

# Long-term impact of commonly performed operations in pediatric urology on reproductive and sexual health

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## Abstract

**Introduction:** Sexual dysfunction is highly prevalent among men of reproductive age. Clinical practice guidelines have been established to assist providers in identification and education of patients who are at increased risk for infertility and sexual dysfunction with certain congenital and acquired urogenital disorders. The authors sought to review the reproductive and sexual health implications of treating common childhood urological conditions with commonly performed surgical procedures.

**Methods:** To ensure the inclusion of influential and highly regarded research, we prioritized citations from the most-frequently cited articles on our respective review topics. Our inclusion criteria considered studies with substantial sample sizes and rigorously designed methodologies. Several topics were reviewed, including penile chordee, hypospadias, posterior urethral valves, varicoceles, undescended testicles, and testicular torsion.

**Results:** For chordee, surgical plication or corporal grafting may be employed. Erectile function remains unaltered post-surgery, while penile length may decrease after repair, which may be avoided using dermal grafts. Hypospadias repair hinges on severity and availability of the urethral plate. Those who underwent hypospadias repair report decreased penile length, but sexual satisfaction, libido, and semen quality are comparable to controls. Posterior urethral valves are usually treated with valve ablation. While valve ablation and bladder neck incision have not been found to affect ejaculatory function, high degree of concurrent renal dysfunction related to nephrogenic and bladder dysfunction may impact semen parameters and erectile function. Regarding varicocele, earlier management has been associated with better long-term fertility outcomes, and surgical intervention is advisable if there is observable testicular atrophy. Earlier repair of undescended testicle with orchiopexy has been found to improve fertility rates as well as decrease malignancy rates. Unilateral orchiectomy for testicular torsion without the ability for salvage has been shown to have decreased semen parameters but unaffected fertility rates.

**Conclusion:** Infertility and sexual dysfunction are multivariable entities, with etiologies both congenital and acquired. At the same time, many common pediatric urology surgeries are performed to correct anatomic pathology that may lead to reproductive dysfunction in adulthood. This review highlights the need for diagnosis and management of pediatric urologic conditions as these conditions may impact long-term sexual function post-operatively.

*Ther Adv Urol*

2024, Vol. 16: 1–13

DOI: 10.1177/  
17562872241249083

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## Plain language summary

### Long-term impact of commonly performed operations in pediatric urology on sexual health

Many men of reproductive age face sexual health challenges, prompting the creation of guidelines for identifying and addressing issues related to urogenital disorders. This study explores the impacts of common surgical procedures on reproductive and sexual health in children with urological conditions. By reviewing extensive literature, the study focuses on the long-term effects of pediatric urologic surgeries, emphasizing influential and frequently cited research for a comprehensive understanding. For conditions like chordee, surgical options such as plication or grafting may be considered. While erectile function typically remains unchanged, there might be a decrease in penile length post-surgery, which can be addressed with specific techniques. Hypospadias repair varies based on severity, with those undergoing the procedure having shorter penises. However, their sexual satisfaction, libido, and semen quality are comparable to others. Treatment of posterior urethral valves (PUV) often involves valve ablation, however some studies have shown altered semen parameters following ablation. Managing varicocele early on leads to better outcomes, and surgery is recommended if testicular atrophy is observed. Orchiopexy and orchiectomy are procedures for undescended testis (UDT) and testicular torsion in children. Pediatric urologic diseases and their surgical interventions can significantly affect sexual function and fertility in adulthood due to their multifactorial nature. While some procedures aim to preserve or enhance sexual potential such as proper urethral development, others may inadvertently impact sexual health negatively, such as necrotic testes removal. This underscores the importance of thorough diagnosis and management of pediatric urologic conditions to safeguard long-term sexual function post-surgery.

**Keywords:** chordee, erectile dysfunction, hypospadias, infertility, penile plication, sexual health, undescended testis, valve ablation, varicolectomy, ventral corporal grafting, testicular atrophy, testicular torsion

Received: 28 October 2023; revised manuscript accepted: 28 March 2024.

