Journal of Pediatric Urology (2014) 10, 186—192

ELSEVIER

Journal of Pediatric urology

Testicular outcome following laparoscopic second stage Fowler—Stephens orchidopexy

Swethan Alagaratnam [a], Calvin Nathaniel [c], Peter Cuckow [a,c], Patrick Duffy [a], Imran Mushtaq [a], Abraham Cherian [a,c], Divyesh Desai [a,c], Edward Kiely [b], Agostino Pierro [b], David Drake [b], Paolo De Coppi [b], Kate Cross [b], Joe Curry [b], Naima Smeulders [a,c,*]

[a] *Department of Paediatric Urology, Great Ormond Street Hospital NHS Foundation Trust, Great Ormond Street, London, UK*
[b] *Department of Paediatric Surgery, Great Ormond Street Hospital NHS Foundation Trust, Great Ormond Street, London, UK*
[c] *Department of Paediatric Urology, University College London Hospitals NHS Foundation Trust, Euston Road, London, UK*

Received 23 October 2012; accepted 1 August 2013
Available online 31 August 2013

KEYWORDS
Cryptorchidism;
Intra-abdominal testis;
Laparoscopic Fowler—Stephens orchidopexy;
Testicular ascent;
Testicular atrophy;
Conjoint tendon

Abstract *Objective:* To assess outcome after laparoscopic second-stage Fowler—Stephens orchidopexy (L2ndFSO).
Patients and methods: Retrospective review of 94 children (aged 0.75—16 years, median 2.75 years), who underwent L2ndFSO for 113 intra-abdominal testes between January 2000 and May 2009: 75 unilateral, 19 bilateral (11 synchronous; 8 metachronous). Follow-up (range 3 months—10.9 years, median 2.1 years) was available for 88 children (102 testes: 71 unilateral, 31 bilateral).
Results: Testicular atrophy occurred in 9 out of 102 (8.8%), including 8 out of 71 (11.3%) unilateral and 1 out of 31 (3.2%) bilateral intra-abdominal testes (multivariate analysis: $p = 0.59$). Testicular ascent ensued in 9 out of 102 (8.8%), comprising four (5.6%) unilateral and five (16.1%) bilateral testicles (multivariate analysis: $p = 0.11$). Of the 18 bilateral testes brought to the scrotum synchronously none atrophied and four (22.2%) ascended, compared to one (7.7%) atrophy and one (7.7%) ascent among the 13 testes brought to

* Corresponding author. Department of Paediatric Urology, Great Ormond Street Hospital NHS Foundation Trust, Great Ormond Street, London WC1N 3JH, UK. Tel.: +44 20 7405 9200; fax: +44 20 7813 8260.
E-mail addresses: Swethan@doctors.org.uk (S. Alagaratnam), Cnathaniel@doctors.org.uk (C. Nathaniel), Peter.Cuckow@gosh.nhs.uk (P. Cuckow), Pgduffy@doctors.org.uk (P. Duffy), Imran.Mushtaq@gosh.nhs.uk (I. Mushtaq), Abraham.Cherian@gosh.nhs.uk (A. Cherian), Divyesh.Desai@gosh.nhs.uk (D. Desai), Edward.Kiely@gosh.nhs.uk (E. Kiely), Agostino.Pierro@gosh.nhs.uk (A. Pierro), David.Drake@doctors.org.uk (D. Drake), Paolo.DeCoppi@gosh.nhs.uk (P. De Coppi), Kate.Cross@gosh.nhs.uk (K. Cross), Joe.Curry@gosh.nhs.uk (J. Curry), Naima.Smeulders@gosh.nhs.uk (N. Smeulders).

http://dx.doi.org/10.1016/j.jpurol.2013.08.005

the scrotum on separate occasions (Fisher exact test: $p = 0.42$ and $p = 0.37$, respectively). Mobilization of the testis through the conjoint tendon tended towards less ascent (multivariate analysis $p = 0.08$) but similar atrophy ($p = 0.56$) compared to mobilization through the deep-ring/inguinal canal. Logistical regression analysis identified no other patient or surgical factors influencing outcome.

