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Laparoscopic Fowler–Stephens Orchidopexy for Non-Palpable Testes in Children: Outcomes and Risk Factors for Postoperative Testicular Atrophy in a 72-Patient Cohort

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Abstract

Background

Non-palpable testes (NPT) represent a challenging form of cryptorchidism that often requires advanced surgical management. Two-stage laparoscopic Fowler–Stephens (FS) orchidopexy is widely used for high intra-abdominal testes to achieve scrotal placement while preserving testicular viability. This study aimed to evaluate the outcomes of this technique and identify risk factors associated with postoperative testicular atrophy.

Methods

We retrospectively analyzed 72 children with 83 NPT who underwent two-stage laparoscopic FS orchidopexy at Habib Thameur Hospital between 2013 and 2022. Demographic characteristics, intraoperative findings, testicular position and volume, presence of epididymo-testicular dissociation (DET), surgical details, and postoperative outcomes were reviewed. Testicular atrophy was defined as a reduction in testicular volume greater than 50% or absence of vascular flow on Doppler ultrasound. Univariate and multivariate logistic regression analyses were performed to determine predictors of surgical failure.

Results

The mean age at surgery was 3.5 years, and DET was identified in 26.5% of cases. The mean interval between the two stages was 11 months. After a mean follow-up of 17 months, successful scrotal positioning was achieved in 86% of testes. Testicular atrophy occurred in 4.7% of cases, and one patient required reoperation due to retraction. Multivariate analysis revealed that DET and an interval of at least one year between surgical stages were independent predictors of failure.

Conclusion

These findings support the effectiveness of two-stage FS orchidopexy for NPT, with low rates of complications. Careful surgical planning, appropriate staging intervals, and close monitoring of DET cases are essential to optimize outcomes.

Introduction

Cryptorchidism, or undescended testis, is one of the most common congenital conditions in boys, affecting approximately 1–3% of full-term infants and up to 30% of preterm babies. Many of these cases remains high in the abdomen and are non-palpable. These cases pose a particular challenge for

surgeons, both because of the complex anatomy and because untreated testes can lead to reduced fertility and an increased risk of malignancy later in life [1–2].

For palpable testis, surgical correction is usually straightforward and highly successful. However, when the testis is non-palpable, management becomes more complex. Over the past decades, laparoscopy has become the gold standard for both diagnosis and management of non-palpable testes. Among the laparoscopic techniques, the Fowler–Stephens (FS) approach has emerged as a reliable method for high intra-abdominal testes. By dividing the testicular vessels in one or two stages, this procedure relies on collateral blood supply from the deferential and cremasteric arteries to preserve testicular function [3–4]

Although many studies report good outcomes with FS orchidopexy, success rates remain variable, and complications such as testicular atrophy or retraction continue to occur. Recent evidence, including a systematic review and meta-analysis, suggests that a two-stage FS procedure may reduce the risk of atrophy and improve overall success rates, but predictors of postoperative outcomes are still inconsistently identified [5].

In this study, we report our institutional experience with laparoscopic Fowler–Stephens orchidopexy in children with non-palpable testes(NPT). Beyond reporting surgical outcomes, we aimed to identify factors associated with postoperative testicular atrophy, with the goal of helping surgeons optimize management strategies for these challenging cases.

Study Design and Population

We conducted a Retrospective cohort study at the Paediatric Surgery Department of Habib Thameur Hospital, Tunis, covering ten years from January 1, 2013, to December 31, 2022. Our series included 72 children with non-palpable testes (NPT) who underwent laparoscopic Fowler–Stephens (FS) orchidopexy.

We excluded children with testes that could be felt under general anaesthesia, as well as those with intra-abdominal testes with a long vascular pedicle that could be managed using standard inguinal orchidopexy. All included patients were treated with the two-stage FS approach, ensuring a consistent surgical protocol across the cohort.

Surgical Technique

First stage – Laparoscopic exploration:

- Laparoscopy allowed us to confirm whether the testis was present, locate it precisely, estimate its size, and check for any dissociation between the epididymis and the testis.
- Gentle traction of the spermatic cord toward the contralateral side helped assess whether its length was sufficient for a one-stage orchidopexy. If not, the FS technique was chosen.

Second stage – Inguinal orchidopexy:

- Through an inguinal incision, we carefully dissected the spermatic cord and vas deferens while preserving a peritoneal sleeve and the gubernaculum.
- The testis was then gently mobilized and positioned in a newly created scrotal pouch (Figure 1).