## Introduction

Infertility and sexual dysfunction are two highly prevalent conditions that men of reproductive age suffer. Approximately 15% of all couples in the United States and at least 180 million people worldwide are affected by infertility. Overall, the male factor substantially contributes to about 50% of all cases of infertility.<sup>1</sup> Additionally, around 20–30% of men globally report at least one sexual disorder. The most common of which are erectile dysfunction (ED) and premature ejaculation, with prevalence rates of 12–19% and 8–31%, respectively.<sup>2</sup> Even though the etiology is not always determined, some of these men may have suffered from childhood urological disease,

which might have increased their risk of acquiring such difficulties in their adulthood.

Clinical practice guidelines have been established to assist providers in the identification and education of patients who are at increased risk for infertility and sexual dysfunction with certain congenital and acquired urogenital disorders such as cryptorchidism, varicoceles, and hypospadias. Unfortunately, despite these advances, the impact of urologic procedures in childhood on future sexual function and fertility is not entirely well-established.<sup>3</sup> Current literature documenting the incidence of these disorders is unavailable due to general underreporting, cultural factors, and

regional variations. There is limited research evaluating the long-term effects of the surgical correction of common pediatric disorders on sexual function in adulthood due to the delays between diagnosis, treatment, and reproductive age.<sup>4</sup> Furthermore, there remains a lack of agreement in regard to appropriate follow-up protocol in pediatric patients undergoing urological procedures.<sup>5</sup> This, along with the increasingly common and accessible usage of phosphodiesterase-5 (PDE-5) inhibitors with minimal physician involvement due to distribution *via* nonphysicians and online entities, makes evaluating this specific patient population increasingly difficult.<sup>6</sup> In addition, the psychiatric aspect of erectile function is of particular concern in the pediatric population. Anatomic abnormalities, such as penile curvature or hypospadias, and the consequences of surgical repairs such as orchiectomies, may lead to detrimental effects on body image, and ultimately sexual function.<sup>7</sup>

Identifying a connection between these treatments and their long-term impact would add valuable information when consulting patients and their families. This paper aims to review the implications of treating common childhood urological conditions with surgical operations on fertility and sexual function in adulthood.

### Chordee and penile curvature

Chordee is a pediatric condition of abnormal ventral penile curvature, which can be isolated or more commonly associated with hypospadias. Hypospadias occurs in around 1/300 births and around 25% of these children may have associated chordee.<sup>8</sup> However, the true incidence of isolated chordee may occur in as high as 4–10% of males.<sup>9</sup> This is partially due to delays in diagnosis in some boys until years after birth. The exact etiology of chordee is unknown; however, recent studies suggest that it may be related to arrested penile development. This is because some ventral penile curvature is found as a normal part of genital development that should normally straighten between 20 and 25 weeks gestation.<sup>9</sup> Importantly, chordee can be highly variable making the indications for repair in the pediatric population controversial since the degree of sexual dysfunction the individual experience due to the curvature is not yet known.

When indicated, repair of chordee depends on the angle of the curvature and includes plication

with or without excision for more mild forms as well as corporal grafting if more severe. If complex curvature is involved, corporal rotation or penile disassembly may be used.<sup>9</sup> The most accepted method for plication is the Nesbit procedure, which involves the excision of a diamond shaped portion of the tunica albuginea at the area of maximum curvature and closure with sutures.<sup>5</sup> While plication for chordee has been shown to decrease penile length,<sup>10</sup> it has not been shown to alter erectile function in adulthood.<sup>11</sup> A study by Nooter *et al.*<sup>12</sup> investigated the long-term effects of surgical plication for patients with congenital penile curvature and reported a small amount of penile shortening in some patients, but intercourse was found to be satisfactory. Despite the negative effects of slightly decreased penile length from plication, erectile function is largely maintained, which is why it is the procedure of choice for mild chordee (<45°). Another technique involves multiple parallel plication without excision of tunica albuginea. For congenital penile curvature, this technique was found to have successful sexual outcomes with minimal shortening of penile length.<sup>13,14</sup>

For more severe forms of chordee, plication may cause excessive penile shortening, making length preserving techniques such as corporal grafting more desirable. Although the choice of grafting material varies, the surgical principles are similar. In brief, the tunica albuginea overlying the corpus cavernosa is incised at the point of maximal curvature, allowing for penile straightening while preserving length. For ventral chordee, this may require urethral mobilization or even incision with a staged urethroplasty. The graft is sutured to the corporal defect with a fine absorbable suture in a watertight fashion and a dartos flap is often used to cover the graft. Although corporal grafting can preserve penile length, there is a paucity of long-term data to truly elucidate the rates of erectile function post repair.