Conclusions: This is the largest series of L2ndFSO to date. A successful outcome is recorded in 85 out of 102 (83.3%) testicles. Atrophy occurred in 8.8% and ascent in 8.8%.

Introduction

Undescended testes are a common finding in newborn males. While spontaneous descent reduces the prevalence from 2 to 8% at birth to 1—2% by 3 months of age [1], it rarely occurs after this time. The impact of cryptorchidism on spermatogenesis [1,2] and testicular malignancy [3] is well recognized, particularly for intra-abdominal testes [4,5]. Recent work has shown early orchidopexy to ameliorate some of these effects [5—8].

The cryptorchid testis is impalpable in 20% of boys. Diagnostic laparoscopy is the gold standard investigation for identifying the location of the testis. The vas deferens and testicular vessels are observed to enter the deep inguinal ring in approximately 40—50% of laparoscopies, blind ending vas deferens and testicular vessels are identified in 20—25%, and intra-abdominal testes are encountered in the remainder [9]. Intra-abdominal testes with sufficient vessel length may be mobilized into the scrotum in one procedure, although, in the vast majority, the gonadal vessels are too short.

Fowler and Stephens [10] described division of the testicular vasculature to aid mobilization, thereby leaving the testes to rely on collateral blood supply along the vas deferens in 1959. Twenty-five years later, Ransley et al. [11] advised a two-staged procedure with an interval between vessel ligation and testicular mobilization. Laparoscopy for division of the vessels was introduced 20 years ago, and more recently for mobilization during the second stage [12—14]. Initial outcome data for the two-stage laparoscopic procedure, based on relatively small case series, have reported success rates varying from 69% to 96.7% (Table 1). The largest series to date was published in 2009 by Hvistendahl and Poulsen [15], demonstrating a successful outcome in 80% of 65 testes.

In this study, we aim to review the results of two-stage laparoscopic Fowler—Stephens orchidopexy (L2ndFSO) and to explore patient and surgical factors on outcome.

Materials and methods

We retrospectively reviewed consecutive L2ndFSO performed under the care of 12 NHS Consultants at our hospitals from January 2000 to May 2009. We excluded procedures requiring orchidectomy or open conversion. The specific outcomes measured were testicular atrophy and ascent. Atrophy was defined as any reduction in the volume of the testis on clinical examination from that expected, based on the contemporaneously recorded operative observation of size. While postoperative assessment was by clinical palpation of the testis in the scrotum by the same Consultant or their Senior Registrar, intraoperative judgement of size was based on a combination of the magnified laparoscopic appearance and direct visualization on placement of the testis in a Dartos pouch. Surgeons recorded testicular size as small/moderate/good-sized and relative to the contralateral side as the same/smaller/

Table 1 Case series reviewing outcomes following laparoscopic two-stage Fowler—Stephens orchidopexy.

Series of L2ndFSO	Number of testes with follow-up	Follow-up period	Atrophy (%)	Displacement (%)	Overall success (%)
This series	102	2.1 years (median)	8.8	8.8	83.3
Hvistendahl et al. [15]	65	3 months	14.0	6.0	80.0
Baker et al. [16]	58	3 groups: 7.7, 8.6, and 20 months (mean)	10.3	1.7	87.9
El-Anany et al. [17]	47	3 years (mean)	4.3	0.0	95.7
Moursy et al. [18]	36	34 months (mean)	5.6	5.6	88.8
El-Gohary [19]	32	6 months to 5 years (mean/median not reported)	9.3	30.0	69.0
Radmayr et al. [20]	29	6.2 years (mean)	6.9	0.0	93.1
Denes et al. [21]	25	6 months to 15 years (mean/median not reported)	12.0	0.0	88.0
Esposito et al. [22]	12	10—17 years (mean/median not reported)	16.7	0.0	83.0

Of 36 cases reported by Esposito et al. follow-up was available for 12 patients.

significantly smaller both intra- and postoperatively, and rarely in centimetres or using an orchidometer. In recognition of the bias introduced by time and different subjective methods of assessment of testicular size intra- and postoperatively as well as wishful thinking by the surgeon at subsequent postoperative examination, atrophy was defined as any diminution in volume from that expected. Ascent was defined as the position of the testis outside the scrotum.

