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The Nonpalpable Testis: A Narrative Review

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Abstract

Purpose—While the nonpalpable testis represents only a small portion of all cryptorchid testes, it remains a clinical challenge for pediatric urologists. Many controversies about the best evaluation and management exist. This narrative review serves as an update on what is known about the nonpalpable testis: etiology, pre-operative evaluation, the best surgical management, novel techniques, and ongoing controversies.

Materials and Methods—A Pubmed® and MEDLINE® search limited to January 2000 to January 2017 was performed using relevant key terms. Of 367 articles, a total of 115 manuscripts were considered for inclusion based on an a priori design. Utilizing a narrative review format, an update on the evaluation and management of the nonpalpable testis including novel concepts and techniques was synthesized.

Results—The nonpalpable testis should be evaluated by physical exam only. Imaging is not indicated for the routine case. The optimal surgical approach and technique remains debated, but several novel techniques have been described. Due to the rarity of the nonpalpable testis, randomized controlled trial and other quality comparisons are difficult. Therefore, several controversies in management remain.

Conclusions—The evaluation and management of the nonpalpable testis remains difficult and some aspects remain debated. Future research should focus on multi-institutional collaborative trials to determine the optimal operative management.

Key Words (MESH terms)

nonpalpable testis; impalpable testis; cryptorchidism; vanished testis; laparoscopic orchiopexy

Introduction

The evaluation and management of the nonpalpable testis (NPT) can be deceptively difficult, even for the most experienced urologist. We lack the ability to predict pre-operatively the presence or absence and location of a NPT. The surgery itself can be difficult, and the best surgical management remains controversial, all of which complicate preoperative counseling. This review serves as an update on what is currently known about the evaluation

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and management of the NPT: current theories of the etiology, the reliability of pre-operative assessments, the controversy regarding the best surgical management, recently described novel procedures, and ongoing controversies.

Materials and Methods

After creating an appropriate a priori design, a PubMed® and MEDLINE® search from January 2000 to January 2017 was performed using relevant key terms (Appendix A). A total of 367 meta-analyses, trial designs, original articles, case reports, abstracts, and systematic reviews written in English language were considered for inclusion. After eliminating 181 non-relevant or duplicate articles, the remaining 186 abstracts were reviewed. Systematic reviews focused on a particular sub-topic, meta-analyses, trial designs, retrospective reviews with large numbers and long-term follow-up, and novel research were given preference. For articles written by the same author using the same cohort of patients, the manuscript with the largest number of patients was included and others excluded to avoid overlapping patients. Articles were not used in the manuscript if their findings were described in a meta-analysis or systematic review. Of the 115 remaining relevant manuscripts, those 65 which could not be included in this manuscript due to limits are listed in Appendix B. One older article was included due to novelty and relevance. A narrative review format was used to synthesize an update on the evaluation and management of the NPT as well novel concepts and techniques.

Background

Epidemiology

Of the 0.8–2% of boys who have a persistent undescended testis by one year of life, approximately 20–35% have a NPT.¹ The NPT falls into one of three categories: nonviable (often referred to as a testicular nubbin, scrotal nubbin, scrotal remnant, atrophic testis, or vanished testis), extra-abdominal, or intra-abdominal. The reported incidence of each varies greatly, as much of the research on this uncommon diagnosis is limited to smaller case series. Most (35–82%) are nonviable.^{2,3} Approximately 3–39% are extra-abdominal.^{2–4} Of the 15–34.1% which are intra-abdominal, approximately 29–44.8% of these are considered “high,” which is poorly defined but is generally implied to be those not amenable to a simple laparoscopic orchiopexy.^{1,3} There is a left-sided predominance of 60–72.5%.^{4–6} Additionally, up to a third of patients may have comorbidities such as a cardiac anomaly, genitourinary anomaly, or congenital syndrome such as Down syndrome, Noonan syndrome, or prune belly syndrome.^{7,8}

Etiology

While the extra-abdominal and intra-abdominal testes are considered to be a failure of normal testicular descent, the cause of the nonviable testis is uncertain. The three primary theories are an intra-uterine vascular event, incomplete development, or the effects of endocrinopathy. These theories may not be mutually exclusive of one another. Nonviable testes have variable findings, such as the presence or absence of a vas deferens and epididymis. This variability may indicate different types of nonviable testes, each with its

own etiology.⁵ The possibility of an intra-uterine vascular event is supported by the similarities between testicular nubbins and postnatally torsed testes: both have a left-sided predominance and similar pathologic findings.⁹ Alternatively, testes may have undergone incomplete development. The Sertoli cells may have transiently formed, released Müllerian inhibiting substance, but then regressed. This is supported by the finding of WT-1, a stable marker of Sertoli cells, in the interstitium of nonviable testes as well as Sertoli cells in some nonviable testes.⁵ Most nonviable testes do not have germ cells, indicating possible interrupted germ cell migration to the genital ridge.⁵ Because pathologic comparisons of the contralateral descended testes in boys with cryptorchidism and a monorchidism are different, endocrinopathy is no longer considered a likely cause of the nonviable testis but is thought to be a cause of the cryptorchid testis.¹⁰

Preoperative Assessment

If the presence or absence and location of a testis could be determined pre-operatively, it would allow for better counseling of parents, decreased parental anxiety, and avoidance of unnecessary surgery.

Imaging

An imaging study that could conclusively diagnose monorchidism could potentially prevent unnecessary surgery; an imaging study that could conclusively determine the location of the testis or its remnant could prevent unnecessary laparoscopy. However, ultrasound remains unreliable for these purposes, detecting only 30% of extra-abdominal testicular nubbins and 38% of viable intra-abdominal testes with an overall a sensitivity of 45% and specificity of 78%.¹¹ Ultrasound is able to detect 97% of viable inguinal testes,¹¹ prompting some to obtain an ultrasound on all patients with a non-palpable testis for operative planning.¹² The 3–39% of patients with viable extra-abdominal testes could avoid laparoscopy with this management; however, this practice has not been shown to reduce overall costs.

Magnetic resonance imaging (MRI) is more accurate than ultrasound in detecting the position of a non-palpable testis. Conventional MRI has a sensitivity of 85% and specificity of 87.5% for this purpose; adding diffusion-weighted imaging increases the sensitivity to 89.5% but does not alter specificity.¹³ However, MRI cannot definitively diagnose monorchidism and thus does not eliminate the need for surgical exploration.¹³ Additionally, it requires sedation for young patients and is costly.^{13,14}

Due to its low sensitivity and the risk of secondary malignancy, computed tomography (CT) has no potential use in evaluating a NPT.¹³

As such, both the American Urologic Association (AUA) and European Association of Urology (EAU) Guidelines recommend against imaging for the routine evaluation of the NPT.^{14,15}

Physical Exam

As the diagnosis of an NPT is based on physical exam alone, there has been great interest in determining if physical exam findings alone can reliably predict intra-operative findings.