Several different corporal graft types have been described with variable follow-up and rates of ED. The use of dermal grafts has been found to preserve erectile function and allowed men to father children while providing superior cosmesis.<sup>12,15</sup> In a study with a mean follow-up of almost 15 years, Guevara *et al.* examined the effects of using small intestinal submucosa (SIS) grafts for severe chordee correction in 19 boys with proximal hypospadias. They compared the outcomes to 18 control participants who were seen in their

pediatric urology offices for other urologic pathologies. Both groups had a median age of 17 years, with an age range of 12–29. The study's findings revealed that there were no significant differences in rates of ED or genital self-perception during adolescence when comparing the boys who underwent SIS grafting to the age-matched controls.<sup>16</sup> Other nongrafting techniques such as corpora cavernosa rotation *via* noncorporotomy technique resulted in improvement in erectile function with no penile shortening.<sup>17</sup> A study by Molina-Escudero *et al.*<sup>18</sup> on corpora cavernosa rotation found similar results.

As it stands, there is a dearth of literature regarding long-term sexual function outcomes associated with corporal grafting for chordee. There are, however, data on the efficacy and outcomes of grafting techniques for conditions such as Peyronie's disease (PD). While chordee and PD exhibit distinct macroscopic and microscopic characteristics, clinicians have explored PD grafts as a means to validate the feasibility and viability of employing similar approaches to address severe chordee. Studies have found grafting to be successful in penile straightening; however, these men were seen to have much higher rates of ED, requiring PDE-5 inhibitors for adequate function.<sup>19,20</sup> Using these data to infer potential long-term consequences in the pediatric population is helpful to adequately inform patients prior to undergoing this procedure. Although recognizing the differences between these conditions, the utilization of PD grafts in the context of chordee underscores the clinical interest in finding innovative solutions for challenging cases in penile reconstructive surgery. Moving forward, work is needed to analyze the effects of surgical correction of severe chordee especially as it relates to changes in sexual function.

However, it is important to note that studies analyzing the use of grafts are limited in their sample size, making it difficult to understand the true benefits of corporal grafting. Sennert *et al.* conducted a study involving 17 patients with proximal and perineal hypospadias with severe chordee, in which the urethral plate and underlying tissue samples were excised and histologically examined. They noted the specimens contained disorganized, hypoplastic smooth muscle of the corpus spongiosum, lack of elastic fibers, and large abnormal embryonal blood sinusoids.<sup>21</sup> It is difficult to elucidate the true benefit of adding grafts into this patient population with dysfunctional

underlying tissue. Although other studies as mentioned above report that grafts preserve erectile function and allow men to father children while providing superior cosmesis,<sup>12,15</sup> further studies are needed to determine if these treatment options truly resolve the underlying issue and prevent future recurrence of penile curvature.

It is also important to note the option of conservative management for chordee. Namely, untreated chordee can lead to lower penile perception (Sexual Health Inventory for Men) scores, poorer mental health, more frequent sitting for urination, greater trouble with sexual intercourse, and more.<sup>22</sup> Therefore, while the long-term outcomes of corporal grafting have yet to be explicated, the benefits of the surgery may outweigh the consequences of untreated chordee.

### Hypospadias

Hypospadias is a common pediatric condition in which the urethral opening is proximal to normal location and located on the ventral aspect of the penis. This affects 1 in 150–300 live births.<sup>23,24</sup> The etiology of hypospadias is not completely understood, but similar to chordee, hypospadias results in an arrest of penile and urethral development. Male external genitalia development is dependent on the conversion of testosterone *via* 5- $\alpha$  reductase to Dihydrotestosterone (DHT). Decreased androgen levels, or defects in androgen signaling receptor pathway, have been demonstrated to lead to hypospadias.<sup>25</sup> Surgical correction may need to be performed in multiple stages depending on the location of the urethral meatus and the extent of the chordee, as well as concurrent malformations such as bifid scrotum, penoscrotal transposition, or cryptorchidism. Distal hypospadias is commonly corrected in one stage operation; however, proximal hypospadias may require a multiple-stage approach.<sup>26</sup> The American Academy of Pediatrics recommends surgical correction to occur between 6 and 18 months of age. This is to limit stress and behavioral issues that may complicate repair in older age groups.<sup>27</sup> Hypospadias may cause both sexual dysfunction due to chordee as well as infertility if the hypospadias is a result of a relative testicular dysfunction.