Variables Collected

- We recorded key information for each patient:
- Age at surgery
- Laterality (unilateral or bilateral)
- Testicular position and estimated volume evaluated by clinical palpation, orchidometer measurement, and ultrasonography
- Presence of epididymo-testicular dissociation
- Postoperative outcomes, including testicular position, atrophy, complications, and any need for reoperation
- Testicular atrophy was defined as a reduction in volume of more than 50% compared with the contralateral testis on ultrasonography or absence of vascular flow on Doppler imaging.
- Potential risk factors for postoperative testicular atrophy—including age at surgery, testicular volume, laterality, and presence of epididymo-testicular dissociation—were recorded and subsequently analysed using univariate and multivariate logistic regression to identify independent predictors.

Outcome Assessment

- **Primary outcome:** success of orchidopexy, defined as placement of the testis in the scrotum.
- **Secondary outcome:** testicular atrophy, evaluated by **clinical palpation, orchidometer measurement, and follow-up ultrasonography**.

Follow-up duration:

Mean follow-up duration was 11 months.

Statistical Analysis

- Continuous variables were summarized as mean ± standard deviation (SD) or median (range), and categorical variables as counts and percentages. Comparisons between groups were performed using the Student's t-test or Mann–Whitney U test for continuous variables, and the Chi-square test or Fisher's exact test for categorical variables, as appropriate.
- Univariate analyses were first performed to assess associations between potential risk factors and postoperative testicular atrophy. Variables with a p-value < 0.20 in univariate analysis were

subsequently entered into a multivariate logistic regression model to identify independent predictors. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. The goodness-of-fit of the model was assessed using the Hosmer–Lemeshow test. Statistical significance was set at $p < 0.05$.

- All analyses were performed using **SPSS version 2022**

Ethical approval:

The study was approved by the Institutional Ethics Committee of Habib Thameur Hospital (approval number: HTHEC-2024-04).

Results

I. Descriptive Study

1. Epidemiology

Over the 10-year study period, 72 children with 83 non-palpable testes (NPT) underwent laparoscopic Fowler–Stephens orchidopexy, corresponding to approximately 7.2 new cases per year (Figure 2). Among 1,400 children operated for undescendant testicule, 10.5% had non-palpable testes, with 56% intra-abdominal with a short spermatic cord, forming the focus of this study (Figure 3).

2. Age and Laterality

The mean age at surgery was 3.5 years (range 1–10.5 years), peaking between 2 and 6 years. Cryptorchidism was unilateral in 85% and bilateral in 15% (11 children), with the left side more commonly affected (49% of unilateral cases).

II. Imaging and Laboratory

In the 11 children with bilateral NPT, karyotyping and hormonal analyses revealed no abnormalities except for one case of GnRH deficiency. Testicular ultrasound was performed in 45 patients, six of whom had bilateral NPT. The testis was not visualized in 13 cases, located intra-abdominally in 17 cases, and near the deep inguinal ring in 21 cases. The mean volume of the cryptorchid testes on ultrasound was 1.1 mL (range 0.4–4.7 mL), with an overall sensitivity of 74.5% (Figure 4).

To better illustrate the detection accuracy, laparoscopic findings were separated into a distinct figure (Figure 4), showing that laparoscopy detected all 83 testes, compared to 32 detected by ultrasound.

III. Surgical Management

All patients underwent a two-stage Fowler–Stephens procedure. During the first laparoscopic stage, 80 testes were found intra-abdominally, and 3 were located near the deep inguinal ring. The mean intraoperative testicular volume was 0.9 mL (range 0.2–4 mL). Epididymo-testicular dissociation (DET)

was noted in 22 cases (26.5%), and associated inguinal hernia was present in 54 cases (65%). All testes had a short spermatic cord and were treated with vessel ligation according to the FS technique.

The second stage was performed via an inguinal approach. After exposure of the inguinal canal, 42 testes were positioned in the inguinal region, while 33 remained intra-abdominal. The deferential artery and hypertrophied gubernaculum were preserved. The mean testicular volume at the second stage was 1.36 mL (range 0.2–10 mL). Sixty-one testes were mobilized without tension, and nine required mobilization under tension. Five very small testes with absent deferential artery and non-hypertrophied gubernaculum were excised. The mean interval between stages was 11 months (range 4–24 months), with one patient delayed due to the COVID-19 pandemic.