Monorchidism in infants is likely caused by a perinatal event, allowing the contralateral descended testis to undergo compensatory hypertrophy. Therefore, a solitary hypertrophic testis could potentially predict monorchidism. Many authors have evaluated this possible association in pre-pubertal males using various cut-offs in testicular size (Table 1). Since perinatal torsion affects the left testis twice as often as the right testis, Belman and Rushton specifically evaluated 22 boys with a left NPT. In their series of 22 patients with a left NPT and a right testis of 2cc or greater, monorchidism was present 95% of the time.⁶

While physical exam may be informative for parental counseling and estimating the length of surgery, monorchidism cannot be definitively determined by physical exam alone. Therefore, surgery must be performed for all patients with a solitary NPT.

Hormonal Treatment

A large meta-analysis by Li et al demonstrated that luteinizing hormone-releasing hormone treatment causes only 8.6% of NPT to become palpable.¹⁹ Other hormonal analogues have not shown long-term efficacy in causing descent of the NPT.^{14,15} As such, both the AUA and EAU do not recommend endocrine treatment to facilitate testicular descent.^{14,15} There is a possibility that hormonal therapy may improve fertility, especially for boys with bilaterally undescended testes. Currently, the EAU does recommend treatment with gonadotrophin-releasing hormone analogues for boys with bilaterally undescended testes for this purpose,¹⁵ but the AUA concluded that while this therapy may be found to be beneficial for further fertility, currently the long-term effect remains unclear.¹⁴

Surgery for the Nonpalpable Testis

Exam Under Anesthesia

Any procedure should begin with an exam under anesthesia to re-evaluate for the presence of a testis when the patient is relaxed. The examiner may consider utilizing lubricant on the fingertips to aid with the exam.¹⁵ While true for all patients, this is especially important for obese patients. Office exams are less accurate in this patient population, but an exam under anesthesia has similar accuracy for both obese and non-obese patients.¹³

Surgical Approach

There are three potential initial surgical approaches to address the NPT, each with its own benefits and limitations. Whether the initial scrotal, inguinal, or laparoscopic approach is utilized, it is imperative to identify the spermatic vessels with an associated testis, nubbin, or evidence of a vanished testis in each case so testicular tissue is not inadvertently missed and left in an ectopic position.

Scrotal Approach

Fewer than a quarter of NPT are found intra-abdominally, while most are found extra-abdominally as either a viable testis or a testicular nubbin. Extra-abdominal testicular nubbins are likely the end result of perinatal torsion, which is thought to always occur after testicular descent.⁶ Therefore, some argue starting with a scrotal approach to identify a testicular nubbin or testis, then proceeding with laparoscopy only if indicated. If a testicular

nubbin is found in the scrotum, it is excised and sent for pathologic confirmation. No herniorrhaphy is indicated in this case as testicular nubbins indicate a closed external ring.^{6,20} If a viable testis is found, a standard orchiopexy with herniorrhaphy is performed. If a patent processus is present without a testis or if there is any uncertainty, the hernia sac is carefully opened after ensuring there is no long looping vas deferens and laparoscopy performed through the inguinal canal.²⁰ In theory, this could avoid unnecessary, time consuming, and costly laparoscopy in the majority of patients.^{6,20} In their series of 43 boys with NPT, Snodgrass et al found laparoscopy is required in only 30% of cases.¹⁷

This approach is remains controversial due to the concern of missing an intra-abdominal testis, which has been described in several case reports.^{21,22} Additionally, cost analysis has shown that the initial scrotal or inguinal approach may actually be slightly more expensive than the initial laparoscopic approach.²¹

Inguinal Approach

Alternatively, an initial inguinal incision can facilitate any indicated surgery including laparoscopy, orchiopexy, or orchiectomy. Again, laparoscopy can be avoided in over 30% of boys with this approach.⁴ However, this approach is more invasive for patients who have a testicular nubbin in the scrotum or an intra-abdominal testis. It is also associated with the same risk of missing an intra-abdominal testis without cost savings as the scrotal approach.²¹

Laparoscopic Approach

The traditional initial approach to the NPT as supported by the AUA Guidelines is laparoscopic or open exploration.¹⁴ While an open procedure is acceptable if laparoscopy is not possible, the laparoscopic approach is equally efficacious and preferred by many surgeons.^{14,23,24} If the testis can reach the dependent scrotum without tension after careful dissection, a laparoscopic orchiopexy without vessel division is performed. If the testis will not reach, either 1 or 2 stage Fowler Stephens Orchiopexy (FSO) with division of the spermatic vessels is typically performed.

Intuitively, orchiopexy without vascular division has the highest success rate at 85–100%.²⁴ However, despite great interest in determining if 1 or 2 stage FSO is superior, there have been no appropriately powered randomized controlled trials or good evidence that demonstrates a statistically significant difference in outcomes. A meta-analysis by Elyas et al demonstrated a pooled estimated success rate of 80% for 1-stage FSO [95% confidence interval (CI) 75–86, I² 11%] and 85% for 2-stage FSO (CI 81–90, I² 43%), although these results should be interpreted with caution due to the moderate heterogeneity for the 2-stage FSO.²³ In their systematic review, Wayne et al concluded that while a two stage repair may be minimally but significantly superior, the difference is so small that the choice of a 1 or 2 stage repair should be dependent on the surgeon's preference.²⁴

The greatest risks of all forms of laparoscopic orchiopexy include relative or complete testicular atrophy and testicular ascent (Table 2). Parents should be cautioned that nearly a quarter of intra-abdominal testes are smaller prior to surgery than the contralateral descended testes, so not all size discrepancy may be due to the surgery.⁸ Other complications

inherent to laparoscopic surgery such as puncture of the colon with a veress needle, cecal volvulus, ileus, wound infection, or herniation through even the smallest trocar sites occur in approximately 5% of cases.¹ Bladder injury during creation of a transperitoneal tunnel for the testis medial to the medial umbilical ligament occurs in up to 3% of cases and may not always cause hematuria or be recognized intra-operatively.²⁵ Because the patent processus vaginalis is typically not ligated during laparoscopic orchiopexy, an indirect inguinal hernia is also possible with an overall risk of less than 1%.²⁶

Autotransplantation

For very high testes, FSO may be inadequate to gain length to bring the testes to an orthotopic location. These testes may be amenable to testicular autotransplantation. The initial stage of the procedure is now routinely performed laparoscopically. First the inferior epigastric vessels are dissected laparoscopically to facilitate the vascular anastomosis later. The testis is also dissected and removed laparoscopically. The microsurgical anastomosis is performed through a subinguinal incision by a pediatric plastic surgeon.²⁹ The long-term success rate is 88%.²⁹

Special Situations

Long Looping Vas Deferens

The vasal blood supply is imperative to preserve during any orchiopexy, especially if spermatic vessel division is required. Inadvertent injury to an unrecognized long looping vas deferens can lead to testicular atrophy. To avoid such an injury, the surgeon should carefully identify the vasal anatomy in every case. If a long looping vas deferens is present, the surgeon should use only blunt dissection without thermal energy to carefully dissect it away from the gubernaculum and bring it into the abdomen.³⁰ If there is any difficulty bringing the full extent into the abdomen or other concern, either an inguinal or scrotal incision can be made to aid with dissection.^{20,30}