Few studies have examined the long-term consequences of hypospadias as well as its repair on sexual function in adults; however, the sexual dysfunction in hypospadias most commonly

results from the severity of the chordee and the repair techniques, which were outlined in the previous section are similar. Furthermore, sexual outcomes of patients who underwent surgical repair as children may be difficult to assess because of the use of outdated surgical techniques in the past and lack of long-term follow-up of patients from pediatric urologists into adulthood.<sup>28</sup> While penile length was found to be significantly shorter in men who have undergone hypospadias repair compared to controls, sexual satisfaction and libido were found to be no different based on self-reported questionnaires.<sup>29</sup>

Fertility may be affected by anatomic consequences of this condition or from testicular dysfunction. Population-based studies have revealed decreased birth rates in men with hypospadias and increased use of assisted reproductive techniques.<sup>30</sup> While semen quality has been found to be noninferior in men with distal repairs, men with more proximal repairs were found to have decreased semen parameters such as concentration and percent of active motile sperm.<sup>31</sup> The incidence of ejaculation disorders in men with proximal hypospadias is unknown, with the incidence varying upon postoperative features and complications of impaired spongiosal tissue, urethral diverticula, and/or stricture disease.<sup>31</sup> While ejaculation can be affected by hypospadias and its subsequent repair, patients who had undergone repair in childhood have reported satisfactory erectile function.<sup>32</sup> The true incidence and etiology of infertility in hypospadias is unknown, especially given that it could result from an ejaculatory disorder or decreased spermatogenesis.

### Posterior urethral valves

Posterior urethral valves (PUVs), occurring in approximately 1 in 5000–8000 births,<sup>33</sup> are a congenital anomaly in which obstructive membranes form in the urethra cause bladder outlet obstruction. Diagnosed antenatally or after birth, PUVs can lead to Potter sequence and pulmonary hypoplasia. Moreover, PUVs are associated with abnormal posterior urethral development, cryptorchidism, and renal failure. Studies have found an incidence rate of 12–16% for cryptorchidism in patients with PUVs.<sup>34,35</sup> Although the lethality of PUV in infancy is typically due to pulmonary hypoplasia, end-stage renal disease requiring renal replacement therapy is common, occurring in about 16% of boys after 10 years of age.<sup>36</sup> Underlying renal dysplasia, erectile function may

also be impacted by impaired renal function that commonly is seen in patients with history of PUV. Studies have shown higher rates of ED in men with chronic kidney disease with multifactorial causes including hormonal imbalances, effects of uremia, and smooth muscle function.<sup>36,37</sup> To clarify the relationship between PUV, surgical treatment, renal disease, and infertility or ED, studies conducted on this topic must specify the renal function of patients and the presence or absence of undescended testicles. This information is crucial to determine whether infertility or ED stems from PUV surgical treatment or secondary renal insufficiency.

In terms of sexual function, some have found that men treated for PUV in childhood had similar rates of ED and paternity rates to men without PUV.<sup>38</sup> A 2013 survey of 16 adult patients with a history of PUV treatment in their first year of life investigated sexual function and semen quality. Many of the patients had normal sexual function and semen quality for paternity, although 28.5% reported mild to medium ED.<sup>39</sup> A similar survey by Woodhouse *et al.*<sup>40</sup> showed some evidence of slow or dry ejaculation, but little evidence of retrograde ejaculation or low sperm count.

Ideally, initial treatment of PUV includes transurethral ablation of the valves shortly after diagnosis. This may be done *via* cystourethroscopy with a cold knife, electrodes, or laser.<sup>41</sup> Furthermore, bladder neck obstruction may persist after valve ablation. An obstruction or abnormal bladder outlet can lead to abnormal ejaculation.<sup>42</sup> Bladder neck incision can be performed concomitantly to improve bladder function. Men treated with both PUV ablation and bladder neck incision were not found to have impaired ejaculatory function or semen parameters.<sup>43</sup>