IV. Postoperative Outcomes

At a mean follow-up of 17 months, 55 testes (86%) were positioned in the scrotum. Among these, 31 testes (48.5%) had normal volume, while 24 (37.5%) had reduced volume. Three testes (4.7%) developed atrophy, and one (1.5%) retracted, requiring a repeat inguinal procedure. Radiological assessment at one year showed a mean testicular volume of 5.8 mL (range 1.2–11 mL) for the operated testes, compared to 14 mL (range 5–20 mL) for the contralateral testes. One patient developed grade 2 intratesticular calcifications (**Figure 5**).

V. Factors Affecting Surgical Success

Multivariate logistic regression was performed to identify independent predictors of surgical failure, including DET, interval ≥1 year between stages, testicular volume, mobilization under tension, and age <2 years. Only the presence of DET (OR 8.6, 95% CI 2.4–31.2, p=0.001) and an interval ≥1 year (OR 5.2, 95% CI 1.3–20.5, p=0.018) were independently associated with failure. Other factors, such as testicular volume at the second stage, mobilization under tension, or age at surgery, were not significant (Table 1).

Table 1. Multivariate logistic regression – predictors of surgical failure

Factor	Adjusted OR	95% CI	p-value
DET present	8.6	2.4 – 31.2	0.001
Interval ≥1 year	5.2	1.3 – 20.5	0.018
Testis eutrophic at 2nd stage	0.7	0.2 – 2.4	0.56
Mobilization under tension	1.3	0.3 – 5.2	0.71
Age <2 years	0.9	0.3 – 2.7	0.88

Discussion

Undescended testes are a common reason for paediatric surgical consultation, affecting roughly 20% of preterm infants, 3% of full-term newborns, and 0.8% of children under one year [1]. In our department, non-palpable testes (NPT) represented 10.5% of all cryptorchid testes. These cases often pose a particular challenge for both diagnosis and treatment.

Age at diagnosis is a critical epidemiological factor influencing both therapeutic strategy and outcomes [2]. According to the Nordic consensus and European Association of Urology guidelines, the optimal age for orchidopexy is between 6 and 12 months [3]. In our series, the mean age at diagnosis was 3.5 years, which is considered delayed. This diagnostic delay affects treatment decisions and expected outcomes [4], often resulting from parental unawareness and the absence of systematic neonatal screening [5].

The diagnosis of cryptorchidism remains primarily clinical. Careful palpation of the scrotum and inguinal canal in a relaxed child is essential [6]. While imaging, particularly ultrasonography, can help locate non-palpable testes, its sensitivity remains modest (66% in our series), and it cannot replace laparoscopic exploration [8,9]. Karyotyping and hormonal workup, performed selectively in our cohort, were normal in nearly all cases, reinforcing the importance of individualized assessment [7].

Today, laparoscopy is considered the gold standard for locating NPT and planning surgery [10]. Testes located high in the abdomen with short spermatic cords often require a two-stage Fowler–Stephens (FS) procedure. These high testes usually have a smaller volume compared with their scrotal counterparts, likely due to prolonged exposure to higher intra-abdominal temperatures, which can impair maturation and lead to gradual atrophy. In our series, mean testicular volume increased from 1.1 mL on preoperative ultrasound to 5.8 mL postoperatively, reflecting both normal growth and the positive impact of surgical descent.

The first stage of FS orchidopexy involves careful mobilization of the testis and ligation of the spermatic vessels to encourage the development of collateral blood supply. We used ultrasonic coagulation, which limits thermal injury (45–50°C vs. 400°C for traditional electrocautery) [12,13]. The second stage, performed after an interval to allow vascularization, ensures secure scrotal fixation while preserving the deferent duct, a peritoneal cuff, and the gubernaculum to maintain testicular blood supply [14].

The second stage may be performed via inguinal or laparoscopic approach with an ipsilateral scrotal counter-incision [14]. Dissection preserves the deferent duct, a peritoneal cuff, and the gubernaculum to maintain collateral blood supply. In our series, all second-stage procedures were performed via inguinal access. Comparative studies, including Casanova et al., suggest that inguinal access allows more delicate manipulation and higher success rates [15].

Tension-free placement remains essential. In our cohort, 61 testes were descended without tension, while 9 were under slight tension. Five extremely small testes were removed due to poor viability and risk of degeneration [16].