Bilateral Nonpalpable Testes

Bilateral nonpalpable testes present a rare and difficult quandary. Newborns with this finding should be immediately evaluated for congenital adrenal hyperplasia with an electrolyte panel. A karyotype should also be obtained. In conjunction with a pediatric endocrinologist, a hormonal evaluation (Müllerian Inhibiting Substance level and other hormonal testing such as HCG stimulation and luteinizing hormone, follicular stimulating hormone, testosterone, and androstenedione levels) should be performed to determine if testicular tissue is present prior to any surgical planning.¹⁴

If hormonal testing indicates the presence of testicular tissues, laparoscopic exploration is performed. If two abdominal testes are present, the decision on how to proceed depends on the size and location of each testis. Kaye and Palmer propose the following algorithm. If one testis is small or very high, intervention on that testis should be delayed until the patient has recovered from orchiopexy on the larger or lower testis. If no vessel division is required on one side, a laparoscopic orchiopexy can be performed at the same time as a first stage FSO on the contralateral side. If both testes require FSO, vessel ligation should be performed on

only one side during the first stage. When the second stage is performed 3–6 months later, the vessel ligation may be performed on the contralateral side in the same setting. If there is any concern about the viability of the first testis after the first stage or any concern that arises during any procedure on one side, however, it is prudent to wait to perform any procedure on the contralateral side for at least 3–6 months.³¹

Postpubertal Male

The optimal management of an intra-abdominal testis in a postpubertal male remains unknown. Due to the associated histologic changes and increased risk of malignancy, the EAU recommends surgeons offer orchiectomy to postpubertal patients with an undescended testis and normal contralateral descended testis.¹⁵ The AUA also recommends considering orchiectomy for intra-abdominal testes and contralateral normal descended testis for these males.¹⁵

Indications for Orchiectomy

If the testis is too high in the retroperitoneum to be amenable to Fowler-Stephens orchiopexy and autotransplantation is not possible, the vas deferens is short or atretic, or the testis appears abnormal, an orchiectomy may be performed if the contralateral testis normal.¹⁴

Testicular Prosthesis

The optimal timing for placement of a testicular prosthesis for patients with monorchidism remains unknown. While prostheses have been shown to improve body image and decrease stress for males with monorchidism,³² few children undergo placement of a prosthesis.³³ Peycelon et al demonstrated significantly increased risk of complications if a prosthesis is placed more than a year after orchiectomy.³³ Delayed prosthesis placement can also lead to scrotal asymmetry which may be difficult to correct. Therefore, Kogan recommends early placement of a prosthesis and considering the use of a large implant in prepubertal patients to avoid scrotal asymmetry as the patient ages.³²

Novel Modifications and Procedures

2-Stage Fowler Stephens Orchiopexy with Monopolar Diathermy Vessel Ligation

AbouZeid et al reported safety of using monopolar diathermy to coagulate the spermatic vessels as proximal as possible instead of performing clip ligation during a first stage FSO. They found no histologic differences between 7 patients who underwent this technique and the 13 patients who underwent traditional clip ligation.³⁴

Intentional Management of the Gubernaculum

Hay et al studied the anatomy of the collateral circulation that forms after 1-stage FSO. During the 2nd stage, they noted that 40% of 100 testes developed prominent vasculature around the vas deferens, whereas 60% developed prominent vasculature from the gubernaculum. No testes developed increased vascularity from both collateral blood supplies. Therefore, they recommend preserving the gubernaculum if possible or transecting it during the first stage if it appears short and unlikely to reach the scrotum. This, in theory,

would force the testis to derive its collateral blood supply from the deferential artery. Nonetheless, the authors noted atrophy in only 3% of patients in their series, representing 7% of patients in whom the gubernaculum was transected during the second stage.³⁵

Complete Laparoscopic Management with Closure of the Internal Ring

Kojima et al reported their experience of managing all patients with NPT entirely laparoscopically.³⁶ For patients with a nubbin or testis beyond the internal ring, the posterior parietal peritoneum around the inguinal canal was incised and the gonad was brought into the abdomen. Laparoscopic orchiopexy or orchiectomy is then performed as indicated. Any hernia or peritoneal defect was also repaired laparoscopically. The authors report no cases of atrophy, testicular ascent, or other intraoperative or postoperative complications in 55 patients.³⁶

Staged Orchiopexy with Vessel Preservation

Dessanti et al described a novel staged traction technique utilizing an anti-adhesion membrane for the management of a low intra-abdominal or intra-canalicular testis.¹² Through an inguinal approach, the first steps of a standard orchiopexy are performed with high ligation of the processus vaginalis and mobilization of the spermatic cord. If the testis cannot then reach the dependent scrotum, a PTFE pericardial membrane is wrapped around the spermatic cord and a traction suture is secured between the dependent scrotum and testis. The second stage is performed 9–12 months later. Through the same inguinal incision, the PTFE membrane is removed without reopening the inguinal canal and the testis is secured in the dependent scrotum. The authors reported this technique was sufficient in 82.2% of 45 patients, while the remainder required opening of the inguinal canal for further mobilization. No patient experienced atrophy of the testis.¹²

Shehata Technique

Shehata et al described a novel laparoscopic staged traction procedure for the high abdominal testis that does not require vessel ligation. During the first stage, the gubernaculum is transected and peritoneum incised lateral to the spermatic vessels to mobilize the testis. The testis is then suture fixated to the anterior abdominal wall medial to the contralateral anterior superior iliac spine. Approximately 12 weeks later, the anchoring suture is removed and a laparoscopic orchiopexy is performed. The fixation to the abdominal wall is thought to avoid stretch injury to the testis or its vessels while allowing for gentle traction from respiration and pressure from the intestines. The authors reported an overall success rate was 84% in 140 testes, with higher success in younger patients.³⁷

Robotic Assisted Laparoscopic Orchiopexy

Robotic assisted laparoscopic orchiopexy has been described. It is feasible with results comparable to conventional laparoscopic orchiopexy.³⁸ However unlike other robotic surgeries, there are no clear advantages over conventional laparoscopy in this setting. With an increased emphasis on cost savings and improved resource utilization with the current changes in healthcare, robotic surgery is unlikely to have a role in laparoscopic orchiopexy.

Other Advances

Transumbilical multiport laparoscopic orchiopexy, where all three trocars are placed around the umbilicus, and single-site laparoscopic orchiopexy have been described in small series.³⁹ Although they require a learning curve and special instruments for the single-site surgery, they appear to have equivalent outcomes to traditional laparoscopic orchiopexy with improved cosmesis.³⁹

Ongoing Controversies

For patients with confirmed monorchidism, there remains great debate whether the scrotal remnant requires removal or if contralateral orchiopexy to prevent torsion of a solitary testis are indicated.