Although patients treated for PUV in recent decades have had an improved prognosis, the long-term effects on fertility and sexual function have not been fully elucidated.<sup>37</sup> Some have shown adequate sperm counts, sperm volume, liquefaction time, and viscosity in those treated for PUV<sup>39</sup>; however, others report abnormalities in sperm agglutination and percentage of immotile sperm.<sup>44</sup> A study by Schober *et al.*<sup>45</sup> assessed lower urinary tract symptoms and semen quality in men with a history of ablated PUV and found significant pyospermia as well as decreased sperm count and motility. A potential etiology of infertility could be the development of uremia, which has been



reported up to 32% within a single case series.<sup>37</sup> Physiologically, uremia has been associated with suboptimal semen parameters, leading to secondary infertility.<sup>46</sup>

Overall, better studies with long-term data are required to better understand the incidence and etiology of infertility in boys with PUV. Although long-term data are lacking, sexual function in males with PUV is largely preserved; however, infertility rates from decreased spermatogenesis or ejaculatory dysfunction is likely increased compared to the general population.

### Varicocele

Varicoceles are an abnormal dilation of pampiniform plexus in the spermatic cord. While this is a relatively uncommon disease in childhood, affecting ~1% of males less than 10 years old, the prevalence increases with age.<sup>47</sup> Almost 15% of 15- to 19-year-old males develop varicoceles, which is similar to the incidence in adult males.<sup>47</sup> Increase in scrotal temperature, secondary to the dilated veins, is thought to lead to testicular atrophy and gonadal dysfunction leading to impaired sperm motility, morphology, and density as a consequence.<sup>48</sup> Furthermore, testicular damage from varicoceles may be progressive and palpable varicoceles, especially grades 2 or 3 should be monitored.

Varicoceles are well-documented to cause infertility in a subset of adolescents. In a 2007 study, Mori *et al.*<sup>49</sup> determined that grade 2 and grade 3 varicoceles cause decreased testicular size and lower sperm quality.<sup>49</sup> In their study, adolescents 14–18 years old, of whom ~86% were Tanner 4 or 5, with grade 3 varicoceles, ejaculated a mean of 30.3 million motile sperm per mL, which was considered by the study to be close to the lower limit of what is considered to be a normal sperm count by the World Health Organization (WHO).<sup>49</sup> However, the study's conclusion is limited due to the inclusion of participants who were not fully developed (Tanner Stage 4). Ultimately, sperm analysis results can be highly variable during puberty, making it challenging to draw definitive conclusions about future fertility based on findings in this age group.

It is hypothesized that the low-normal sperm concentration found in an adolescent with a grade 3

varicocele is in fact a harbinger of what will eventually develop into WHO-defined oligospermia of 15 million sperm per mL. Unfortunately, it is unclear which men will have testicular insult and subsequent infertility from the presence of a varicocele and who will not. Furthermore, in pediatric patients who are not yet Tanner 4 or 5 and a semen analysis cannot be performed, it is unclear who may need repair, and thus, surrogate markers such as relative testicular size or volume may need to be considered.

Adolescent varicoceles' diagnosis, treatment, and repair are controversial. For example, varicocelectomy, the surgical correction of varicocele, is controversial with a lack of consensus among pediatric urologists due to the absence of well-established prepubertal clinical markers of infertility.<sup>47</sup> Management of varicoceles in the pediatric population has generally been based on severity of testicular atrophy – greater than 2 mL difference or greater than 20% volume difference when compared to the contralateral testicle. These guidelines are based on cutoffs where lower motile sperm count as well as infertility have been seen.<sup>50–53</sup> One retrospective review found that paternity rates in men who had been treated for varicoceles as adolescents with microsurgical varicocele repair had higher rates of paternity and shorter times to conception compared to men whose varicoceles were conservatively followed.<sup>54</sup> Semen parameters were also noted to be significantly better in the treatment group.<sup>54</sup> Conversely, men who had undergone sclerotherapy for varicoceles as adolescents were found to have equivalent paternity rates compared to men who were conservatively followed.<sup>55</sup> Overall, further studies are needed to determine which prepubertal parameters should be evaluated for early surgical correction of the varicocele and how that can improve fertility in adulthood.