The interval between the two stages is crucial to allow neovascularization. Literature reports a mean interval of 6 months, with extremes ranging from 3 to 7 months [17,18]. In our series, the mean interval was 11 months, reflecting clinical scheduling and follow-up constraints.

Outcomes of FS orchidopexy are favourable. A meta-analysis including 1991 intra-abdominal testes reported success rates of 85% for single-stage and 87% for two-stage FS procedures, with an overall atrophy rate of 10% [19]. In our study, 55 testes were successfully positioned, 3 developed atrophy, and 1 required reoperation for retraction, resulting in an overall success rate of 86%.

Recent studies reported orchidopexy in a single stage approach. However, a recent meta-analysis by Fung et al. concluded that two-stage laparoscopic Fowler–Stephens orchidopexy provides higher success rates and lower testicular atrophy [20].

Multivariate analysis identified two factors significantly associated with orchidopexy failure: epididymo-testicular dissociation (DET) and an interval exceeding one year between stages (p=0.001 and p=0.014, respectively). Early intervention remains critical to optimize testicular survival, particularly in cases with DET [11]. Tension at orchidopexy was not significantly associated with retraction in our cohort (p=0.35).

Long-term follow-up is essential to assess fertility potential and malignancy risk, as these outcomes manifest over decades [20]. In cases of absent or vanishing testes, prepubertal prosthesis placement is recommended to minimize psychological impact [21].

Conclusion

Non-palpable testes represent a complex subset of cryptorchidism that requires careful, individualized management. Our study confirms that two-stage Fowler–Stephens orchidopexy achieves high success (86%) with minimal atrophy. Key risk factors for postoperative failure include epididymo-testicular dissociation and prolonged intervals between stages. Early diagnosis, adherence to recommended staging intervals, meticulous surgical technique, and structured follow-up are critical to preserving testicular growth and function. Educating parents about the importance of follow-up and potential anatomical risks further supports optimal outcomes. These findings provide practical guidance for paediatric surgeons managing high intra-abdominal testes and underscore the importance of long-term surveillance to safeguard fertility and hormonal function.

Declarations

Ethics approval: Approved by Ethical comity of Habib Thameur Hospital

Consent to participate: Informed consent was obtained

Consent for publication: obtained

Availability of data: Data available on request

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Author contributions:

- **Cyrine Saadi:** Conceptualization, study design,
- **Fares Chaabouni:** data collection, data analysis, manuscript drafting.
- **Souha Laarif:** Surgical procedures, data interpretation, critical revision of the manuscript.
- **Malak Boughdir:** Statistical analysis, figure preparation, manuscript editing.
- **Aida Daib:** Literature review, patient follow-up, supervision.
- **Youssef Hellal:** Surgical procedures, Literature review, patient follow-up, supervision.
- **All authors** read and approved the final manuscript.

