parameters after re-treatment of varicocele would not be unique among the techniques used for the treatment of recurrent varicoceles, and we included percentage of improvement in semen parameters from pre-treatment to post-treatment to compare between the techniques.

Indications for re-treatment of varicocele for recurrence were no improvement in semen parameters, not achieving pregnancy, ART

TABLE 2 Pregnancy rates according to treatment methods for recurrent varicoceles

Treatment methods	# Pregnancy	# Total	Rate (%)	*p* Value
Surgery (open + laparoscopic)	129	291	44.3	.007
Radiologic intervention	5	28	17.9	
Open surgery	109	257	42.4	Open versus laparoscopic: .07 Open versus radiologic: .012 Laparoscopic versus radiologic: .001
Laparoscopic surgery	20	34	58.8	
Radiologic intervention	5	28	17.9	

Note:Surgery (open+laparoscopic) versus radiologic intervention: .007

unsuccess, pain or persistence of testicular volume loss after at least 6 months of initial varicocele treatment.

Post-treatment improvement rate in semen parameters, spontaneous pregnancy and complication rates (recurrence, hydrocele, testicular atrophy and infection–haematoma) was compared between the treatment methods. In addition, interventional failure related to surgical and radiologic methods was reviewed.

2.4 | Statistical analysis

For statistical analyses, SPSS® (Statistical Package for the Social Sciences Inc) version 20.0 package program was employed. Categorical variables as frequencies and percentages (%) were expressed. Post-treatment improvement rate in sperm parameters, spontaneous pregnancy rates and complications such as hydrocele, varicocele recurrence, testicular atrophy, infection–haematoma and interventional failure rate was compared using a Pearson's chi-square test among the techniques. A *p* value of <.05 was considered statistically significant.

3 | RESULTS

3.1 | Spontaneous pregnancy

Table 2 shows spontaneous pregnancy rates according to treatment methods. Overall spontaneous pregnancy rates were 42.4% in the open surgery group, 58.8% in the laparoscopic surgery group and 17.9% in the radiologic intervention group. The open and laparoscopic surgery groups had higher pregnancy rates than the radiologic intervention group ($p = .012$ and $p = .001$, respectively). The pregnancy rate was 44.3% in the surgery group (as the combination of open and laparoscopic surgeries) and 17.9% in the radiological interventions, revealing significant difference between the techniques ($p = .007$).

3.2 | Improvement in sperm parameters

Post-treatment improvement in sperm parameters was seen in 110 of 142 (77.5%) patients who had open surgical method and in 35 of 56 (62.5%) patients who had radiological interventions, revealing significant difference between the two groups ($p = .032$). There was only one study, reporting outcomes of laparoscopic varicocelectomy which did not include sperm parameters. For this reason, improvement rate in sperm parameters was not included related to the laparoscopic varicocelectomy.

3.3 | Complications

As shown in Table 3, post-treatment recurrence rates were 3.8% in the open surgical methods, 17.6% in the laparoscopic surgery and 3.3% in the radiological interventions. The recurrence rate was the highest in the laparoscopic surgery when compared to the open surgery and radiologic intervention ($p < .001$ and $p = .001$, respectively). However, of the 144 patients in which status of technical success or failure of radiologic interventions was reported, 17 (11.8%) had technical failure with the radiological interventions. To subanalyse surgery group, recurrence rate was 0.6% in the microsurgical methods and 19% in the macroscopic methods, revealing significant difference ($p < .001$).

As shown in Table 4, post-treatment testicular atrophy rates were significantly higher in the laparoscopic surgery (2.9%) than in the open surgery group (0.3%; $p = .033$). However, to analyse subgroups, testicular atrophy rate was significantly higher in the macroscopic surgery (1.6%) than in the microscopic surgery group (0%; $p = .024$; Table 4A).

