Original Article

Staged laparoscopic traction versus laparoscopic staged Fowler-Stephens for intra-abdominal testis: A systematic review and meta-analysis

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ABSTRACT

Background: In pediatric urology, undescended testes are frequently seen. The superiority of the Fowler-Stephens orchiopexy (FSO) or Shehata's traction orchiopexy (STO) procedures for intra-abdominal testes (IAT) is up for dispute. The two methods and their results in patients with IATs are compared in this systematic review and meta-analysis.

Patients and Methods: In addition to a manual Google search, we conducted searches in PubMed, Scopus, Web of Science, Google Scholar, and the Cochrane Library between 2008 and July 2023. All studies that compared the STO and FSO in the treatment of IATs were included, whether they were case-control, cross-sectional, cohort observational, or randomized controlled trials. An open Meta Analyst was used for the meta-analysis. The odds ratio (OR) for dichotomous variables and the mean difference for continuous variables were used to compare the two methods.

Results: The final meta-analysis contained five publications. With a statistically significant *P value 0.03*), the comparison revealed that the STO was linked to a greater success rate (87%) than the FSO approach (66%). The OR was reported to be 2.749 (95% confidence interval: 1.101, 6.864). The STO was observed to cause less atrophy compared with the FSO technique, as no cases of atrophy were observed in the STO technique, however, FSO was associated with a 12.6% atrophy rate with a statistically significant *P value*. The OR was observed to be 0.171 (95% confidence interval: 0.043, 0683, *P=0.013*).

Conclusion: In IAT children, STO may have a higher success and lower atrophy rates than FSO, despite statistical significance, however, randomized controlled trials with larger sample sizes and many compared parameters are needed to confirm these findings.

Key Words: Fowler-Stephens, laparoscopy, Shehata, testis, traction.

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INTRODUCTION

Undescended testes are a prevalent condition in pediatric urology, the incidence of cases of cryptorchidism varied from 9.2 to 30% for preterm babies and from 3.4 to 5.8% for full-term babies[1]. The descent of the testes was arrested in the abdominal cavity and did not pass to the scrotal sac, which is the primary cause of this illness[2,3]. In terms of medicine, there are two types of undescended testes: palpable and impalpable undescended testes[2,4]. Impalpable testes make up nearly 20% of undescended testes. Many impalpable testes are actually intra-abdominal testis (IAT)[1,5]. Although magnetic resonance imaging and B-ultrasound can aid in determining the presence of IATs, laparoscopy is still an essential method for the identification, diagnosis, and management of IAT[6].

In their classification, Hay *et al*. types III and IV are the most amenable to staged procedures for IATs[7].

Because of its relatively low learning curve and high success rate, pediatric urologists choose the Fowler-Stephens orchiopexy (FSO) technique[8]. Spermatic vascular transection removes the constraint caused by the short spermatic cord, and the collateral arteries are supposed to provide the testes with blood[9,10]. As technology develops, the overall success rate for taking testes down to the scrotum is around 80–86%; nevertheless, the primary drawback is the closure of the spermatic arteries, which might result in atrophy or deformity[11–13].

To preserve the entire vascularity and simultaneously release the constrained spermatic cord, Shehata[14] described a traction approach to elongate the testicular arteries rather than divide them. The short spermatic cord is stretched by gravity and gut peristalsis for a specific period before the testis can be taken down to the scrotum using this technique. Shehata described his initial experience on a series of 10 testes in 2008[14]. He then reported the results of 140 IATs treated with his modified approach,

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which involved burying the suture intracorporeally and removing the extracorporeal plastic tubing[15]. The future seemed bright, other pediatric urologists have increasingly embraced this method of treating IATs, and some have suggested modifying the time intervals[16–18].

The fundamental distinction between the two laparoscopically assisted techniques is how the constriction of the short testicular arteries is treated. In one, traction is utilized, while in the other, transection gives time to collateral circulation to develop. Therefore, we conducted this systematic review and meta-analysis to compare the two techniques and their different outcomes in patients with IAT.