Logistic regression models were performed to assess the effect of patient factors (age, comorbidity, bilaterality) and surgical factors (use of clips or diathermy for testicular vessel ligation, with or without vessel division at the first stage, mobilization through the deep ring or through the conjoint tendon medial to the deep ring, and suturing the testis within a scrotal Dartos pouch during the second stage). Cases with bilateral intra-abdominal testes were analysed for differences in outcome following synchronous or metachronous second-stage procedures, and for testes mobilized through the deep ring and inguinal canal the effect of gubernacular preservation or division on outcome was explored using the Fisher exact test.

Results

Ninety-nine children underwent L2ndFSO for 118 intra-abdominal testes between January 2000 and May 2009. Five children did not meet our inclusion criteria: three children required open conversion and two needed orchidectomy for atrophy following the first-stage of the procedure. In the remaining 94 children with 113 testes, 19 children presented with bilateral intra-abdominal testes. In this group, 11 children underwent synchronous L2ndFSO for both testes. The remaining eight boys had their second-stage procedures at different times.

The median age of the 94 patients was 2.75 years (8 months–16 years) at the first stage. Six boys were lost to follow-up (4 unilateral, 2 bilateral). Three children with bilateral intra-abdominal testes had follow-up for one testis: one was followed-up for one testis, but was lost to follow-up after the second L2ndFSO, two underwent right-sided L2ndFSO with contralateral descent to the scrotum in one and the inguinal canal in one. The remaining 88 children, with 71 unilateral and 31 bilateral undescended testes (Table 2), were followed-up for a median 2.1 years (range 3 months–10.9 years). Nine children (8 unilateral and 1 bilateral undescended testes) attended a single appointment less than 6 months postoperatively (median 4.6 months): two testes had atrophied and two ascended. In order to avoid distortion of the results, the nine children were included in the outcomes analysis, in spite of their limited follow-up.

In 56 children (64.7%), an intra-abdominal testis was an isolated anomaly (Table 3). The remaining 32 children had comorbidities: 19 (21.6%) complex congenital syndromes, three (3.4%) congenital cardiac abnormalities, and 10 (11.4%) renal/genital abnormalities. The median time interval between the first and the second stage was 9 months.

Overall, 85 out of 102 (83.3%) testicles achieved satisfactory outcomes (Table 4). Testicular atrophy was identified in 9 out of 102 testicles (8.8%). This included 8 out of 71 (11.3%) unilateral and 1 out of 31 (3.2%) bilateral intra-abdominal testes (multivariate analysis $p = 0.59$). Testicular ascent was noted in 9 out of 102 testicles (8.8%), comprising four (5.6%) unilateral and five (16.1%) bilateral cases (multivariate analysis $p = 0.11$). One testis atrophied and ascended in the unilateral group.

Of the 18 bilateral testicles brought to the scrotum during the same procedure none atrophied, compared with one (7.7%) among the 13 testes brought to the scrotum on separate occasions (Fisher exact test $p = 0.42$). Testicular ascent was observed in four (22.2%) of the 18 bilateral testicles brought to the scrotum during the same procedure, compared with one (7.7%) among the 13 testes brought to the scrotum on separate occasions (Fisher exact test $p = 0.37$).

Eight children developed testicular ascent, including one bilateral. Of the nine ascended testes, four testes are in a scrotal position following open redo orchidopexy, two are waiting for surgery or review, one is unfit for anaesthesia, one suffered concurrent atrophy, and one was lost to further follow-up.

Logistical regression modelling examined the effect of patient and surgical factors on testicular atrophy (Table 5) and testicular ascent (Table 6). No factor appeared to independently affect the risk of testicular atrophy or ascent. However, passage of the mobilized testis through the deep ring carried an increased risk of testicular ascent with a p value approaching significance ($p = 0.08$) without improving testicular viability ($p = 0.56$). Of 40 testes

Table 2 Number of children meeting the inclusion criteria and with follow-up.