### Orchiopexy

Orchiopexy is a surgical procedure indicated for patients who have undescended testis (UDT), known as cryptorchidism, or are diagnosed with testicular torsion (TT). This can result in testes located either in a location on its natural descent from the abdomen *in utero* or ectopically in areas such as the femoral canal or the perineum. Affected boys may have unilateral or bilateral UDT and cryptorchidism, which can be congen-

ital or acquired. The etiology of UDT is multifactorial and testicular hypofunction *in utero* as well as maternal alcohol use, smoking, and analgesics during pregnancy are risk factors.<sup>56–58</sup> Epidemiological research has demonstrated that cryptorchidism is more common in preterm newborns and UDT is more likely to occur on the right side.<sup>59</sup> A population-based study found concordance rates of 3.4% in half-brothers, 8.8% in full brothers, and this number rises to 24% and 27% in dizygotic and monozygotic twins, respectively.<sup>60</sup> Both maternal and paternal factors appear to be implicated in the occurrence of cryptorchidism. Therefore, patients who have a familial history of UDT may be at increased risk of cryptorchidism. Orchiopexy should be performed in all patients with cryptorchidism between 6 and 18 months to improve fertility rates and decrease malignancy risk.<sup>61</sup>

As cryptorchidism is a risk for both future malignancy and infertility, orchiopexy procedures are necessary if the testis does not naturally descend.<sup>62</sup> In terms of infertility, men with bilateral UDT have a sixfold increased risk for being infertile when compared to those with unilateral UDT and normal men, which may be owed to greater histological changes such as severe fibrosis of the stromal connective tissue.<sup>62–64</sup> Specifically, one retrospective review found that azoospermia or oligospermia was reported in double the percentage of cases of bilateral UDT (66–87.5%) as compared to unilateral UDT (33–35%).<sup>65</sup> Patients with bilateral UDT had significantly compromised paternity as compared to a control group, whereas patients with unilateral UDT did not.<sup>63,66</sup> Hormonal therapy has been studied in a limited fashion to address these fertility issues; however, it is not currently recommended due to evidence of low success rates of testicular descent.<sup>67</sup> Additionally, hormonal therapy with human chorionic gonadotropin or gonadotropin-releasing hormone may interfere with spermatogenesis and alter the hypothalamic–pituitary–gonadal (HPG) axis, thus leading to impaired fertility in the future.<sup>68</sup> These potential detrimental effects of hormonal therapy for UDT have not been fully evaluated, and long-term data are lacking.

There are various techniques to this surgical operation and physicians will employ different methods based on the specific case presentation.

Palpable testes within the inguinal canal typically require a conventional orchiopexy (CO), which uses an inguinal incision to access the UDT and a scrotal incision to fix the testes within a superficial dartos pouch within the scrotum and is typically seen as the primary surgical choice.<sup>69</sup> For testicles that are within the superficial inguinal pouch or high scrotum, the CO can be employed as well as a single scrotal incision technique, in which an incision is made in the hemiscrotum to access the testicle and fix it within the scrotum.<sup>69</sup> Laparoscopic orchiopexy has been traditionally implemented in the case of UDTs, nonpalpable testis; however, recent research has suggested the clinical effectiveness of laparoscopic procedures in palpable UDTs as well.<sup>70</sup> The advantages of laparoscopic orchiopexy include enhanced visualization and exploration of the abdominal cavity and total release of the spermatic vessels allowing positioning of the testes without tension.<sup>69</sup>

Cryptorchidism can result in infertility due to a variety of factors such as altered temperature and circulation of blood. Parameters including sperm concentration, motility, inhibin B levels, and testicular volume are significantly decreased in bilateral cryptorchid patients even after orchiopexy.<sup>71</sup> However, timing of the orchiopexy is critical in these patients to mitigate the severity of infertility. Early surgical intervention, before the age of 1, experienced the greatest increase in serum inhibin B.<sup>63</sup> Inhibin B has been associated with normal Sertoli cell function and spermatogenesis.<sup>72</sup> The longer an orchiopexy surgery is delayed, the more likely testicular damage and volume reduction will occur, however, whether testicular volume is a reliable measure for fertility remains unclear.<sup>73</sup> Another marker of fertility is the germ cell per tubule count (GC/T). A cohort of 14 boys who had orchiopexy prior to the age of 6 months had a normal GC/T, whereas boys who had the same procedure between the age of 6–24 months had a lower count.<sup>74</sup> It is important to note that although the benefits of orchiopexy have been demonstrated, this surgery will repair pathologies related to temperature; however, any intrinsic abnormalities within the testicles will remain following the procedure. Therefore, patients with bilateral UDT may not necessarily have improved fertility outcomes following orchiopexy. Nevertheless, orchiopexy, regardless of the approach, should be hastily considered in boys with cryptorchidism to decrease infertility and future malignancy risk.