Management of the nonviable testis

The management of the nonviable testis currently depends on its location and surgeon preference. Any intra-abdominal testicular remnant should always be excised due to the high incidence of residual germ cells and therefore the risk of malignant transformation that may be unrecognized in an intra-peritoneal position (Table 2). However, when an atretic vas and vessels are seen terminating at or entering a closed internal ring suggesting the presence of an extra-abdominal testicular nubbin,² the decision whether to explore the scrotum or inguinal canal to excise it or observe remains controversial.² Series vary regarding the presence and incidence of germ cells within the testicular nubbins (Table 2). Residual germ cells have the theoretical potential for malignant transformation. There is one report in the literature of intratubular germ cell neoplasia (ITGCN) in a testicular nubbin in the scrotum, although there was no immunohistological confirmation.⁴⁰ To date, there have been no additional reports of ITGCN or any reports of germ cell neoplasia in an extra-abdominal testicular nubbin. The findings do not vary with age of the patient, indicating that any residual germ cells will persist over time.⁴¹ Those who advocate for removal of the extra-abdominal testicular nubbin feel any risk of tumor is unacceptable when it could easily be removed, whereas those who believe removal is unnecessary feel this risk is negligible. A survey of 121 members of pediatric urologic societies showed that only 12% explore for the testicular nubbin.⁴²

Management of the contralateral testis

In the setting of a solitary testis, many surgeons advocate for performing contralateral testicular fixation to prevent a catastrophic event of torsion of the solitary testis. However, the true incidence of torsion in this situation is not well reported. Martin and Rushton performed contralateral scrotal exploration in 50 patients with a testicular nubbin to evaluate for possible risk of future torsion. They found that only one patient had a partial bell clapper anomaly in the contralateral descended testis, whereas 21 of 27 patients who presented with acute testicular torsion later in life were found to have a bell clapper anomaly of the contralateral testis.⁵⁰

Currently, the management of the contralateral testis is left to the discretion of the surgeon. Of 121 surgeons in pediatric urologic societies, only 28% report that they perform a fixation of the contralateral testis when monorchidism is surgically diagnosed.⁴²

Conclusions

Laparoscopy is now often the first choice of surgeons for intra-abdominal exploration for the NPT. An argument can be made to start with a scrotal incision to explore for a scrotal nubbin or hernia sac, and proceed to laparoscopy only if the nubbin is not identified, although this remains controversial. The high intra-abdominal testis continues to be an under-appreciated challenge. Despite advances in techniques, operative outcomes remain mediocre.

Many questions remain greatly contested and unclear. Is there a better technique for management of the high testis? Is orchiopexy of the contralateral descended testis indicated in the setting of monorchidism? With the exceedingly rare incidence of ITGCN, do all testicular nubbins need to be excised?

While there are many single-center reviews addressing these questions, the incidence of the NPT is relatively low. Therefore, collaborative efforts are needed to give more comprehensive, meaningful answers.

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Appendix A

Keyterms used for literature search

nonpalpable testicle
nonpalpable testis
non-palpable testicle
non-palpable testis
impalpable testicle
impalpable testis
monorchidism
laparoscopic orchiopexy
testicular nubbin
vanished testis
vanished testicle
testicular regression syndrome

Appendix B

Additional Recommended References

1. Abbas TO, Al-Shahwani N, Hayati A, Hady Samaha A, Bassiouny IE, Ali M. Role of ultrasonography in the preoperative assessment of impalpable testes: a single center experience. *ISRN urology*. 2012; 2012:560216. [PubMed: 22567419]
2. Abbas TO, Hayati A, Ismail A, Ali M. Laparoscopic management of intra-abdominal testis: 5-year single-centre experience-a retrospective descriptive study. *Minimally invasive surgery*. 2012; 2012:878509. [PubMed: 22474586]
3. Abolyosr A. Laparoscopic versus open orchiopexy in the management of abdominal testis: a descriptive study. *International journal of urology : official journal of the Japanese Urological Association*. Nov; 2006 13(11):1421–1424. [PubMed: 17083396]
4. AbouZeid AA, Mousa MH, Soliman HA, Hamza AF, Hay SA. Intra-abdominal testis: histological alterations and significance of biopsy. *The Journal of urology*. Jan; 2011 185(1):269–274. [PubMed: 21075394]
5. Adesanya OA, Ademuyiwa AO, Bode CO, Adeyomoye AA. Diagnostic value of high resolution ultrasound in localisation of the undescended testis in children. *African journal of paediatric surgery : AJPS*. Apr-Jun; 2013 10(2):127–130. [PubMed: 23860061]
6. Alzahem A. Laparoscopy-assisted orchiopexy versus laparoscopic two-stage fowler stephens orchiopexy for nonpalpable testes: Comparative study. *Urology annals*. Apr; 2013 5(2):110–114. [PubMed: 23798870]
7. Ang CW, Forrest J. Diagnostic laparoscopy and management of the impalpable testis—a review of 10 years' practice at a non-paediatric specialist centre. *Journal of pediatric urology*. Jun; 2008 4(3): 214–217. [PubMed: 18631929]
8. Bae KH, Park JS, Jung HJ, Shin HS. Inguinal approach for the management of unilateral non-palpable testis: is diagnostic laparoscopy necessary? *Journal of pediatric urology*. Apr; 2014 10(2): 233–236. [PubMed: 24206784]
9. Bagga D, Teckchandani N, Kumar V, Grover SB, Yadav DK, Acharya SK. Predictive factors for successful vessel-intact laparoscopic orchiopexy for intra-abdominal testes. *Journal of pediatric urology*. Aug; 2013 9(4):453–457. [PubMed: 23269107]
10. Bracho-Blanchet E, Unda-Haro S, Ordorica-Flores R, et al. Laparoscopic treatment of nonpalpable testicle. Factors predictive for diminished size. *Journal of pediatric surgery*. Jul; 2016 51(7):1201–1206. [PubMed: 26896053]
11. Braga LH, Kim S, Farrokhyar F, Lorenzo AJ. Is there an optimal contralateral testicular cut-off size that predicts monorchism in boys with nonpalpable testicles? *Journal of pediatric urology*. Aug; 2014 10(4):693–698. [PubMed: 25008806]
12. Breyer BN, DiSandro M, Baskin LS, Hsieh MH. Obesity does not decrease the accuracy of testicular examination in anesthetized boys with cryptorchidism. *The Journal of urology*. Feb; 2009 181(2):830–834. [PubMed: 19095266]
13. Budianto IR, Tan HL, Kinoshita Y, Tamba RP, Leiri S, Taguchi T. Role of laparoscopy and ultrasound in the management of “impalpable testis” in children. *Asian journal of surgery*. Oct; 2014 37(4):200–204. [PubMed: 24661449]
14. Casanova NC, Johnson EK, Bowen DK, et al. Two-Step Fowler-Stephens orchiopexy for intra-abdominal testes: a 28-year single institution experience. *The Journal of urology*. Oct; 2013 190(4):1371–1376. [PubMed: 23624208]
15. Castillo-Ortiz J, Muniz-Colon L, Escudero K, Perez-Brayfield M. Laparoscopy in the surgical management of the non-palpable testis. *Frontiers in pediatrics*. 2014; 2:28. [PubMed: 24783184]
16. Chan KW, Lee KH, Wong HY, et al. Use of laparoscopy as the initial surgical approach of impalpable testes: 10-year experience. *World journal of clinical pediatrics*. Nov 08; 2015 4(4): 155–159. [PubMed: 26566489]
17. Chang M, Franco I. Laparoscopic Fowler-Stephens orchiopexy: the Westchester Medical Center experience. *Journal of endourology*. Jun; 2008 22(6):1315–1319. [PubMed: 18484895]