No. of testes (boys in brackets)	Unilateral testes	Bilateral testes		Total
		Synchronous procedures	Metachronous procedures	
Overall	75 (75)	22 (11)	16 (8)	113 (94)
Lost to follow-up	4 (4)	4 (2)	3 (0)[a]	11 (6)
Remainder with follow-up	71 (71)	18 (9)	13 (8)[a]	102 (88)

[a] Three children: all children underwent bilateral first-stage laparoscopic Fowler–Stephens orchidopexy. Follow-up available for one testis, but not for the second testis, one open orchidopexy for contralateral testis 6 months later, and one child had a spontaneously descended testis 6 months following the second-stage procedure on the contralateral side.

Table 3 Age distribution and incidence of comorbidity among the 86 children followed for up to 9 years after laparoscopic second-stage Fowler–Stephens orchidopexy.

Age at 1st stage	Number	Comorbidity	Comorbidity (%)
<2	25	9	36.0
>2–5	46	18	39.1
>5–9	12	4	33.3
>10	3	1	33.3

Table 4 Outcomes on follow-up after laparoscopic second-stage Fowler–Stephens orchidopexy.

Outcome	Unilateral testes	Bilateral testes		Total
		Synchronous procedures	Metachronous procedures	
Number of testes	71	18	13	102
Atrophy, *n* (%)	8[a] (11.3)	0 (0)	1 (7.7)	9[a] (8.8)
Ascent, *n* (%)	4[a] (5.6)	4 (22.2)	1 (7.7)	9[a] (8.8)
Overall failure, *n* (%)	11[a] (15.5)	4 (22.2)	2 (15.4)	17 (16.7)

[a] One testis atrophied and ascended on follow-up.

routed through the deep ring and inguinal canal, the gubernaculum could be preserved in four and was divided in 19; this information was not recorded for the remaining 17. No statistically significant difference in atrophy (0/4 vs. 2/19, Fisher exact test: $p = 1$) or ascent (1/4 vs. 3/19, Fisher exact test: $p = 1$) was observed between gubernacular preservation and its division.

Discussion

Half a century ago, Fowler and Stephens revolutionized the management of the intra-abdominal testis by advocating the division of the short tethering testicular vasculature and mobilization of the testis on its collateral blood supply along the vas deferens [10,22]. In order to permit time for the collateral vessels to strengthen prior to mobilization, the procedure is often carried out in two stages several months apart [11]. A recent meta-analysis observed the two-staged approach to achieve a higher success rate than combined vessel ligation and testicular mobilization, although there was no difference in outcome from an open versus a laparoscopic approach [23]. Our study is the largest series of L2ndFSO to date. Overall, 85 of 102 (83.3%) testicles achieved satisfactory outcomes.

Our results for L2ndFSO are similar to other large series (Table 1). Testicular atrophy occurred in 8.8% in our group. Hvistendahl and Poulsen [15] reported atrophy in 14% of 65 testes, and Baker et al. [16] reported atrophy in 10% of 58 testes. Assessment of testicular atrophy was based on clinical palpation. We compared the size of the testes on follow-up to the size noted during the Fowler–Stephens procedure performed under the care of the same Consultant. Atrophy was defined as any reduction in the size of the testis from that expected, based on the contemporaneously recorded operative observation of size, and not on

Table 5 Multivariate analysis of patient and surgical factors on testicular atrophy.

Variable	Number (info available)	Univariate analysis				Multivariate analysis			
		OR	95% CI for OR		*p* Value	OR	95% CI for odds ratio		*p* Value
			Lower	Upper			Lower	Upper	
Patient characteristics									
No comorbidities	64	1.00				1.00			
Comorbidities	37	0.47	0.09	2.37	0.38	0.33	0.03	3.80	0.37
Age <2 years	26	1.00				1.00			
Age >2 years	75	1.23	0.24	6.36	0.80	1.01	0.15	6.60	0.99
Unilateral	71	1.00				1.00			
Bilateral	31	0.26	0.03	2.16	0.21	0.49	0.04	6.63	0.59
First stage									
Diathermy of vessels	31	1.00				1.00			
Clip to vessels	62	1.55	0.30	8.19	0.60	1.06	0.06	19.1	0.97
Vessels divided	40	1.00				1.00			
Vessels not divided	53	1.87	0.44	7.95	0.40	3.91	0.33	47.0	0.28
Time interval between stages<6 months	22	1.00							
Time interval between stages>6 months	79	0.52	0.12	2.28	0.39	0.57	0.08	3.96	0.57
Second stage									
Mobilized through conjoint tendon medial to the deep ring	56	1.00				1.00			
Mobilized through the deep ring and inguinal canal	40	0.68	0.16	2.88	0.60	1.74	0.27	11.1	0.56
Suture fixation in Dartos pouch	73	1.00				1.00			
No suture fixation in Dartos pouch	22	0.39	0.05	3.28	0.38	–	–	–	1.00

Goodness of the fit of the model assessed by the Hosmer and Lemeshow test. $p = 0.28$. OR: odds ratio.