### Torsion/Orchiectomy

Orchiectomy is the surgical removal of the testes. It is indicated in select patients who are diagnosed with TT with a nonsalvageable testis at the time of exploration. TT is a common urological emergency, specifically in males under the age of 18, with the most common occurrence in the neonatal and peripubertal period.<sup>75,76</sup> TT results from twisting of the spermatic cord along the testicular axis leading to testicular ischemia. Most cases of TT are the result of bell-clapper deformity; however, trauma can be an inciting event.<sup>77</sup> Immediate medical intervention to restore blood flow is required to prevent irreversible ischemic injury and loss of the torsed testis. In the event the testis is deemed nonviable, an orchiectomy is performed. An identifiable risk factor for performing orchiectomy at the time of TT is increasing age.<sup>77,78</sup>

Patients with a torsed testis that was salvaged earlier in life through orchiopexy instead of orchiectomy were reported to have a higher insemination rate and shorter mean time to pregnancy with their partners compared to those who had a torsion later in adulthood. These differences may suggest that orchiectomies may have a negative impact on the fertility potential of men.<sup>79</sup> However, testicular salvage may not always be an option, such as in the case of total necrosis and ischemia. Other studies report no differences in paternity rates among patients who had undergone orchiopexy at time of TT repair *versus* those who underwent orchiectomy.<sup>80,81</sup> Irkilata *et al.*<sup>82</sup> found no statistically and or clinically significant differences in semen parameters and hormone levels such as Follicle-Stimulating Hormone (FSH) and inhibin B in post-pubertal cryptorchid men who underwent simple orchiectomy. In rat studies, FSH, Lutenizing Hormone (LH), and testosterone levels did not change in rats, 6 months post-orchiectomy compared to controls.<sup>83</sup> Skoogh *et al.*<sup>7</sup> also reports that orchiectomy can lead to detrimental psychological effects such as shame and embarrassment. These studies highlight the need for prompt diagnosis and surgical exploration for boys with suspected TT in order to increase rates of testicular salvage. Notably, there is overwhelming evidence that reports unaffected fertility rates in men who have undergone unilateral orchiectomy.<sup>81,84</sup> Although certain parameters such as sperm density may be decreased compared to controls, these levels are still in the

normal range for patients with unilateral orchiectomies.<sup>84</sup>

Follow-up studies that evaluate hormone levels, spermatogenesis, and sperm parameters are needed in patients who previously had an orchiectomy due to TT. Urologists need to discuss the risks of this procedure to their patients. As future research reveals the long-term impacts of this procedure, interventions may be put in place to improve patient outcomes. Finally, studies that measure fertility outcomes in patients with intravaginal compared to extravaginal (neonatal) torsion have yet to be performed. Extravaginal torsion occurs in fetuses and neonates when the testis, epididymis, and tunica vaginalis twist on the spermatic cord. This leads to degeneration and necrosis.<sup>85</sup> Intravaginal torsion, on the other hand, typically occurs in the peripubertal period, and is associated with the classical ‘bell-clapper deformity’. Attachment of the tunica vaginalis is high, and this leads to twisting of the spermatic cord.<sup>86</sup> One review article found lower rates of salvage for neonatal torsion compared to adolescent/pubertal torsion.<sup>87</sup> Additional research is needed to determine long-term fertility outcomes in these patients and identify any differences (Table 1).

### Conclusion

Pediatric urologic disease and the surgical procedures that correct them can have profound impact on sexual function and fertility in adulthood. Infertility and sexual dysfunction are multivariable entities, with etiologies both congenital and acquired. Simultaneously, there are conditions managed by pediatric urologists *via* surgical intervention that have potential impact on both sexual health and fertility. These procedures are often performed to preserve or restore sexual potential for a patient, whether it be ensuring adequate erectile and urethral form and function or a healthy endocrine axis with appropriately placed testes. There are also instances where the consequences of a necessary procedure can potentially alter sexual health for the worse, such as the removal of a necrotic testis. This review highlights the need for careful diagnosis and management of pediatric urologic conditions as common pediatric urologic conditions may impact the long-term sexual function of an individual after their pediatric urologic surgical encounter.