18. Dave S, Manaboriboon N, Braga LH, et al. Open versus laparoscopic staged Fowler-Stephens orchiopexy: impact of long loop vas. *The Journal of urology*. Nov; 2009 182(5):2435–2439. [PubMed: 19765743]
19. Denes FT, Saito FJ, Silva FA, Giron AM, Machado M, Srougi M. Laparoscopic diagnosis and treatment of nonpalpable testis. *International braz j urol : official journal of the Brazilian Society of Urology*. May-Jun;2008 34(3):329–334. discussion 335.
20. Desireddi NV, Liu DB, Maizels M, Rigsby C, Casey JT, Cheng EY. Magnetic resonance arteriography/venography is not accurate to structure management of the impalpable testis. *The Journal of urology*. Oct; 2008 180(4 Suppl):1805–1808. discussion 1808–1809. [PubMed: 18721972]
21. Dessanti A, Falchetti D, Iannuccelli M, et al. Cryptorchidism with short spermatic vessels: staged orchiopexy preserving spermatic vessels. *The Journal of urology*. Sep; 2009 182(3):1163–1167. [PubMed: 19625047]
22. El-Anany F, Gad El-Moula M, Abdel Moneim A, et al. Laparoscopy for impalpable testis: classification-based management. *Surgical endoscopy*. Mar; 2007 21(3):449–454. [PubMed: 17054004]
23. Elderwy AA, Kurkar A, Abdel-Kader MS, et al. Laparoscopic versus open orchiopexy in the management of peeping testis: a multi-institutional prospective randomized study. *Journal of pediatric urology*. Aug; 2014 10(4):605–609. [PubMed: 25042877]
24. Fine RG, Franco I. Laparoscopic orchiopexy and varicocelectomy: is there really an advantage? *The Urologic clinics of North America*. Feb; 2015 42(1):19–29. [PubMed: 25455169]
25. Frimberger D, Malm-Buatsi E, Kropp BP, Aston CE, Godiwalla SY, Palmer BW. Reliance of preoperative scrotal examination versus final operative findings in the evaluation of non-palpable testes. *Journal of pediatric urology*. Oct; 2015 11(5):255.e251–255. [PubMed: 25979218]
26. Gatti JM, Cooper CS, Kirsch AJ. Bimanual digital rectal examination for the evaluation of the nonpalpable testis. *The Journal of urology*. Jul; 2003 170(1):207–210. [PubMed: 12796691]
27. Gaudino R, Cavarzere P, Camilot M, Teofoli F, Zampieri N, Tato L. Prepubertal serum inhibin B in cryptorchid infants and in monorchid boys with compensatory testicular hypertrophy. *Fertility and sterility*. Dec; 2008 90(6):2217–2221. [PubMed: 18191850]
28. Gonzalez KW, Dalton BG, Snyder CL, Leys CM, St Peter SD, Ostlie DJ. The anatomic findings during operative exploration for non-palpable testes: A prospective evaluation. *Journal of pediatric surgery*. Jan; 2016 51(1):128–130. [PubMed: 26563527]
29. Grinspon RP, Habib C, Bedecarras P, Gottlieb S, Rey RA. Compensatory function of the remaining testis is dissociated in boys and adolescents with monorchidism. *European journal of endocrinology*. Mar; 2016 174(3):399–407. [PubMed: 26671976]
30. Guo J, Liang Z, Zhang H, et al. Laparoscopic versus open orchiopexy for non-palpable undescended testes in children: a systemic review and meta-analysis. *Pediatric surgery international*. Sep; 2011 27(9):943–952. [PubMed: 21476074]
31. Hamidi N, Telli O, Bagci U, et al. Outcomes of Laparoscopic Treatment Modalities for Unilateral Non-palpable Testes. *Frontiers in pediatrics*. 2016; 4:13. [PubMed: 26973822]
32. Harper L, Gatibelza ME, Michel JL, Bouty A, Sauvat F. The return of the solitary testis. *Journal of pediatric urology*. Oct; 2011 7(5):534–537. [PubMed: 20869919]
33. Hodhod A, Capolicchio JP, Jednak R, El-Sherbiny M. Testicular hypertrophy as a predictor for contralateral monorchism: Retrospective review of prospectively recorded data. *Journal of pediatric urology*. Feb; 2016 12(1):34.e31–35. [PubMed: 26279100]
34. Ismail K, Ashour M, El-Afifi M, et al. Laparoscopy in the management of impalpable testis: series of 64 cases. *World journal of surgery*. Jul; 2009 33(7):1514–1519. [PubMed: 19363581]
35. Jamalalail YA, Guerra LA, Leonard MP. Selective use of laparoscopy in nonpalpable undescended testes. *Urology annals*. Jan-Mar;2016 8(1):81–83. [PubMed: 26834408]
36. 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. *International journal of urology : official journal of the Japanese Urological Association*. Jul; 2005 12(7):668–672. [PubMed: 16045560]