Table 6 Multivariate analysis of patient and surgical factors on testicular ascent.

Variable	Number (info available)	Univariate analysis				Multivariate analysis			
		OR	95% CI for OR		p Value	OR	95% CI for odds ratio		p Value
			Lower	Upper			Lower	Upper	
Patient characteristics									
No comorbidities	64	1.00				1.00			
Comorbidities	37	1.42	0.36	5.70	0.62	5.23	0.06	5.00	0.58
Age<2 years	26	1.00				1.00			
Age>2 years	75	2.99	0.36	25.09	0.31	1.21	0.10	13.89	0.88
Unilateral	71	1.00				1.00			
Bilateral	31	3.17	0.79	12.75	0.10	7.57	0.63	91.36	0.11
First stage									
Diathermy of vessels	31	1.00				1.00			
Clip to vessels	62	1.55	0.30	8.19	0.60	1.01	0.07	15.7	0.99
Vessels divided	40	1.00				1.00			
Vessels not divided	53	1.53	0.35	6.77	0.58	0.91	0.05	17.0	0.95
Time interval between stages<6 months	22	1.00				1.00			
Time interval between stages>6 months	79	0.97	0.19	5.05	0.97	0.72	0.06	8.66	0.79
Second stage									
Mobilized through conjoint tendon medial to the deep ring	56	1.00				1.00			
Mobilized through the deep ring and inguinal canal	40	2.52	0.57	11.2	0.22	6.36	0.81	50.0	0.08
Suture fixation in Dartos pouch	73	1.00				1.00			
No suture fixation in Dartos pouch	22	0.94	0.18	4.91	0.94	0.21	0.01	4.78	0.32

Goodness of the fit of the model assessed by the Hosmer and Lemeshow Test. $p = 0.94$; OR: odds ratio.

a postoperative comparison with the contralateral testis only.

The majority of the studies listed in Table 1 similarly based their outcomes on subjective clinical assessment, with the following exceptions: Esposito et al. [22] employed ultrasound for volumetric measurement of the testis, Radmayr et al. [20] used Doppler flow, and El-Anany et al. [17] used technetium-99m to confirm testicular viability. The validity of clinical assessment in the judgement of testicular size is supported by Sijstermans et al. [24], who documented strong correlation between ultrasound measurements of the testis and palpation (orchidometer). Furthermore, significant reduction in testicular size reliably identified non-viable testes as assessed by technetium-99m [17].

Interestingly, Esposito et al. [22] found all operated intra-abdominal testes to be smaller than the normally descended contralateral gonad after 10–17 years following L2ndFSO. This was also noted by Sijstermans et al. [24] after open inguinal orchidopexy for palpable cryptorchid testes. However, comparison of the unilaterally operated cryptorchid testis to percentiles for age showed that only 3% more than expected measured less than the 10th centile, and 5% more than expected were below the 50th centile for age. This suggests that the difference in size between the operated and the normally descended contralateral testes may reflect hypertrophy of the normal contralateral testis, rather than a degree of atrophy in all operated cryptorchid testes. It stresses the importance of comparing postoperative size to, for instance, the intraoperative assessment of the same testis rather than the contralateral side, despite the potential bias introduced by the time lag and different methods of assessment. While postoperative assessment in our series was by clinical palpation of the testis in the scrotum, intraoperative judgement of size was based on a combination of the magnified laparoscopic appearance and direct visualization on placement of the testis in a Dartos pouch.