PATIENTS AND METHODS:

Database search

From 2008 to July 2023, we looked through PubMed, Scopus, Web of Science, Google Scholar, and the Cochrane Library (U.S. National Library of Medicine (NLM), National Institutes of Health (NIH), Town: Bethesda, State: Maryland, Country: United States) to find relevant papers for our systematic review and meta-analysis. To identify any studies that were overlooked, we also manually searched Google. The following search methodology was employed: (((Fowler-Stephens) OR (F-S) OR (FSO) AND (intraabdominal testis) OR (abdominal testis) OR (cryptorchidism) OR (high-level testis) OR (test*) OR (undescended testis) AND ((traction]) OR (Shehata).

Screening and eligibility

After searching the included databases, the duplicates were removed using Mendeley Reference Manager. The included studies were uploaded to Rayyan could start the screening. Title and abstract screening were done first then the included articles from this procedure were screened again by full-text. The inclusion criteria were any observational studies (case-control, cross-sectional, and cohort) and randomized controlled trials (RCTs) comparing the Shehata's traction orchiopexy (STO) and FSO technique in the treatment of impalpable undescended testes. We excluded reviews, case reports, case series, meta-analyses, and studies investigating different techniques in undescended testes.

Data extraction

Data extraction of the included studies was done using Microsoft Excel sheets, to include the baseline characteristics and summary as sample size, study design, age, interval in STO and FSO, and follow-up period. The outcomes of the two procedures were also extracted to be incorporated into the meta-analysis, such as success rate in taking testes down to scrotum, operation time in the first and second stages, rate of atrophy, and retraction.

Quality assessment

The New-Castle-Ottawa scale, which has a maximum score of nine stars, was used to evaluate the quality of the included observational studies. A study is deemed low quality if it receives a score of 0–3, moderate quality if it receives a score of 4–6, and high quality if it receives a score of 7–9. The Cochrane Risk of Bias assessment tool (Rob2) was used to evaluate the risk of bias in relation to RCTs.

Statistical analysis

Meta-analysis was conducted using Open Meta Analyst software. For continuous variables, mean difference (MD) was used for the comparison between the two techniques. For dichotomous variables, the odds ratio (OR) was interpreted for comparison. The pooled analysis was done using a random effect model with a 95% confidence interval (CI), and the *P value* was considered significant if it was smaller or equal to 0.05. Heterogeneity was assessed using I2 and a *P value* of 0.05 as well.

RESULTS:

Searching process and screening

The searching methods through the assigned databases gave results of 44 articles that were reduced to 28 for title and abstract screening after duplicate removal. Then, a total of 14 articles entered the full-text screening to result in five articles [19–23] in the final meta-analysis (Fig. 1), representing the PRISMA for the studies included.

Quality assessment

Three of the cohort studies were of high quality according to NOS, with scores of 7, 8, and 9, while only one study was of moderate quality with a score of 6 (Table 1).

Regarding the included RCT, the risk of bias assessment for the randomized controlled trial conducted by Dawood *et al*. was evaluated using the Cochrane Rob2 tool. The analysis encompassed five key domains: bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. The study was judged to have a low risk of bias across all domains, indicating that the trial was well-conducted with appropriate randomization methods, adherence to intervention protocols, complete outcome data, unbiased outcome measurements, and transparency in outcome reporting. Overall, the study demonstrated high methodological rigor and internal validity.

Baseline characteristics

Among the five included articles, four were cohort studies and one was RCT. Interval in the STO, and FSO techniques varied between 3 to 6 months, while the follow-up period ranged from 6 to 12 months. (Table 2).

Meta-analysis

The comparison between the STO and the FSO technique showed that Shehata's traction technique was associated with a higher success rate (87%) compared with the FSO technique (66%) (regarding the descent of testes to scrotum by physical examination, with good vascularity by ultrasound examination) with a statistically significant *P value* (0.03). The OR was reported to be 2.749 (95% CI: 1.101, 6.864) (Fig. 2).