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Figures

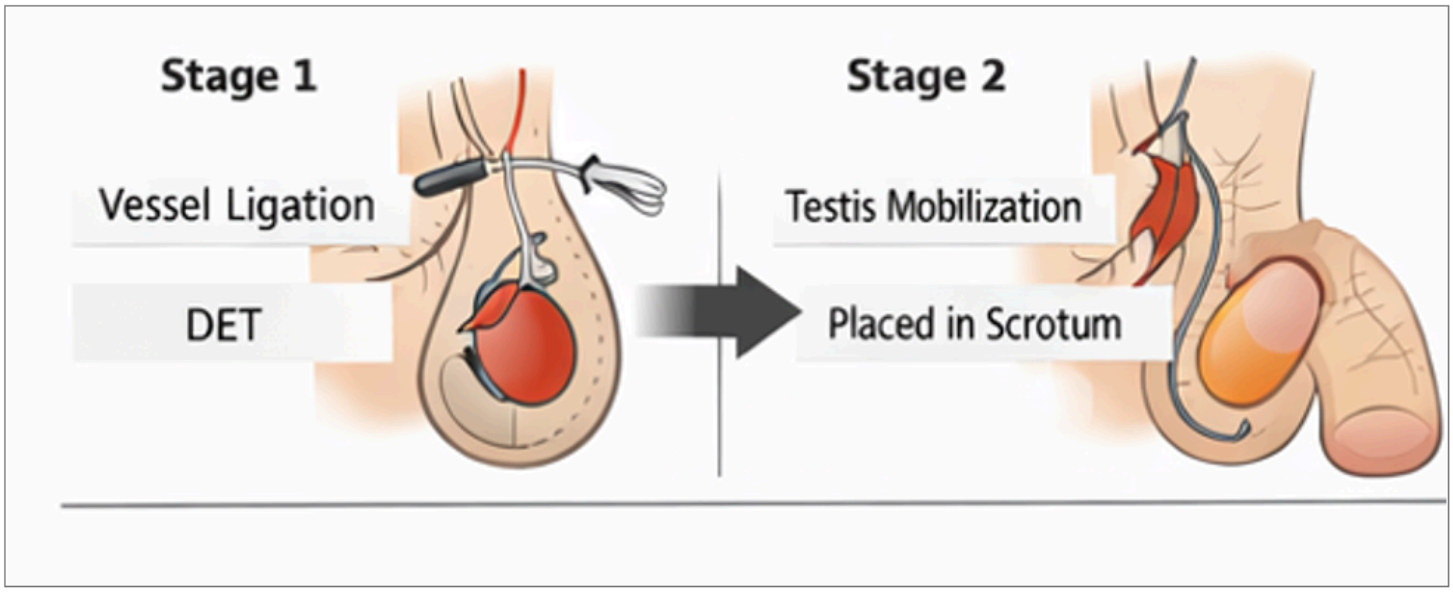


Figure 1

Fowler–Stephens orchidopexy procedure : Stage 1 (vessel ligation) and Stage 2 (mobilization into scrotum)