37. Kelley BP, Higuera S, Cisek LJ, Friedman J, Heller L. Combined laparoscopic and microsurgical techniques for testicular autotransplantation: is this still an evolving technique? *Journal of reconstructive microsurgery*. Oct; 2010 26(8):555–558. [PubMed: 20640978]
38. Kim C, Bennett N, Docimo SG. Missed testis on laparoscopy despite blind-ending vessels and closed processus vaginalis. *Urology*. Jun.2005 65(6):1226.
39. Kim J, Min GE, Kim KS. Laparoscopic orchiopexy for a nonpalpable testis. *Korean journal of urology*. Feb; 2010 51(2):106–110. [PubMed: 20414422]
40. Kogan S. The clinical utility of testicular prosthesis placement in children with genital and testicular disorders. *Translational andrology and urology*. Dec; 2014 3(4):391–397. [PubMed: 26816795]
41. Mahdi BD, Rahma C, Mohamed J, Riadh M. Single-port laparoscopic surgery in children: A new alternative in developing countries. *African journal of paediatric surgery : AJPS*. Apr-Jun;2015 12(2):122–125. [PubMed: 26168750]
42. Mehendale VG, Shenoy SN, Shah RS, Chaudhari NC, Mehendale AV. Laparoscopic management of impalpable undescended testes: 20 years' experience. *Journal of minimal access surgery*. Oct; 2013 9(4):149–153. [PubMed: 24250059]
43. Mishra PK, Chong C, Tsang T. A modified technique of laparoscopic mobilisation and transfer of intra-abdominal testis via inguinal canal. *Pediatric surgery international*. Apr; 2015 31(4):403–406. [PubMed: 25672281]
44. Mohammed A, Yassin M, Hendry D, Walker G. Contemporary practice of testicular prosthesis insertion. *Arab journal of urology*. Dec; 2015 13(4):282–286. [PubMed: 26609448]
45. Moursy EE, Gamal W, Hussein MM. Laparoscopic orchiopexy for non-palpable testes: outcome of two techniques. *Journal of pediatric urology*. Apr; 2011 7(2):178–181. [PubMed: 20541475]
46. Onal B, Kogan BA. Additional benefit of laparoscopy for nonpalpable testes: finding a contralateral patent processus. *Urology*. Jun; 2008 71(6):1059–1063. [PubMed: 18342920]
47. Ostlie DJ, Leys CM, Fraser JD, Snyder CL, St Peter SD. Laparoscopic Orchiopexy Requiring Vascular Division: A Randomized Study Comparing the Primary and Two-Stage Approaches. *Journal of laparoendoscopic & advanced surgical techniques. Part A*. Jun; 2015 25(6):536–539. [PubMed: 25974325]
48. Palmer LS, Rastinehad A. Incidence and concurrent laparoscopic repair of intra-abdominal testis and contralateral patent processus vaginalis. *Urology*. Aug; 2008 72(2):297–299. discussion 299. [PubMed: 18579186]
49. Park JH, Park YH, Park K, Choi H. Diagnostic laparoscopy for the management of impalpable testes. *Korean journal of urology*. May; 2011 52(5):355–358. [PubMed: 21687397]
50. Peycelon M, Rossignol G, Muller CO, et al. Testicular prostheses in children: Is earlier better? *Journal of pediatric urology*. Aug; 2016 12(4):237.e231–236. [PubMed: 27264050]
51. Pirgon O, Dunder BN. Vanishing testes: a literature review. *Journal of clinical research in pediatric endocrinology*. Sep; 2012 4(3):116–120. [PubMed: 22985611]
52. Powell C, McIntosh J, Murphy JP, Gatti J. Laparoscopic orchiopexy for intra-abdominal testes-a single institution review. *Journal of laparoendoscopic & advanced surgical techniques. Part A*. May; 2013 23(5):481–483. [PubMed: 23560656]
53. Sharifiaghdas F, Beigi FM. Impalpable testis: laparoscopy or inguinal canal exploration? *Scandinavian journal of urology and nephrology*. 2008; 42(2):154–157. [PubMed: 17853013]
54. Shehata SM. Laparoscopically assisted gradual controlled traction on the testicular vessels: a new concept in the management of abdominal testis. A preliminary report. *European journal of pediatric surgery : official journal of Austrian Association of Pediatric Surgery ... [et al] = Zeitschrift fur Kinderchirurgie*. Dec; 2008 18(6):402–406.
55. Shehata SM, Shehata SM, M ABF. The intra-abdominal testis: lessons from the past, and ideas for the future. *Pediatric surgery international*. Oct; 2013 29(10):1039–1045. [PubMed: 23995239]
56. Sonmez K, Karabulut R, Turkyilmaz Z, Kaya C, Pehlivan Y, Basaklar AC. For Better Orchiopexy, Processus Vaginalis Should Be Dissected and a High Ligation Should Be Performed. *Rambam Maimonides medical journal*. Jul 28.2016 7(3)
57. Taran I, Elder JS. Results of orchiopexy for the undescended testis. *World journal of urology*. Aug; 2006 24(3):231–239. [PubMed: 16676187]

58. Tokar B. Do we need laparoscopic abdominal exploration for a testicular nubbin palpated in the inguinal region? A case with type IV polyorchidism. *European journal of pediatric surgery : official journal of Austrian Association of Pediatric Surgery ... [et al] = Zeitschrift fur Kinderchirurgie*. May; 2010 20(3):203–204.
59. Vijayaraghavan SB. Sonographic localization of nonpalpable testis: Tracking the cord technique. *The Indian journal of radiology & imaging*. Apr; 2011 21(2):134–141. [PubMed: 21799597]
60. Vos A, Vries AM, Smets A, Verbeke J, Heij H, van der Steeg A. The value of ultrasonography in boys with a non-palpable testis. *Journal of pediatric surgery*. Jul; 2014 49(7):1153–1155. [PubMed: 24952806]
61. Wolffenbittel KP, Kok DJ, Den Hollander JC, Nijman JM. Vanished testis: be aware of an abdominal testis. *The Journal of urology*. Mar; 2000 163(3):957–958. [PubMed: 10688030]
62. Yamazaki Y, Suzuki M, Shiroyanagi Y, Matsuno D, Tanaka Y. Scrotal nubbins associated with blind-ending spermatic vessels and a normal vas deferens on laparoscopy. *International journal of urology : official journal of the Japanese Urological Association*. Nov; 2009 16(11):902–904. [PubMed: 19863626]
63. Yee DS, Duel BP. Omental herniation through a 3-mm umbilical trocar site. *Journal of endourology*. Feb; 2006 20(2):133–134. [PubMed: 16509799]
64. Yucel S, Ziada A, Harrison C, Wilcox D, Baker L, Snodgrass W. Decision making during laparoscopic orchiopexy for intra-abdominal testes near the internal ring. *The Journal of urology*. Oct; 2007 178(4 Pt 1):1447–1450. discussion 1450. [PubMed: 17706708]
65. Zakaria OM, Hokkam E, El Kadi KE, et al. Examination under anesthesia for management of impalpable undescended testis: a traditional technique revisited. *World journal of surgery*. May; 2013 37(5):1125–1129. [PubMed: 23474855]

Abbreviations and Acronyms

NPT	nonpalpable testis
MRI	magnetic resonance imaging
AUA	American Urologic Association
EUA	European Association of Urology
FSO	Fowler Stephens Orchiopexy
CI	confidence interval
ITGCN	Intratubular germ cell neoplasia

References

1. Baker LA, Docimo SG, Surer I, et al. A multi-institutional analysis of laparoscopic orchidopexy. *BJU international*. Apr; 2001 87(6):484–489. [PubMed: 11298039]
2. Ueda N, Shiroyanagi Y, Suzuki H, Kim WJ, Yamazaki Y, Tanaka Y. The value of finding a closed internal ring on laparoscopy in unilateral nonpalpable testis. *Journal of pediatric surgery*. Mar; 2013 48(3):542–546. [PubMed: 23480909]
3. Papparella A, Romano M, Noviello C, et al. The value of laparoscopy in the management of non-palpable testis. *Journal of pediatric urology*. Dec; 2010 6(6):550–554. [PubMed: 20106723]
4. Kanemoto K, Hayashi Y, Kojima Y, Tozawa K, Mogami T, Kohri K. The management of nonpalpable testis with combined groin exploration and subsequent transinguinal laparoscopy. *The Journal of urology*. Feb; 2002 167(2 Pt 1):674–676. [PubMed: 11792951]
5. Mizuno K, Kojima Y, Kamisawa H, et al. Feasible etiology of vanishing testis regarding disturbance of testicular development: histopathological and immunohistochemical evaluation of testicular

nubbins. International journal of urology : official journal of the Japanese Urological Association. May; 2012 19(5):450–456. [PubMed: 22247958]