As regards atrophy, STO was observed to cause less atrophy compared with the FSO technique, as no cases of atrophy were observed in Shehata's traction technique. However, FSO was associated with a 12.6% atrophy rate with a statistically significant *P value*. The OR was observed to be 0.171 (95% CI: 0.043, 0683, *P=0.013*) (Fig. 3).

Regarding the time of first stage of operation, Shehata's technique was associated with a statistically significant longer time with MD of 10.901 (95%CI: 1.937, 19.866, *P=0.017*) with a significant heterogeneity (I2=94.56%, *P<0.001*) (Fig. 4). By conducting sensitivity analysis using the leave-one-out method, it was obvious that An-Ye *et al*. study was the source of heterogeneity (Fig. 5).

A comparison of the operation time during the second stage of surgery between the two groups across the included studies revealed no statistically significant difference. The MD was –0.72min with a 95% CI ranging from –7.32 to 5.88, and a *P value* greater than 0.05. This suggests that neither surgical technique demonstrated a clear advantage in terms of operative duration for the second stage. The analysis was based on data from four studies: Ye *et al*., Bawazir and Maghrabi, Dawood *et al*. and Liu *et al*. each evaluating variations of staged laparoscopic orchiopexy techniques for managing high IAT in pediatric patients.

STO was associated with a lower rate of retraction (14.5%) compared with the FSO technique (23.7%). However, this was non-statistically significant (*P>0.05*) with an OR of 0.678 (95% CI: 0.267, 1.724) (Fig. 6).

Table 1: Quality assessment of the included cohort studies using the New Castle Ottawa Scale

Question	An Ye 2022	Bawazir and Maghrabi 2021	Liu 2021	Alekrashy 2023
Consistency of the exposed cohort	★	★	★	★
Careful choosing of the non-exposed cohort	★	★	★	★
Measurement of exposure	★	★	★	★
Evidence indicating the desired outcome was absent at the beginning of the study	-	★	★	-
Covariance comparability based on design or analysis	★	★	★★	★
Result evaluation	★	★	★	★
Was follow-up prolonged enough to produce results?	★	★	★	★
Cohorts' follow-up is adequate.	-	★	★	★
Overall score	6	8	9	7

Table 2: Baseline characteristics of the included studies

Study ID	Sample size		Study design	Age, mean ± SD months		Interval of STO	Interval of FSO	Follow Up
	STO	FSO		STO	FSO			
An Ye 2022	16	15	Cohort	–	–	3 months	3 months	6 months
Bawazir and Maghrabi 2021	11	18	Cohort	20.27±10.57	24.39±17.53	3 months	6 months	12 months
Dawood 2021	20	21	RCT	32.6±27.3	29.5±27.1	6 months	6 months	6 months
Liu 2021	22	23	Cohort	15.38±2.14	15.30±2.38	3 months	6 months	6 months
Alekrashy 2023	20	18	Cohort	32.4±4.8	30±22.8	6 months	6 months	12 months