Radmayr et al. [20] did not observe a difference in size between the intra-abdominal testis placed in the scrotum by two-stage Fowler–Stephens orchidopexy and the normally descended contralateral testis. Could this reflect a younger age at surgery? Recent studies have demonstrated better testicular outcomes if orchidopexy for the palpable undescended testis is carried out at a younger age. Canavese et al. [8] demonstrated significantly improved sperm counts and mobility on long-term follow-up for children who underwent orchidopexies aged <1 year compared with 2 years. In addition, Kollin et al. [25] randomized 70 children to orchidopexy at 9 months or orchidopexy deferred to 3 years. At 2 years of age, the ultrasound testicular volume was significantly higher in the operated group than the undescended group awaiting orchidopexy. Compared with the normally descended contralateral testis, even in the neonatal period, the undescended palpable testis was smaller. While the descended contralateral testis showed gradual growth, the volume of the undescended testis increased during the first 6 months of life, but failed to grow thereafter until brought into a scrotal position. The median age of our patient group was 2.75 years, which is higher than the now recommended age of <1 year. This is due to the following reasons. First, recommendations for the timing of orchidopexy have steadily reduced during the last decades. Secondly, a third of our patient group had significant comorbidities requiring other more urgent procedures. Thirdly, most children had undergone initial assessments for cryptorchidism at another institution before referral to our departments. Multivariate analysis indicated no difference in testicular atrophy or ascent between patients aged under or over 2 years. However, it must be stressed that postoperative testicular size is a dubious indicator of the ultimate outcome measure: post-pubertal testicular function.

Hvistendahl and Poulsen [15] observed better outcomes for patients with bilateral intra-abdominal testes than the unilateral group and attributed this to the younger age at operation for the bilateral group. In our series, there was no difference in age at L2ndFSO between unilateral and bilateral cases. Testicular atrophy was similar for both groups though a greater tendency to ascent was noted for bilateral L2ndFSO (multivariate analysis $p = 0.11$). Particularly in boys with bilateral intra-abdominal testes, the scrotum is frequently hypoplastic. Could the lack of space within the scrotum force the testes back into the groin? To help answer this question, we explored differences in outcomes for the timing of L2ndFSO for bilateral intra-abdominal testes, with regards to synchronous or metachronous procedures. Although a tendency to an increased risk of ascent was noted for bilateral intra-abdominal testes as a whole, undertaking the second stage synchronously or metachronously did not appear to affect testicular atrophy or ascent (Fisher exact test $p = 0.42$ and $p = 0.37$, respectively). While the numbers may simply have been too small to demonstrate a difference, we could not find any other reports comparing outcomes following synchronous and metachronous bilateral orchidopexy.

Overall, testicular ascent was noted in 8.8%. Many other studies report no testicular ascent on follow-up. Hvistendahl and Poulsen [15] reported a 6% displacement rate and El-Gohary [19] reported a rate of 30%. Does this wide range in outcomes reflect a difference in technique, definition, duration of follow-up, bilaterality, patient age, or other factors? This question is difficult to answer, as precise descriptions of "ascent" let alone details of operative techniques are frequently unreported. El-Gohary [19], who observed testicular ascent in 30%, defined even a high scrotal position as displacement. Similar to Baker et al. [16], we defined testicular ascent in our series as a testicular position outside the scrotum.

Interestingly, two boys, both less than 2 years, who underwent bilateral first-stage ligation of testicular vessels followed by a right L2ndFSO, showed spontaneous descent of the contralateral testis 4 and 11 months after vessel ligation: to a groin position enabling open orchidopexy in one, and to the scrotum in the other. The median gap between the first- and second-stages was 9 months in our series. The interval did not appear to affect the outcome of L2ndFSO. The shortest interval was 3.5 months resulting in a successful outcome. What is the ideal interval? Allowing time for improvement in the collateral vasculature and/or possible spontaneous descent after first-stage vessel ligation has to be balanced against recent work indicating benefit from early orchidopexy on testicular function and risk of malignant change [5–8]. Ransley et al. [11] suggested that in theory an interval of as little as 3 weeks might be adequate for enhancement of collateral vasculature. Spontaneous descent after vessel ligation at mean age 36 months (range 11–68 months) was also observed by Robertson et al. [26]: 10/25 testes had adopted a more descended position at mean age 44 months (range 15–95 months), affording an open inguinal orchidopexy instead of L2ndFSO in three.