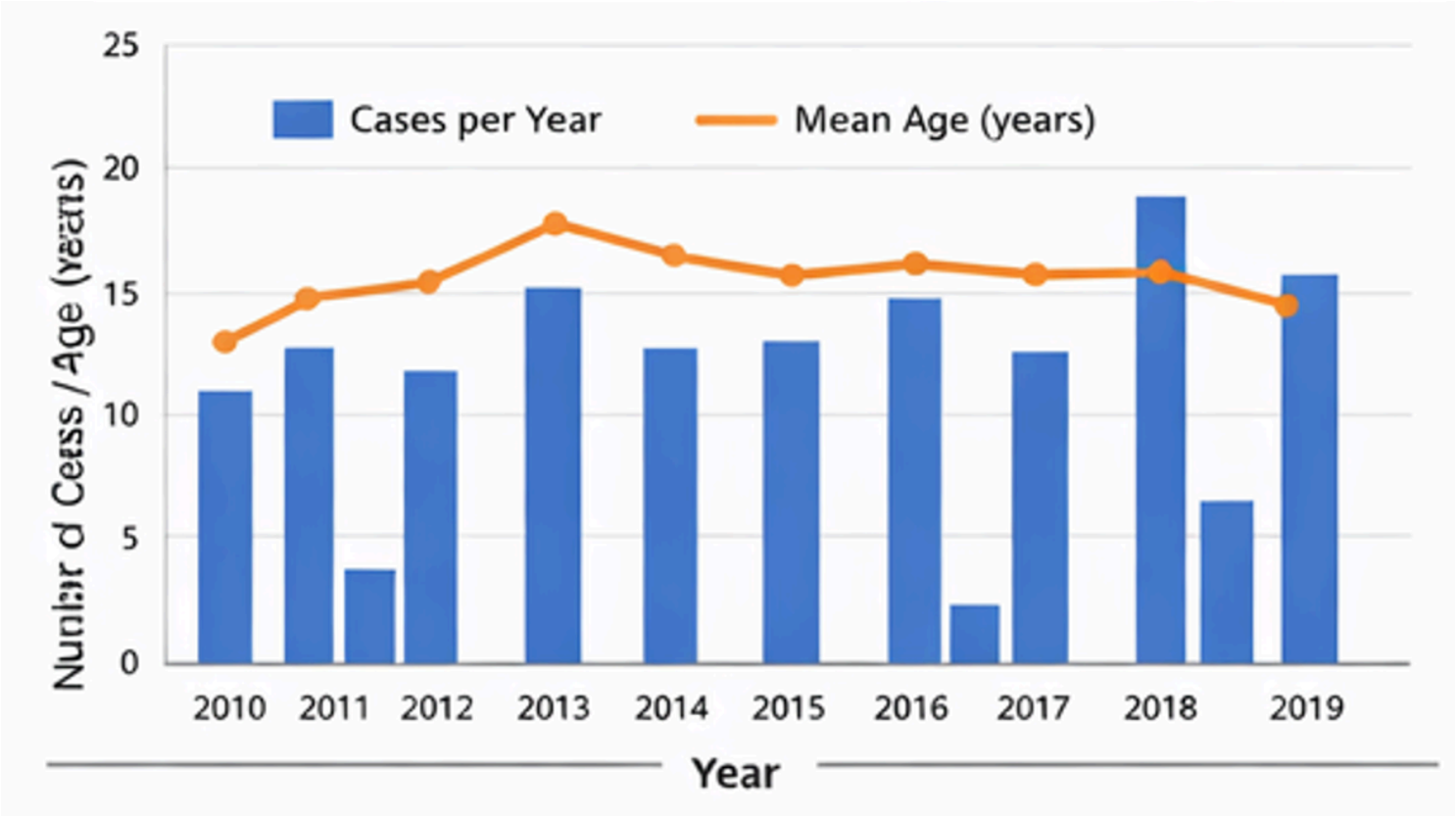


Figure 2

Annual incidence and age distribution of children with non-palpable testes (NPT).