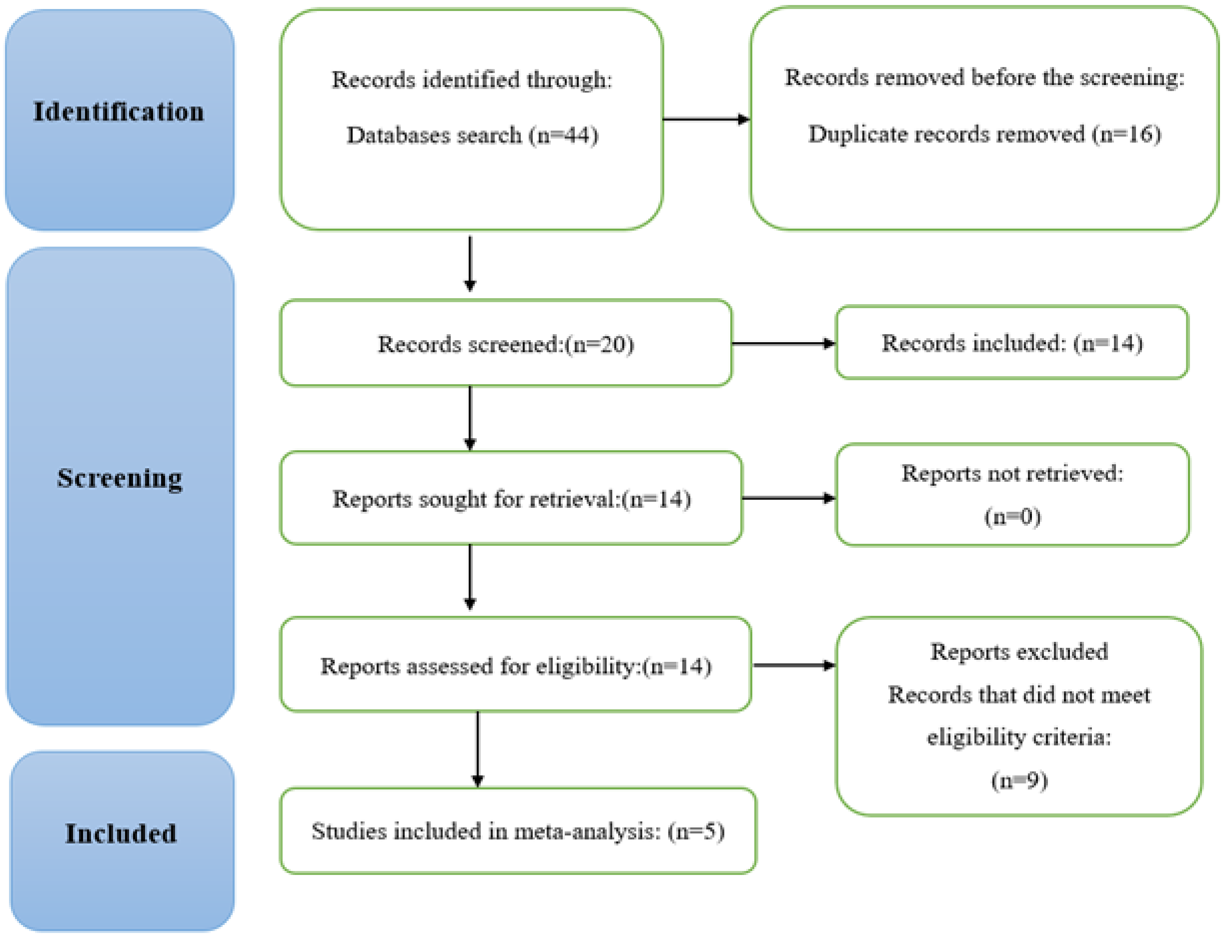

Fig. 1: PRISMA flow diagram of the included studies.

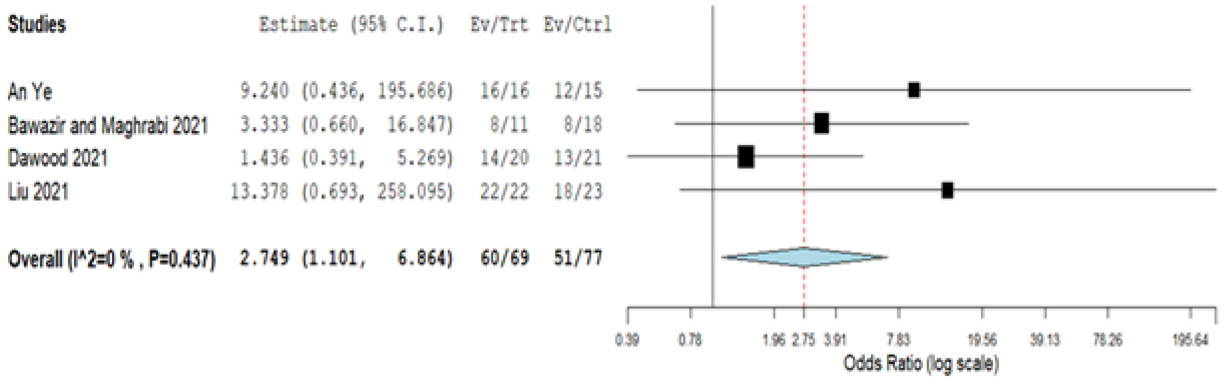

Fig. 2: Comparison between both techniques regarding success rate.