6. Belman AB, Rushton HG. Is an empty left hemiscrotum and hypertrophied right descended testis predictive of perinatal torsion? The Journal of urology. Oct; 2003 170(4 Pt 2):1674–1675. discussion 1675–1676. [PubMed: 14501689]
7. Alagaratnam S, Nathaniel C, Cuckow P, et al. Testicular outcome following laparoscopic second stage Fowler-Stephens orchidopexy. Journal of pediatric urology. Feb; 2014 10(1):186–192. [PubMed: 24045121]
8. Bracho-Blanchet E, Unda-Haro S, Ordorica-Flores R, et al. Laparoscopic treatment of nonpalpable testicle. Factors predictive for diminished size. Journal of pediatric surgery. Jul; 2016 51(7):1201–1206. [PubMed: 26896053]
9. Emir H, Ayik B, Elicevik M, et al. Histological evaluation of the testicular nubbins in patients with nonpalpable testis: assessment of etiology and surgical approach. Pediatric surgery international. Jan; 2007 23(1):41–44. [PubMed: 17031713]
10. Kraft KH, Bhargava N, Schast AW, Canning DA, Kolon TF. Histological examination of solitary contralateral descended testis in congenital absence of testis. The Journal of urology. Feb; 2012 187(2):676–680. [PubMed: 22177918]
11. Tasian GE, Copp HL. Diagnostic performance of ultrasound in nonpalpable cryptorchidism: a systematic review and meta-analysis. Pediatrics. Jan; 2011 127(1):119–128. [PubMed: 21149435]
12. Dessanti A, Falchetti D, Iannuccelli M, et al. Cryptorchidism with short spermatic vessels: staged orchiopexy preserving spermatic vessels. The Journal of urology. Sep; 2009 182(3):1163–1167. [PubMed: 19625047]
13. Tasian GE, Copp HL, Baskin LS. Diagnostic imaging in cryptorchidism: utility, indications, and effectiveness. Journal of pediatric surgery. Dec; 2011 46(12):2406–2413. [PubMed: 22152893]
14. Kolon TF, Herndon CD, Baker LA, et al. Evaluation and treatment of cryptorchidism: AUA guideline. The Journal of urology. Aug; 2014 192(2):337–345. [PubMed: 24857650]
15. Radmayr C, Dogan HS, Hoebeke P, et al. Management of undescended testes: European Association of Urology/European Society for Paediatric Urology Guidelines. Journal of pediatric urology. Dec; 2016 12(6):335–343. [PubMed: 27687532]
16. Hurwitz RS, Kaptein JS. How well does contralateral testis hypertrophy predict the absence of the nonpalpable testis? The Journal of urology. Feb; 2001 165(2):588–592. [PubMed: 11176443]
17. Snodgrass WT, Yucel S, Ziada A. Scrotal exploration for unilateral nonpalpable testis. The Journal of urology. Oct; 2007 178(4 Pt 2):1718–1721. [PubMed: 17707015]
18. Shibata Y, Kojima Y, Mizuno K, et al. Optimal cutoff value of contralateral testicular size for prediction of absent testis in Japanese boys with nonpalpable testis. Urology. Jul; 2010 76(1):78–81. [PubMed: 20472272]
19. Li T, Gao L, Chen P, et al. A systematic review and meta-analysis of comparative studies assessing the efficacy of luteinizing hormone-releasing hormone therapy for children with cryptorchidism. International urology and nephrology. May; 2016 48(5):635–644. [PubMed: 26898822]
20. Snodgrass W, Chen K, Harrison C. Initial scrotal incision for unilateral nonpalpable testis. The Journal of urology. Oct; 2004 172(4 Pt 2):1742–1745. discussion 1745. [PubMed: 15371803]
21. Lorenzo AJ, Samuelson ML, Docimo SG, Baker LA, Lotan Y. Cost analysis of laparoscopic versus open orchiopexy in the management of unilateral nonpalpable testicles. The Journal of urology. Aug; 2004 172(2):712–716. [PubMed: 15247768]
22. Wolffenbuttel KP, Kok DJ, Den Hollander JC, Nijman JM. Vanished testis: be aware of an abdominal testis. The Journal of urology. Mar; 2000 163(3):957–958. [PubMed: 10688030]
23. Elyas R, Guerra LA, Pike J, et al. Is staging beneficial for Fowler-Stephens orchiopexy? A systematic review. The Journal of urology. May; 2010 183(5):2012–2018. [PubMed: 20303527]
24. Wayne C, Chan E, Nasr A. What is the ideal surgical approach for intra-abdominal testes? A systematic review. Pediatric surgery international. Apr; 2015 31(4):327–338. [PubMed: 25663531]
25. Hsieh MH, Bayne A, Cisek LJ, Jones EA, Roth DR. Bladder injuries during laparoscopic orchiopexy: incidence and lessons learned. The Journal of urology. Jul; 2009 182(1):280–284. discussion 284–285. [PubMed: 19450839]