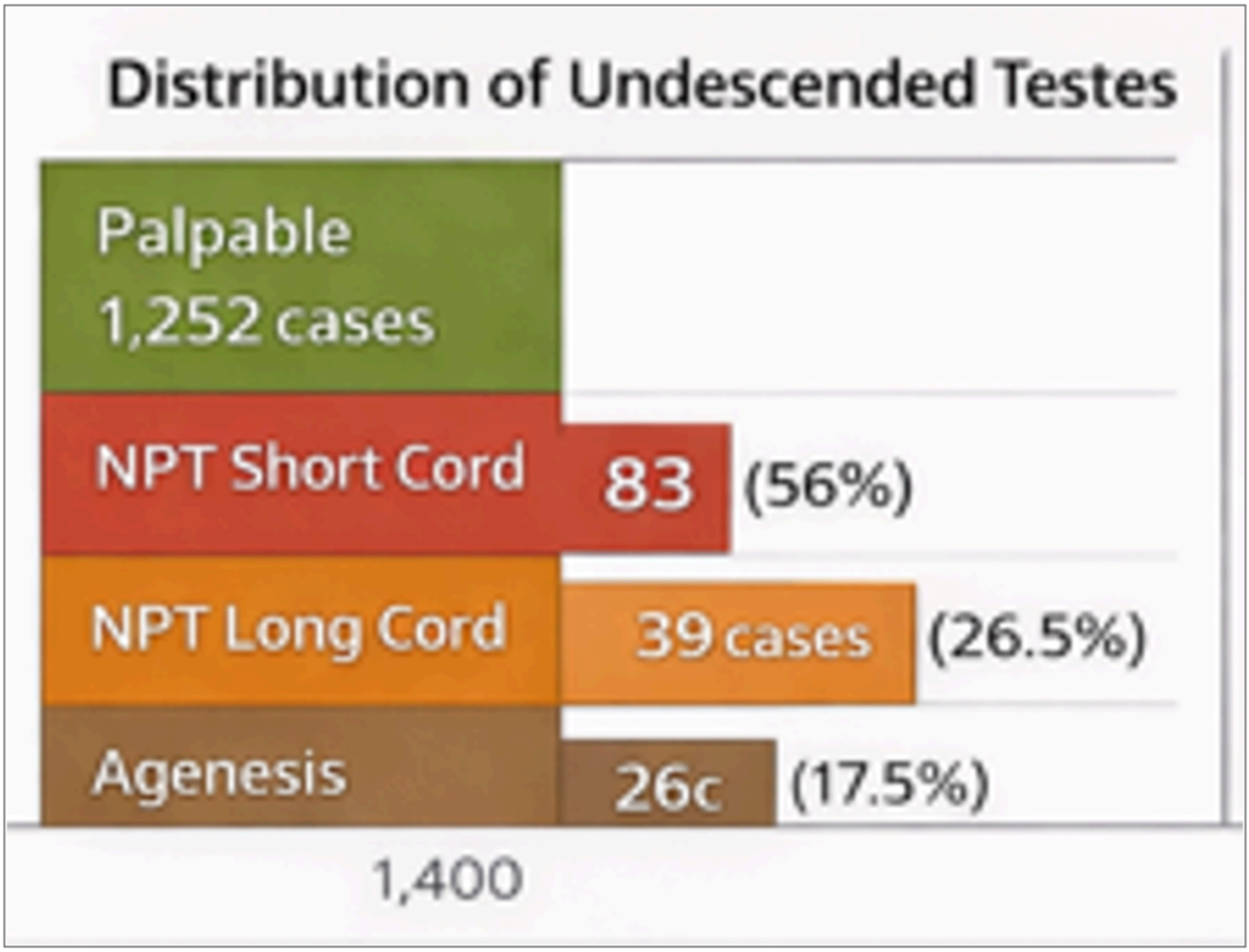


Figure 3

Distribution of testes types : palpable vs non-palpable (short/long cord) vs agenesis

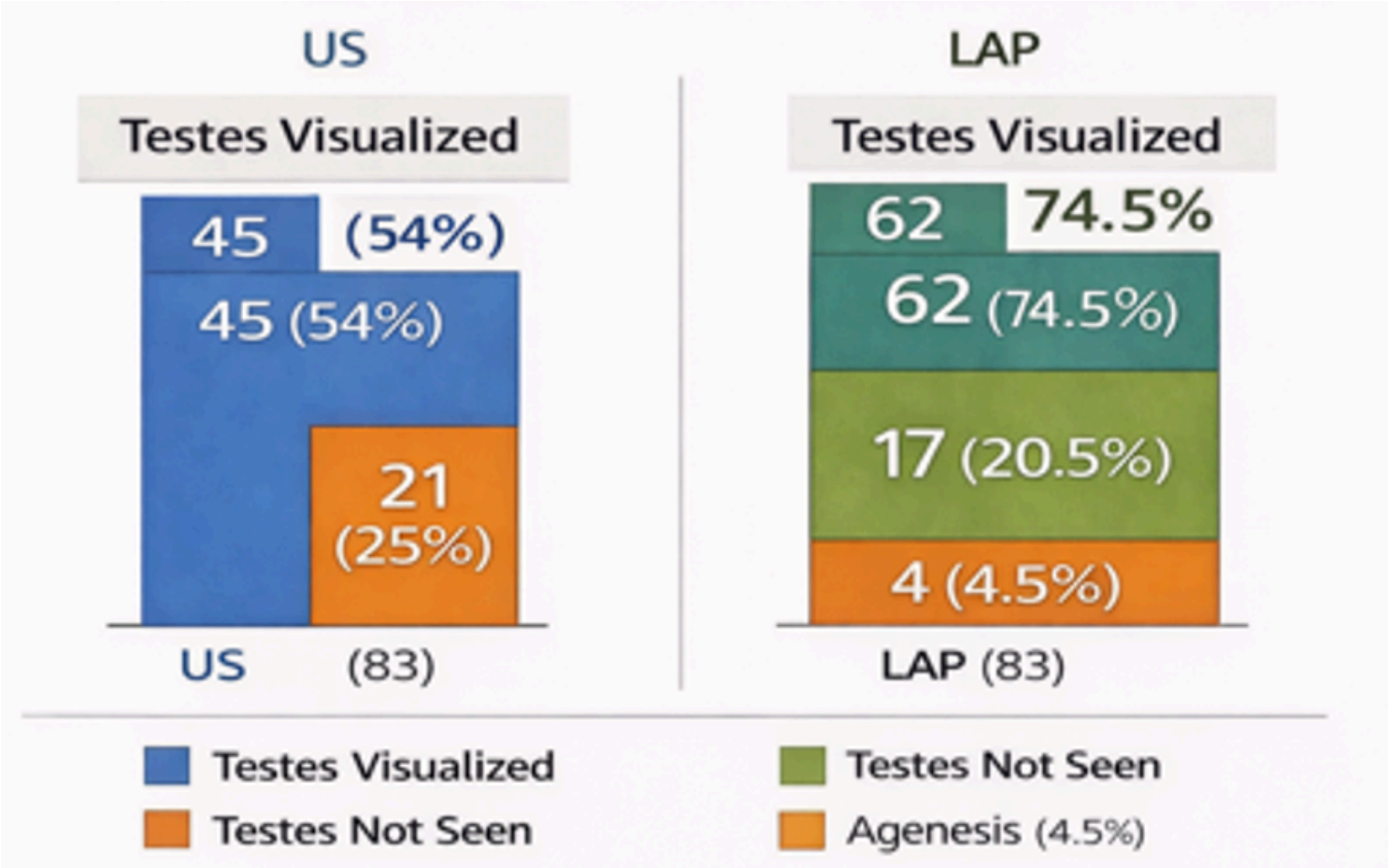


Figure 4

ultrasound detection vs laparoscopic findings.