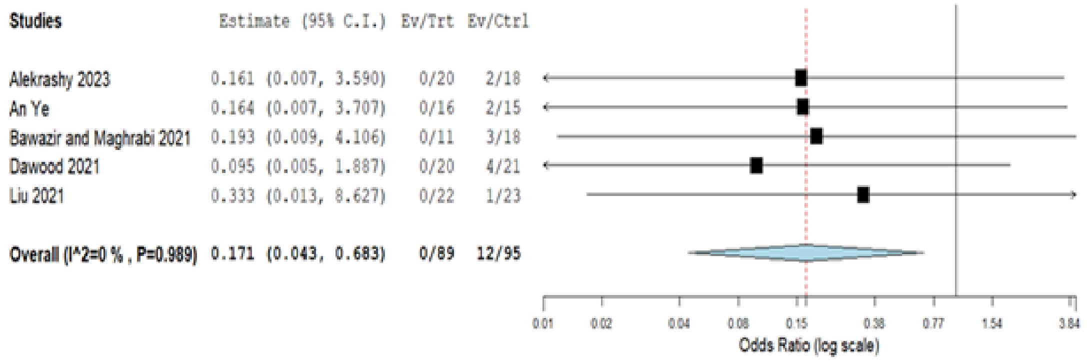

Fig. 3: Comparison between both groups regarding atrophy.

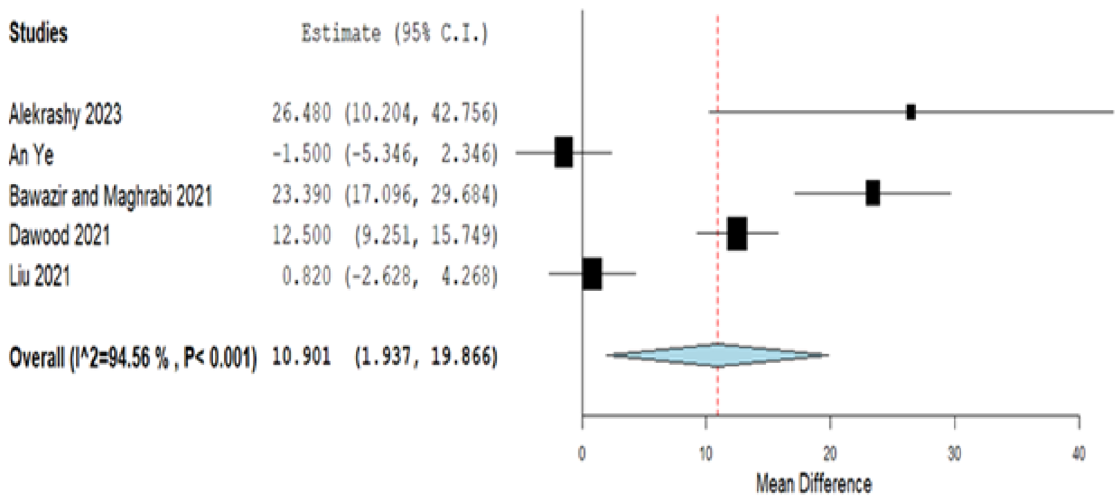

Fig. 4: Comparison between STO and FSO technique regarding first stage operation time.