Only two intra-abdominal testes (1.6%) needed orchidectomy for atrophy following ligation of the testicular vessels to 118 testes; in the remainder, a viable testis was observed during L2ndFSO. Ransley et al. [11] stressed the importance of leaving the testis itself undisturbed during the first-stage, ligating the gonadal vessels at least 1–2 cm proximally. They postulated that double ligation and division, rather than single ligation and leaving the testicular vessels in continuity, would reduce the risk of new collateral vessel growth around the ligature which would require division at the subsequent mobilization potentially impacting testicular viability. Like Robertson et al. [26], we found no effect on testicular atrophy or ascent after L2ndFSO from either clipping versus diathermy ligation of the testicular vessels, or their division.

Others have suggested that in addition to the collateral blood supply along the vas deferens, vessels arising from the gubernaculum should be preserved during L2ndFSO and the testis mobilized to the scrotum through the deep ring along the patent processus vaginalis [26]. Nevertheless, Robertson et al. [26] reported three (14%) testicular atrophies in 21 testes brought to the scrotum using this technique. Logistical regression modelling in our study identified no benefit for testicular viability from mobilization through the inguinal canal (multivariate analysis $p = 0.56$). Instead, a higher incidence of ascent approaching significance (multivariate analysis $p = 0.08$) was noted for passing the testis through the deep ring and canal rather than forging a more direct path through the conjoint tendon. Additional groin incision for preservation of the gubernacular vessels has been proposed, with good results in one small series [27]. In our cohort, the gubernaculum was documented to have been preserved in only four of 40 testes routed through the deep ring and inguinal canal without discernible statistically significant benefit for atrophy or ascent. Surgeons commented that even for testes brought to the scrotum through the inguinal canal, preservation of the gubernacular vessels is frequently not possible in view of the gubernaculum's extrascrotal insertion in congenitally undescended testes [28].

Conclusions

This is the largest study of L2ndFSO to date. Only two testes (1.6%) were lost after first stage vessel ligation. Following L2ndFSO, testicular atrophy was noted in 8.8%, displacement in 8.8% and an overall successful outcome in 83.3%. For bilateral intra-abdominal testes, a higher incidence of ascent was observed, although performing the second stage procedures on one or two separate occasions made no significant difference to outcome. Mobilization of the testis through the deep ring and inguinal canal rather than re-routing through the conjoint tendon carried a greater risk of ascent (approaching significance, $p = 0.08$) without impacting testicular viability. Logistical regression analysis identified no other patient or surgical factors influencing outcome.

Conflict of interest

None.

Funding

None.

Ethical approval

Institutional approval obtained.

References

[1] Virtanen HE, Bjerknes R, Cortes D, Jorgensen N, Rajpert-De Meyts E, Thorsson AV, et al. Cryptorchidism: classification, prevalence and long-term consequences. Acta Paediatr 2007;96:611—6.

[2] Lee PA, Coughlin MT. Fertility after bilateral cryptorchidism. Evaluation by paternity, hormone, and semen data. Horm Res 2001;55:28—32.

[3] Dieckmann KP, Pichlmeier U. Clinical epidemiology of testicular germ cell tumors. World J Urol 2004;22:2—14.

[4] Carmignani L, Morabito A, Gadda F, Bozzini G, Rocco F, Colpi GM. Prognostic parameters in adult impalpable ultrasonographic lesions of the testicle. J Urol 2005;174:1035—8.

[5] Tasian GE, Hittelman AB, Kim GE, DiSandro MJ, Baskin LS. Age at orchiopexy and testis palpability predict germ and Leydig cell loss: clinical predictors of adverse histological features of cryptorchidism. J Urol 2009;182:704—9.

[6] Pettersson A, Richiardi L, Nordenskjold A, Kaijser M, Akre O. Age at surgery for undescended testis and risk of testicular cancer. N Engl J Med 2007;356:1835—41.

[7] Caldamone AA, Amaral JF. Laparoscopic stage 2 Fowler-Stephens orchiopexy. J Urol 1994;152:1253—6.

[8] Canavese F, Mussa A, Manenti M, Cortese MG, Ferrero L, Tuli G, et al. Sperm count of young men surgically treated for cryptorchidism in the first and second year of life: fertility is better in children treated at a younger age. Eur J Pediatr Surg 2009;19:388—91.