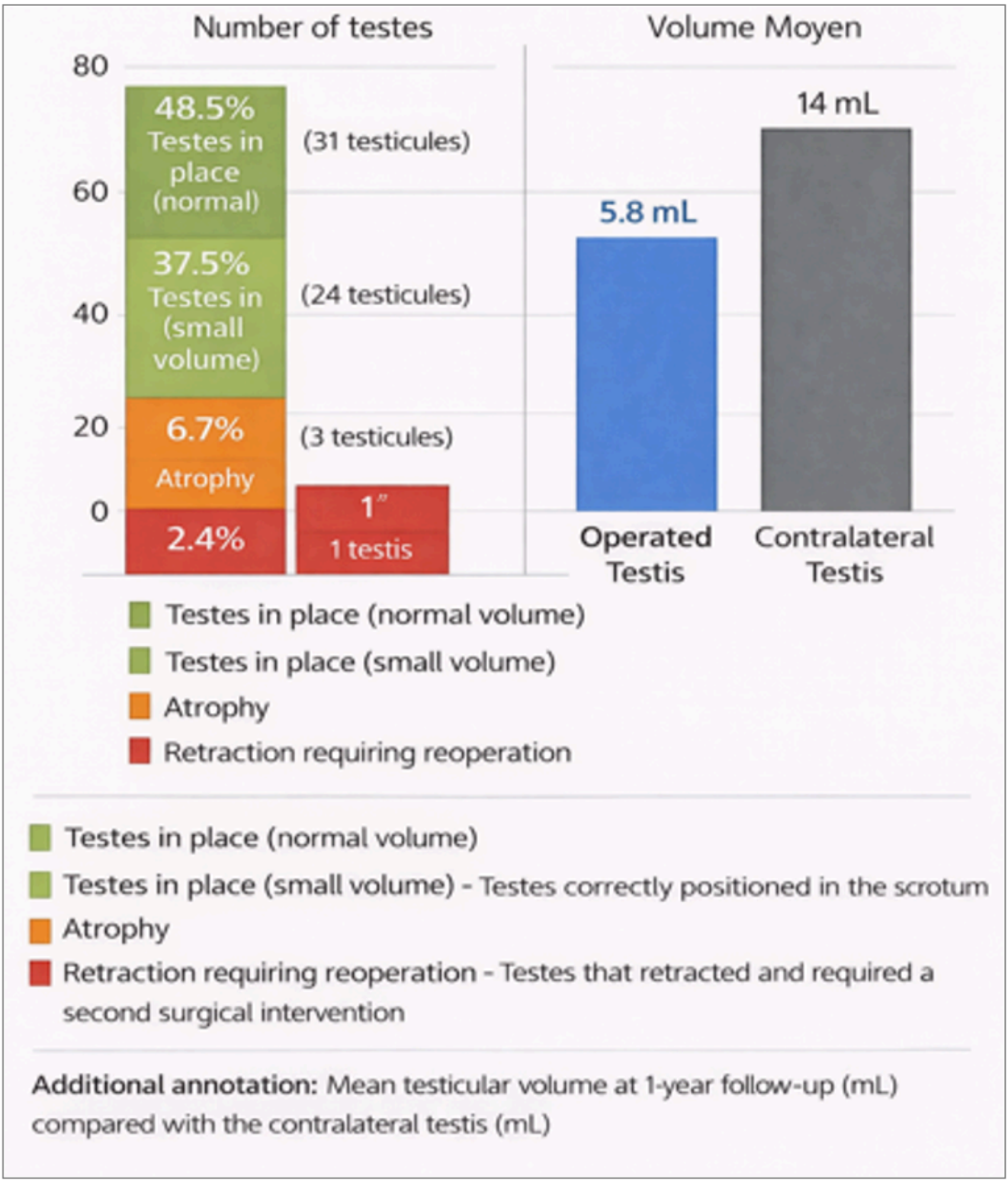


Figure 5

Postoperative outcomes. Comparative histogram: testes in place, atrophy, retraction; mean volume at 1 year vs contralateral