Post-treatment hydrocele rate did not differ between the open (3.1%) and laparoscopic surgery group (2.9%; $p = .970$; Table 4B). However, the hydrocele rate was higher in the macroscopic surgery group (6.6%) than in the microscopic group (2.3%), revealing no significance ($p = .081$). No significant differences were observed in the haematoma–infection rates among the treatment methods, as shown in Table 4C.

4 | DISCUSSION

Primary varicoceles in adults and adolescents have been treated with open surgical via macroscopic or microscopic approach, laparoscopic and radiologic intervention via embolisation or sclerotherapy (Çayan & Akbay, 2018; Çayan et al., 2017, 2009; Rotker & Sigman, 2016). Our previous meta-analysis, consisting of 36 studies, has reported overall spontaneous pregnancy rate as 37.7% with the high inguinal technique, 42% with the microsurgical varicocelectomy, 30% with the laparoscopic varicocelectomy, 33.2% with the radiologic embolisation and 36% with the macroscopic inguinal varicocelectomy for the treatment of primary varicocele in infertile men (Çayan et

TABLE 3 Post-treatment recurrence rates according to treatment methods

Treatment methods	# Recurrence	# Total	Rate (%)	*p* Value
Open surgery	14	372	3.8	Open versus laparoscopic: <.001 Open versus radiologic: .765 Laparoscopic versus radiologic: .001
Laparoscopic surgery	6	34	17.6	
Radiologic intervention	6	184	3.3	
Microscopic surgery	2	309	0.6	<.001
Macroscopic surgery	12	63	19	

Note: Microscopic versus macroscopic: <.001

al., 2009). They also reported the least postoperative complications including recurrence and hydrocele with the microsurgical varicocelectomy among the treatment methods for primary varicocele in infertile men.

In the literature, there are only 21 studies reporting outcomes of treatment for recurrent varicoceles with the different approaches (open surgery: nine, radiologic intervention: eight and comparative studies: four; Çayan & Akbay, 2018; Chawla et al., 2005; Chen, 2014; Çift & Yucel, 2018; Feneley et al., 1997; Flati el al., 2004; Glassberg et al., 2011; Grober et al., 2004; Guevara et al., 2015; Jargiello et al., 2015; Kaufman et al., 1983; Kenawi, 1998; Kim et al., 2012; Lund & Jensen, 1997; Madjar et al., 1998; Mazzoni et al., 2002; Moon et al., 2012; Niedzielski et al., 2001; Punekar et al., 1996; Sze et al., 2008; Yan et al., 2017). However, fertility outcomes after surgical treatment of recurrent varicoceles in infertile men have been reported in only four studies. In a study by Grober et al., (2004), 40% of the couples achieved pregnancy via natural conception or use of ART, and none of the 54 patients had recurrence after microsurgical subinguinal redo varicocele repair. Chen (2014) demonstrated spontaneous pregnancy rate as 13.1%, and he also investigated predictive factors of successful redo varicocelectomy in 48 infertile men with recurrent varicocele. Lower follicle-stimulating hormone and peak retrograde flow on Doppler ultrasound, longer time to recurrent varicocele, preoperative higher testicular volume and a higher number of ligated veins were found as predictive factors of successful redo varicocelectomy. Flati et al. (2004) reported 32.3% of pregnancy with a 2.96% of recurrence rate in 34 infertile men who underwent microsurgical shunt for the treatment of recurrent varicocele. Çayan and Akbay (2018) compared outcomes of microsurgical redo varicocelectomy versus observation in 217 infertile men who underwent varicocelectomy, but still had recurrent varicoceles. They reported that microsurgical subinguinal redo varicocelectomy provided significantly higher improvement in total motile sperm count and increase in total testosterone level than the observation.