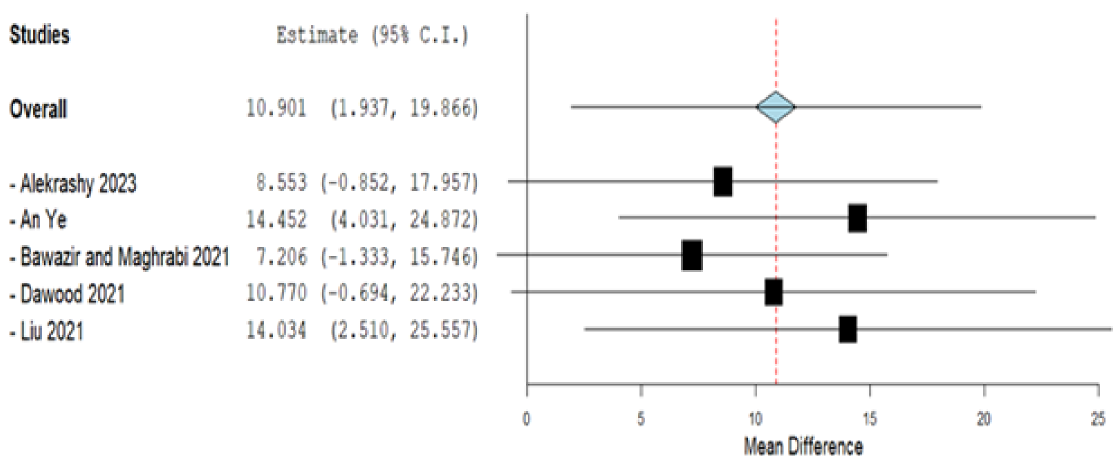

Fig. 5: Leave-one-out analysis of first stage operation time between both groups.

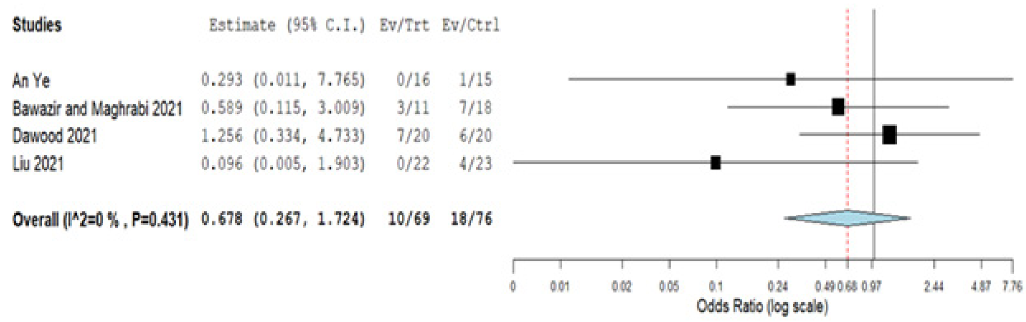

Fig. 6: Comparison between both groups regarding the rate of retraction.

DISCUSSION

The present study showed that STO is as good as FSO in treating IAT, but may be associated with better outcomes compared with FSO regarding the success, and atrophy rate. However, the STO is associated with a longer time in the first stage of operation compared with FSO with no difference between them in the second stage.

Surgical therapy of the high IAT is linked with a poorer success rate than inguinal orchiopexy, despite the fact that undescended testes is a common issue in pediatric surgery[24]. For many years, FSO has been the surgical method used to treat high IAT. Blood vessels of the spermatic cord must be cut, during the two-stage waiting period, which might last up to 6 months, which presents several disadvantages[25,26]. Numerous authors used laparoscopic-assisted traction testicular fixation for high IAT[17,27]. Shehata refined the testicular traction concept based on previous studies[14].

The foundation of FSO is the testes' distinctive anatomical trait of having three feeding blood vessels. Both tactics are based on many basic ideas. After the testicular artery (main supply) closes, peripheral blood flow is encouraged to nourish the testis[28]. However, when collateral circulation has not recovered following the acute ischemia brought on by testicular artery ligation, researchers wonder if the testes are irreversibly injured, which would have a detrimental effect on adult spermatogenesis and fertility. Numerous studies have previously shown that testicular histopathological damage results in a decrease in volume. In actuality, testicular artery division results in volume loss[25]. Tang *et al*. came to the conclusion that spermatogenic arrest and Leydig cell hyperplasia are caused by spermatic vessel closing and division[29]. The amount of Sertoli cells and the size of the testis did not alter before and after cutting and splitting the spermatic vasculature, according to research on spermatogonia and seminiferous tubule reduction by Rosito *et al*.[30]. Therefore, spermatogenesis and fertility may still be affected even if the testicular volume is normal. Not every testis has three common arteries. Although it cannot be practically assured, Shehata's traction approach would be most beneficial for IATs with just two blood arteries, which make up 20% of the testes[31].