**Table 1.** Summary of common pediatric urology surgeries.

Procedure/Condition treated	Key findings
Chordee and penile curvature	<ul style="list-style-type: none"> <li>Length of follow-up may impact the true incidence of chordee and abnormal penile curvature.</li> <li>Surgical plication is the technique used for correction; however, more severe cases may require corporal grafting, corporal rotation, or penile disassembly.</li> <li>Multiple plication techniques have been used including plication alone, plication with excision or incision of tunica albuginea.</li> <li>Although penile length may be decreased after repair, erectile function and sensitivity has been shown to be unaltered even when more invasive surgical repair is needed.</li> <li>Penile length shortening may be avoided with the use of dermal grafts, and short-term data suggest sexual function may be preserved with this approach as well; however, long-term data are lacking.</li> <li>Limited studies look at fertility issues after chordee repair.</li> </ul>
Hypospadias	<ul style="list-style-type: none"> <li>Repair is based on severity and availability of urethral plate.</li> <li>Men who have undergone hypospadias repair had significantly shorter penises, but sexual satisfaction and libido appears to be normal in short-term studies; long-term data are lacking.</li> <li>Semen quality appears to be noninferior compared to controls in men treated for hypospadias.</li> <li>Delivery of ejaculate may be affected secondary to urethral stricture or diverticula formation post-operatively as well as inadequate spongiosum tissue, resulting in impaired ejaculation.</li> </ul>
Posterior urethral valves (PUV)	<ul style="list-style-type: none"> <li>Treated with valve ablation or with a more proximal urinary diversion <i>via</i> vesicostomy or ureterostomy. Men treated with valve ablation were not found to have affected ejaculatory function.</li> <li>Varying evidence is present regarding semen quality after repair, with some noting normal counts, volume, and viscosity, while others note abnormal agglutination and greater numbers of immotile sperm.</li> <li>There is a higher incidence of cryptorchidism in this patient population which may affect semen parameter.</li> <li>A large portion of patients with PUV have renal dysfunction which in itself can negatively affect erectile function. Only a minority of patients treated for PUV report erectile dysfunction but these studies do not specify renal function of these patients.</li> </ul>
Varicocele	<ul style="list-style-type: none"> <li>Surgical intervention indicated if testicular atrophy is evident (&gt;2 mL difference/20% volume difference)</li> <li>Early management of condition has been associated with higher paternity rates and shorter conception times compared to conservative management.</li> <li>Limited evidence is present on impact of varicocele repair and sexual function.</li> </ul>
Orchiopexy	<ul style="list-style-type: none"> <li>Conducted when children are found to have undescended testis or fixation of testicle in those with history of torsion.</li> <li>Infertility risk can be mitigated if repair of undescended testis occurs prior to 1 year of age.</li> <li>Early intervention improved germ cell per tubule count, a marker of fertility.</li> <li>Limited evidence is present on impact of orchiopexy repair and sexual function.</li> <li>Hormonal therapy to assist in descent is not currently recommended and may likely interfere with spermatogenesis. Limited data exist on its long-term effects.</li> </ul>
Torsion/Orchiectomy	<ul style="list-style-type: none"> <li>Used in management for children with testicular torsion.</li> <li>Varied evidence is seen regarding fertility: one study notes lower insemination rates and longer time to pregnancy when treated with orchiectomy <i>versus</i> orchiopexy for torsion, and another study notes no difference in paternity rates.</li> <li>Outside of the negative psychological impact that may be in men with a single testicle, hormone levels and sexual function do not appear to be compromised.</li> <li>Neonatal torsion was found to have lower rates of salvage compared to adolescent/pubertal torsion. No studies have been completed comparing the long-term fertility outcomes comparing these two.</li> </ul>

## Declarations

*Ethics approval and consent to participate*  
Not applicable.

*Consent for publication*  
Not applicable.

### Author contributions

**Alexandra Geada:** Project administration;  
Writing – original draft.

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**Ranjith Ramasamy:** Supervision; Writing –  
review & editing.

*Acknowledgement*  
None.

### Funding

The authors received no financial support for the  
research, authorship, and/or publication of this  
article.

### Competing interests

The authors declare that there is no conflict of  
interest.

*Availability of data and materials*  
Not applicable.

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