[9] Kanemoto K, Hayashi Y, Kojima Y, Maruyama T, Ito M, Kohri K. Accuracy of ultrasonography and magnetic resonance imaging in the diagnosis of non-palpable testis. Int J Urol 2005;12:668—72.

[10] Fowler R, Stephens FD. The role of testicular vascular anatomy in the salvage of high undescended testes. Aust N Z J Surg 1959;29:92—106.

[11] Ransley PG, Vordermark JS, Caldamone AA, Berllinger MF. Preliminary ligation of the gonadal vessels prior to orchidopexy for the intra-abdominal testicle. A staged Fowler-Stephens procedure. World J Urol 1984;2:266—8.

[12] Bloom DA, Ayers JW, McGuire EJ. The role of laparoscopy in management of nonpalpable testes. J Urol 1988;94:465—70.

[13] Jordan GH, Winslow BH. Laparoscopic single stage and staged orchiopexy. J Urol 1994;152:1249—52.

[14] Diamond DA, Caldamone AA. The value of laparoscopy for 106 impalpable testes relative to clinical presentation. J Urol 1992;148:632—4.

[15] Hvistendahl GM, Poulsen EU. Laparoscopy for the impalpable testes: experience with 80 intra-abdominal testes. J Pediatr Urol 2009;5:389—92.

[16] Baker LA, Docimo SG, Surer I, Peters C, Cisek L, Diamond DA, et al. A multi-institutional analysis of laparoscopic orchidopexy. BJU Int 2001;87:484—9.

[17] El-Anany F, Gad El-Moula M, Abdel Moneim A, Abdallah A, Takahashi M, Kanayama H, et al. Laparoscopy for impalpable testis: classification-based management. Surg Endosc 2007;21:449—54.

[18] Moursy EE, Gamal W, Hussein MM. Laparoscopic orchiopexy for non-palpable testes: outcome of two techniques. J Pediatr Urol 2011;7:178—81.

[19] El-Gohary MA. The role of laparoscopy in the management of impalpable testes. Pediatr Surg Int 1997;12:463—5.

[20] Radmayr C, Oswald J, Schwentner C, Neururer R, Peschel R, Bartsch G. Long-term outcome of laparoscopically managed nonpalpable testes. J Urol 2003;170:2409—11.

[21] Denes FT, Saito FJ, Silva FA, Giron AM, Machado M, Srougi M. Laparoscopic diagnosis and treatment of nonpalpable testis. Int Braz J Urol 2008;34:329—34.

[22] Esposito C, Vallone G, Savanelli A, Settimi A. Long-term outcome of laparoscopic Fowler-Stephens orchiopexy in boys with intra-abdominal testis. J Urol 2009;181:1851—6.

[23] Elyas R, Guerra LA, Pike J, De Carli C, Betoli M, Bass J, et al. Is staging beneficial for Fowler-Stephens orchiopexy? A systematic review. J Urol 2010;183:2012—8.

[24] Sijstermans K, Hack WW, van der Voort-Doedens LM, Meijer RW. Long-term testicular growth and position after orchidopexy for congenital undescended testis. Urol Int 2009;83:438—45.

[25] Kollin C, Karpe B, Hesser U, Granholm T, Ritzen EM. Surgical treatment of unilaterally undescended testes: testicular growth after randomization to orchiopexy at age 9 months or 3 years. J Urol 2007;178:1589—93.

[26] Robertson SA, Munro FD, Mackinlay GA. Two-stage Fowler-Stephens orchidopexy preserving the gubernacular vessels and a purely laparoscopic second stage. J Laparoendosc Adv Surg Tech A 2007;17:101—7.

[27] Mahomed A, Adams S, Islam S. Initial success with gubernacular-sparing laparoscopic-assisted Fowler-Stephens orchidopexy for intra-abdominal testes. J Laparoendosc Adv Surg Tech A 2012;22:192—4.

[28] Hutson JM, Nation T, Balic A, Southwell BR. The role of the gubernaculum in the descent and undescent of the testis. Ther Adv Urol 2009;1:115—21.