By maintaining the internal spermatic artery, vas deferens artery, and vein throughout the procedure, Shehata's method successfully secured the testicular blood supply[32]. During the first stage, when the testis is properly positioned, the gut pushes the spermatic cord lower and backward. The main advantage of this strategy is that, with the help of continuous respiratory movement or chronic intestinal compression, the spermatic cord blood vessels may be gradually extended, preventing testicular ischemia caused by forcible pulling[15].

Shehata *et al*. conducted STO on ten IATs with ages ranging from 1 to 5 year. A slipped traction suture was changed to a FSO in one instance. After an average follow-up period of 8.7 months, 90% showed proper elongation after traction, with a successful scrotal position[14]. The same author reported mid-term outcomes of his method on a larger group of patients in a subsequent trial; 140 IAT cases who underwent STO, with ages ranging from 6 months to 9 years, and a mean follow-up of 16 (6–36) months. He reported an 84% success rate and 11% traction suture slippage. One limiting aspect of why STO is not appropriate for all cases of impalpable testis is that the highest success rate was achieved by those under 2 years old and with an IAT distance of less than 2cm from the IR. As the distance between the IAT and the ipsilateral IR increased, success progressively decreased, particularly in older children[15].

Two (10%) patients had suture slippage after the initial step of STO, according to Dawood *et al*.[20].

Given that both instances were older than 7 years, it is possible that the small testicular arteries, which have limited flexibility and elasticity, were under too much strain. Both of them have FSO. This could be a relative drawback of this strategy for individuals with atypically small arteries, especially older kids.

The use of phased procedures has significantly reduced the rate of testicular atrophy, which was very high in the early stages of FSO[33]. In Alagaratnam *et al*.'s investigation, B-ultrasound follow-up showed just one occurrence of testicular atrophy, which is typically commensurate with the atrophy rate documented in other studies[34]. Because the testicular blood arteries were preserved, the Shehata group did not exhibit testicular atrophy. According to certain studies on the long-term follow-up results of testicular FSO surgery, the testicular volume was reduced even though the testicular blood flow was virtually unaffected[25,35]. However, because Shehata traction orchiopexy has not been employed for a long time, long-term follow-up results are now unavailable.

Researchers believed that the intestine's weight might be the origin of the elongation mechanism in Shehata's technique. Furthermore, researchers thought that breathing while repeatedly contracting the abdominal muscles may aid in stretching the spermatic cord blood vessels[15]. A major issue regarding STO is that no histological evidence of the non-injurious effect of needle injury to the testis on theoretical or histological background has been studied.

Regarding the intraoperative confirmation criterion of high IAT, there is currently no agreement. Some studies have suggested that if the testicles were located less than 2cm from the inner ring, they may be immediately lowered and placed in the abdominal cavity[36–38]. This selection criterion makes sense since prior experience has demonstrated that the IAT can be directly lowered and secured to the scrotum when it is less than 2cm from the inner ring. There are, nonetheless, varying viewpoints. Bagga *et al*.[39], Agrawal *et al*.[36], and Esposito *et al*.[25] all propose staged surgery when the gap is greater than 1cm, less than 2.5cm, and 3cm, respectively. The selection criteria that can be utilized as a consensus may necessitate additional multicenter, big sample, and long-term follow-up studies to nullify the possible personal bias.