26. Metwalli AR, Cheng EY. Inguinal hernia after laparoscopic orchiopexy. *The Journal of urology*. Nov.2002 168(5):2163. [PubMed: 12394749]
27. Alam A, Delto JC, Blachman-Braun R, et al. Staged Fowler-Stephens and Single-stage Laparoscopic Orchiopexy for Intra-abdominal Testes: Is There a Difference? A Single Institution Experience. *Urology*. Nov 11.2016
28. Esposito C, Vallone G, Savanelli A, Settimi A. Long-term outcome of laparoscopic Fowler-Stephens orchiopexy in boys with intra-abdominal testis. *The Journal of urology*. Apr; 2009 181(4):1851–1856. [PubMed: 19233407]
29. Tackett LD, Wacksman J, Billmire D, Sheldon CA, Minevich E. The high intra-abdominal testis: technique and long-term success of laparoscopic testicular autotransplantation. *Journal of endourology*. Aug; 2002 16(6):359–361. [PubMed: 12227909]
30. Shalaby MM, Shoma AM, Elanany FG, Elganainy EO, El-Akkad MA. Management of the looping vas deferens during laparoscopic orchiopexy. *The Journal of urology*. Jun; 2011 185(6 Suppl): 2455–2457. [PubMed: 21555012]
31. Kaye JD, Palmer LS. Single setting bilateral laparoscopic orchiopexy for bilateral intra-abdominal testicles. *The Journal of urology*. Oct; 2008 180(4 Suppl):1795–1799. discussion 1799. [PubMed: 18721983]
32. Kogan S. The clinical utility of testicular prosthesis placement in children with genital and testicular disorders. *Translational andrology and urology*. Dec; 2014 3(4):391–397. [PubMed: 26816795]
33. Peycelon M, Rossignol G, Muller CO, et al. Testicular prostheses in children: Is earlier better? *Journal of pediatric urology*. Aug; 2016 12(4):237.e231–236.
34. AbouZeid AA, Moussa MH, Shalaby MS, Safoury HS, El-naggar O, Hay S. Feasibility and safety of monopolar diathermy as an alternative to clip ligation in laparoscopic Fowler-Stephens orchiopexy. *Journal of pediatric surgery*. Oct; 2012 47(10):1907–1912. [PubMed: 23084205]
35. Hay SA. Collateral circulation after spermatic vessel ligation for abdominal testis and its impact on staged laparoscopically assisted orchiopexy. *Journal of laparoendoscopic & advanced surgical techniques. Part A*. Feb; 2007 17(1):124–127. [PubMed: 17362189]
36. Kojima Y, Mizuno K, Kamisawa H, Kato T, Kohri K, Hayashi Y. Laparoscopic management of nonpalpable testis: new treatment strategy. *Journal of endourology*. Apr; 2011 25(4):635–640. [PubMed: 21381960]
37. Shehata S, Shalaby R, Ismail M, Abouheba M, Elrouby A. Staged laparoscopic traction-orchiopexy for intraabdominal testis (Shehata technique): Stretching the limits for preservation of testicular vasculature. *Journal of pediatric surgery*. Feb; 2016 51(2):211–215. [PubMed: 26655212]
38. Volfson IA, Munver R, Esposito M, Dakwar G, Hanna M, Stock JA. Robot-assisted urologic surgery: safety and feasibility in the pediatric population. *Journal of endourology*. Nov; 2007 21(11):1315–1318. [PubMed: 18042021]
39. Mei H, Pu J, Qi T, et al. Transumbilical multiport laparoscopic orchiopexy in children: comparison with standard laparoscopic orchiopexy. *Urology*. Dec; 2012 80(6):1345–1349. [PubMed: 23206780]
40. Rozanski TA, Wojno KJ, Bloom DA. The remnant orchiectomy. *The Journal of urology*. Feb; 1996 155(2):712–713. discussion 714. [PubMed: 8558712]
41. Law H, Mushtaq I, Wingrove K, Malone M, Sebire NJ. Histopathological features of testicular regression syndrome: relation to patient age and implications for management. *Fetal and pediatric pathology*. Mar-Apr;2006 25(2):119–129. [PubMed: 16908461]
42. Broderick KM, Martin BG, Herndon CD, Joseph DB, Kitchens DM. The current state of surgical practice for neonatal torsion: a survey of pediatric urologists. *Journal of pediatric urology*. Oct; 2013 9(5):542–545. [PubMed: 23305767]
43. De Luna AM, Ortenberg J, Craver RD. Exploration for testicular remnants: implications of residual seminiferous tubules and crossed testicular ectopia. *The Journal of urology*. Apr; 2003 169(4): 1486–1489. [PubMed: 12629397]
44. Renzulli JF 2nd, Shetty R, Mangray S, Anderson KR, Weiss RM, Caldamone AA. Clinical and histological significance of the testicular remnant found on inguinal exploration after diagnostic

- laparoscopy in the absence of a patent processus vaginalis. *The Journal of urology*. Oct; 2005 174(4 Pt 2):1584–1586. discussion 1586. [PubMed: 16148657]
45. Storm D, Redden T, Aguiar M, Wilkerson M, Jordan G, Sumfest J. Histologic evaluation of the testicular remnant associated with the vanishing testes syndrome: is surgical management necessary? *Urology*. Dec; 2007 70(6):1204–1206. [PubMed: 18158048]
46. Antic T, Hyjek EM, Taxy JB. The vanishing testis: a histomorphologic and clinical assessment. *American journal of clinical pathology*. Dec; 2011 136(6):872–880. [PubMed: 22095372]
47. Nataraja RM, Asher CM, Nash R, Murphy FL. Is routine excision of testicular remnants in testicular regression syndrome indicated? *Journal of pediatric urology*. Jun; 2015 11(3):151.e151–155. [PubMed: 25913475]
48. Hegarty PK, Mushtaq I, Sebire NJ. Natural history of testicular regression syndrome and consequences for clinical management. *Journal of pediatric urology*. Jun; 2007 3(3):206–208. [PubMed: 18947736]
49. Bader MI, Peeraully R, Ba'ath M, McPartland J, Baillie C. The testicular regression syndrome—do remnants require routine excision? *Journal of pediatric surgery*. Feb; 2011 46(2):384–386. [PubMed: 21292092]
50. Martin AD, Rushton HG. The prevalence of bell clapper anomaly in the solitary testis in cases of prior perinatal torsion. *The Journal of urology*. May; 2014 191(5 Suppl):1573–1577. [PubMed: 24679875]

Figure 1.
Flow-diagram for study selection.

Table 1

Studies evaluating testis size as a predictor of monorchidism.

Testis Size	N	Number with monorchidism	Number with viable testis	Author
> 2cm	16	14	2	Hurwitz and Kaptein, 2001 ¹⁶
2cm	22 [*]	21	1	Belman and Rushton, 2003 ⁶
	20	17	3	Snodgrass et al, 2007 ¹⁷
	33	29	4	Shibata et al, 2010 ¹⁸
1.8–2cm	15	14	1	Hurwitz and Kaptein, 2001 ¹⁶
1.8-<2cm	10	9	1	Snodgrass et al, 2007 ¹⁷
	7	3	4	Shibata et al, 2010 ¹⁸
TOTAL 1.8 cm	123	107 (87.0%)	16 (13.0%)	
<1.8 cm	25	12	13	Hurwitz and Kaptein, 2001 ¹⁶
	10	2	8	Snodgrass et al, 2007 ¹⁷
	15	1	14	Shibata et al, 2010 ¹⁸
TOTAL <1.8 cm	50	15 (30.0%)	35 (70.0%)	

* Study included only patients with a left sided NPT.

Table 2

Outcomes of laparoscopic orchiopexies (open techniques excluded).

	Laparoscopic Orchiopexy (no vessel division)	1-Stage FSO	2-Stage FSO
Diminished Size of Testis	12% ⁸	–	37.8% ⁸
Atrophy of Testis	2.2–6% ^{1,8}	8–22.2% ^{1,27}	8.8–11.4% ^{1,7,27}
Poorly Positioned Testis	0.6% ¹	7.4–20% ^{1,27}	1.7–25% ^{*,1,7,28}

* 25% at follow-up of 10–17 years²⁸

Table 3

Studies evaluating for the presence of germ cells in testicular remnants.

Author	Total Number of Nubbins	Nubbins WITH germ cells	Nubbins WITHOUT germ cells
Rozanski et al, 1996 ⁴⁰	50	5 (1/5 with ITGCN)	45
De Luna et al, 2003 ⁴³	71	4	67
Renzulli et al, 2005 ⁴⁴	110	8	102
Emir et al, 2007 ⁹	39	2	37
Hegarty et al, 2007 ⁴⁵	117	0	117
Storm et al, 2007 ⁴⁶	56	8	48
Antic et al, 2011	30	0	30
Bader et al, 2011 ⁴⁷	180	19	161
Muzino et al, 2012 ⁵	88	3	85
Ueda et al, 2013 ²	81	6	75
Natajara et al, 2015 ⁴⁸	132	12	120
TOTAL	954	67 (7.0%); 1 (0.1%) ITGCN	887 (93.0%)