TABLE 4 Post-treatment testicular atrophy (A), hydrocele (B) and haematoma–infection (C) rates according to surgical treatment methods

A

Treatment methods	# Testicular atrophy	# Total	Rate (%)	*p* Value
Open surgery	1	370	0.3	.033
Laparoscopic surgery	1	34	2.9	
Microscopic surgery	0	309	0.0	.024
Macroscopic surgery	1	61	1.6	

B

Treatment methods	# Hydrocele	# Total	Rate (%)	*p* Value
Open surgery	11	360	3.1	.970
Laparoscopic surgery	1	34	2.9	
Microscopic surgery	7	299	2.3	.081
Macroscopic surgery	4	61	6.6	

C

Treatment methods	# Hematoma–infection	# Total	Rate (%)	*p* Value
Open surgery	5	333	1.5	Open versus laparoscopic: .528 Open versus radiologic: .765 Laparoscopic versus radiologic: .411
Laparoscopic surgery	1	34	2.9	
Radiologic intervention	1	28	3.6	
Microscopic surgery	3	272	1.1	.207
Macroscopic surgery	2	61	3.3	

Note: Microscopic versus macroscopic: .207

They also reported significantly higher spontaneous pregnancy rate with the microsurgical varicocelectomy (39.7%) than the observation (15.8%). Microsurgical redo varicocele repair also significantly reduced treatment with ART for achieving pregnancy. In the present review to compare outcomes of all the methods to treat recurrent varicoceles, overall spontaneous pregnancy rate was 42.4% with the open surgery, 58.8% with the laparoscopic surgery and 17.9% with the radiologic interventions. The open and laparoscopic surgery groups had significantly higher pregnancy rates than the radiologic intervention group. In addition, surgical series as the combination of open and laparoscopic surgeries (44.3%) had significantly higher pregnancy rate than the radiological interventions (17.9%). In addition, post-treatment improvement rates in sperm parameters were significantly higher in the open surgical methods (77.5%) than in the radiological interventions (62.5%).

Recurrence of varicocele may be seen in 0 to 45% of men who underwent primary repair, depending on the original treatment approach (Çayan et al., 2017, 2009; Rotker & Sigman, 2016). Recurrence and hydroceles have been reported with higher incidence after repair of paediatric varicoceles (Çayan et al., 2017; Nees & Glassberg, 2011). Rotker and Sigman (2016) reviewed varicocele recurrence as an outcome after the treatment, and they reported up to 35% of recurrence, depending on the primary technique. They suggested that recurrence of varicocele should be diagnosed with venography, and the recurrence should be fixed via surgery or radiologic interventions. In a review, consisted of four comparative studies, the recurrence rate of primary varicocele repair was 17.2% with the laparoscopic technique, 1.9% with the microsurgical varicocelectomy and 13.7% with the macroscopic varicocelectomy (Ding et al., 2012). The authors also suggested additional ligation of external spermatic veins to decrease varicocele recurrence.

Recurrence of varicocele after primary treatment can be seen due to ineffective venous ligation or persistence of some collateral veins missed during the primary surgery in the majority of patients (Grober et al., 2004; Murray et al., 1986). However, in some cases, the recurrence might be due to dilated external spermatic vein channels which are not ligated during the primary surgery (Çayan & Akbay, 2018). In the present review; post-treatment recurrence rates were 3.8% in the open varicocelectomy series, 17.6% in the laparoscopic series and 3.3% in the radiological interventions. The recurrence rate was the highest in the laparoscopic varicocelectomy, when compared to the open surgery and radiologic interventions. To compare open surgical groups, overall recurrence rate was significantly lower in the microsurgical varicocelectomy series (0.6%) than in the macroscopic varicocelectomy series (19%).