Shehata's strategy is not equally successful in controlling all high-level IATs since it necessitates a minimum length of testicular vasculature, even if traction appears to be the most effective technique for releasing the restriction brought on by a short spermatic cord. Elsherbeny *et al*. observed that high IATs more than 2cm away from the internal ring and those within 2cm of the internal ring yielded less favorable outcomes for Shehata's approach[16]. Furthermore, it appeared that, beyond a specific range, the increased length of the testicular arteries did not positively correlate with the duration of traction. Testicular vascular ligation may be necessary in cases where the spermatic cord is too short for traction to induce appropriate elongation[16].

Special benefits are provided by laparoscopic FSO surgery for the treatment of high-level IAT. For example, the testicular collateral circulation has to wait a long time following spermatic cord blood vessel transection[36]. The significance of the testicular ischemia test during surgery was demonstrated. Unfortunately, testicular atrophy occurs in around 10% of users of this technique[26]. To test for testicular ischemia, the spermatic cord blood arteries are blocked with a silk thread for ten minutes, making sure to make only undoable knots. The testicular blood supply is then monitored to determine whether there are any discernible variations between the two blocking times. If there is no obvious ischemic change in the testis after spermatic vascular occlusion, it is appropriate for FSO surgery since it suggests that the testicular collateral blood supply is abundant and the gubernaculum's blood supply is good[19].

Operative time comparison looks less logical because the length of the procedure depends on the surgeon's abilities and choice of time points. Both of the operational processes are rather basic and straightforward to learn. The success rates at various surgical ages were also compared. Shehata and Abouheba discovered that STO differed significantly depending on age groups: there is a greater success rate in the younger age group which is a significant barrier to the use of STO in all IAT situations[15,17]. Castillo-Ortiz *et al*. also recommended orchiopexy before the age of two to increase the chances of a successful Shehata's treatment[40]. However, according to Kaye *et al*. and Stec *et al*.[41,42], age at surgery was not a significant determinant.

Even though the Shehata approach has numerous advantages, certain drawbacks must be addressed in more research in the future. Three out of 34 older boys' testicles occasionally had testicular slippage during traction and fixation, according to Abouheba *et al*.[17]. Additionally, during the second step of laparoscopic surgery, both testes were fused simultaneously in one infant with bilateral IAT.

Additionally, Shehata *et al*. noted that whereas the success rate of traction was only 64% for boys older than 6 years old, it was over 90% for boys younger than 2 years old[15]. Therefore, we need to carry out further study and choose the best surgical strategy to treat bilateral, older males with high IAT.

Transfixing testicular parenchyma with a fixation suture may cause injury to the testis, perhaps leading to fertility difficulties, and this is still a source of worry to give a fair comparison of both approaches that require further investigation and follow-up.

CONCLUSION

STO is associated with a higher success rate and a lower rate of atrophy compared with the FSO technique in children with IAT. Therefore, it is suggested to be done with better outcomes. Considering that STO is not suitable for all types of IAT, further RCTs with larger sample sizes especially with very high IAT are still required to prove these findings.

Limitations

Our meta-analysis included all published articles in the literature comparing STO and FSO techniques in all available outcomes. This allows a comprehensive recent overview of the published data to obtain clear evidence. However, still exist some limitations in the present study. Firstly, the small sample size of the included study articles may produce inaccurate results or the results may not reach adequate statistical significance. Secondly, we have only one included RCT and the others are observational cohort studies which may produce bias. Thirdly, the surgical plan was chosen subjectively, the clinical evaluation was biased, and the success criterion was also prone to subjectivity. Fourthly, retrospective study design may produce various types of bias.

As a result, we have several suggestions that will be covered in future research. More RCTs with bigger sample sizes are required for a greater level of evidence. It is also expected that the males will be monitored throughout maturity, preferably until marriage, to assess their reproductive potential. Since histology is more trustworthy research than size, volume, or vascularity assessments, ethical considerations cannot be made. Based on previous animal research and damage hypotheses, each individual will really have notable histological and functional changes between their contralateral and operative testes.

CONFLICT OF INTEREST

There are no conflicts of interest.

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