Radiologic interventions have been most preferred method to treat recurrent varicoceles because of the least invasive procedure and radiologically diagnosis of non-visualised small veins in the management of recurrent varicoceles (Feneley et al., 1997; Glassberg et al., 2011; Guevara et al., 2015; Jargiello et al., 2015; Kaufman et al., 1983; Kim et al., 2012; Mazzoni et al., 2002; Moon et al., 2012; Niedzielski & Paduch, 2001; Punekar et al., 1996; Sze et al., 2008). Redo varicocele repair might cause surgical complications, including testicular atrophy, hydrocele and nerve injury; and venography might allow detection of the small internal spermatic veins or lumbar crossover veins which could be missed during varicocele surgery or re-canalised postoperatively (Chrouser, Vandersteen, Crocker, & Reinberg, 2004; Kim et al., 2012; Lund & Jensen, 1997). However, extra exposure to X-radiation is disadvantage of the radiologic intervention. In addition, in the present review, technical failure rate was 11.8% in the radiological interventions.

Studies support that varicocelectomy, performed without optical magnification, is inadequate to visualise spermatic veins, lymphatics and artery branches, easily. Small internal spermatic vein channels may not be visualised during conventional macroscopic varicocelectomy. These small vein channels may be dilated leading to recurrence over the time (Çayan & Akbay, 2018; Çayan et al., 2009; Rotker & Sigman, 2016). In addition to varicocele recurrence, varicocelectomy, performed without optical magnification, might cause higher incidence of hydrocele formation and testicular atrophy. In the present review, laparoscopic varicocelectomy had significantly higher post-treatment testicular atrophy rate (2.9%) than the open varicocelectomy series (0.3%). However, to analyse subgroups, testicular atrophy rate was significantly higher in the macroscopic varicocelectomy series (1.6%) than in the microsurgical varicocelectomy series (0%). Post-treatment hydrocele rate did not differ between the open (3.1%) and laparoscopic surgery groups (2.9%). However, the hydrocele rate was significantly higher in the macroscopic varicocelectomy series (6.6%) than in the microsurgical varicocelectomy series (2.3%).

Other rare complications of redo varicocele repair include haematoma, infection and damage of the nerve branches. In addition, in the present review, no significant differences were observed in haematoma–infection rates among the treatment methods. Although laparoscopic varicocelectomy can also provide higher magnification, disadvantages of this method over open microsurgical approach would be higher cost and work off day, requiring long learning skills, general anaesthesia and placement of a urethral catheter. A needle or trocar insertion might cause intestinal and major vascular injuries, leading to laparotomy. A meta-analysis has reported 7.6% of major complications rate with the laparoscopic varicocelectomy series (Çayan et al., 2009).

5 | LIMITATIONS

Despite the important of the findings related to outcomes of the treatment for recurrent varicocele, our study has some limitations. Totally, 612 patients (adults and adolescents) were included in the 21 studies for the analysis. Some of the studies included in this analysis have limited number of patients. Some studies were conducted by the radiologists in the radiologic intervention studies. Therefore, some clinical data were missing in those studies. Some studies have reported only pregnancy rates, but it is not clear whether the pregnancies occurred spontaneously or with the use

of ART. In addition, there was only one study reporting outcomes of laparoscopic varicocelectomy which did not include sperm parameters in their study. For this reason, improvement rate in sperm parameters was not included related to the laparoscopic varicocelectomy in this analysis.

6 | CONCLUSIONS

This systematic review suggests that surgical methods have higher spontaneous pregnancy rates and higher improvement in post-treatment sperm parameters than radiological interventions for the treatment of recurrent varicocele. In addition, microsurgical redo varicocelectomy has lower recurrence and testicular atrophy rates than macroscopic varicocelectomy series. Patients with recurrent varicoceles should be informed based on these findings.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

Selahittin Çayan involved in study design, literature search, acquisition of data, analysis and interpretation of data, drafting the article and final approval of the completed review; İrfan Orhan involved in study design, literature search, revising the paper for intellectual content and final approval of the completed review; Erdem Akbay involved in acquisition of data, analysis and interpretation of data, revising the paper for intellectual content and final approval of the completed review; and Ateş Kadıoğlu involved in study design, revising the paper for intellectual content and final approval of the completed review.

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