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Abstract

Background/Objective: Tarlov cysts or spinal perineurial cysts are uncommon lesions. These are mostly incidental findings on magnetic resonance imaging or myelograms. The objectives of this study were to describe Tarlov cysts of the sacral region as a potential cause for retrograde ejaculations and review available management options.

Methods: Case report and literature review.

Results: A 28-year-old man presented with back pain and retrograde ejaculations resulting in infertility. After microsurgical excision of large perineurial cysts, back pain resolved, but semen quality showed only marginal improvement. Later, the couple successfully conceived by intrauterine insemination. To the best of our knowledge, this is the first reported case of Tarlov cyst associated with retrograde ejaculation and infertility.

Conclusions: Despite being mostly asymptomatic and an incidental finding, Tarlov cyst is an important clinical entity because of its tendency to increase in size with time. Tarlov cysts of the sacral and cauda equina region may be a rare underlying cause in otherwise unexplained retrograde ejaculations and infertility. Microsurgical excision may be a good option in a select group of patients.

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Key Words: Tarlov's cysts; Retrograde ejaculation; Infertility; Surgical indications; Techniques

INTRODUCTION

The exact nature of spinal perineurial cysts was unclear until Isadore M. Tarlov published his studies in 1938 (1). Incidence is estimated at approximately 5% (2), but symptomatic cases are rare, constituting less than 1% of the total (3). Because of the low incidence of symptomatic cases, it is difficult to formulate clear operative indications. However, in the presence of severe symptoms, it may become necessary to provide a definitive answer. This case is an example in which Tarlov cysts of the sacrum were implicated as a cause of retrograde ejaculation and infertility. The case was managed by microsurgical excision of the cysts.

CASE REPORT

A 28-year-old man presented to an infertility clinic with a history of “dry” ejaculations and progressive low back pain for the past 2 years. He also noticed passing of cloudy urine after intercourse. The couple sought consultation for infertility, because they had been unable to conceive for 1.5 years. There was no medical history of diabetes mellitus, hypertension, recurrent chest infections, or any inguinoscrotal or retroperitoneal surgeries. There was no history of trauma to the testes, loss of libido, mumps, epididymo-orchitis, delayed or non-descent of testes, or testicular torsion. He did not have any headaches, visual field defects, anosmia, or gynecomastia and had never received chemoradiation. There was no history of any drug intake or exposure to toxins or history suggestive of varicocele or hydrocele. On general examination, body hair was normal in distribution with no gynecomastia. On local examination of the gonads, the urethral meatus was normal in location and size. There were no abdominal or inguinoscrotal scars. Both testes were normal in size and shape, and no tenderness was noted in the epididymis, spermatic cord, or testicles. Testicular sensations were intact bilaterally along with a

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normal vas deferens on both sides. No dilated veins or varicocele were seen in lying or standing position or after the Valsalva maneuver. No significant neurologic deficit was present apart from decreased perianal sensations in the S2/S3 dermatomes.

The initial clinical diagnosis of retrograde ejaculation was made, which was further confirmed by the high percentage of spermatozoa in the postmasturbatory urine sample with normal motility and morphology. Once the duplex ultrasound scan ruled out any blockage in the seminal vesicles or ejaculatory ducts, an endocrine evaluation comprising testosterone, luteinizing hormone (LH), and follicular-stimulating hormone (FSH) was undertaken. Laboratory assays showed normal values: testosterone, 18 nmol/L (reference range, 10–30 nmol/L); FSH, 6 U/L (reference range, 1.5–9.0 U/L); LH, 5.4 U/L (reference range, 1.5–9.0 U/L). Baseline blood studies showed normal hemoglobin (14.8 g/dL), white cell count (8,400/mm³), and blood glucose (6.2 mmol/L). Because of low clinical suspicion of any genetic abnormality, karyotyping was deemed unnecessary.

After excluding other possible etiologies, the cause of his infertility was attributed to retrograde ejaculations. The volume of antegrade ejaculation was typically very low (in the range of 0.1–0.5 mL). Laboratory analysis of the specimen showed a grossly subnormal concentration of spermatozoa (<2,000,000/mL). Motility and morphology were within normal limits, however, with more than 40% of spermatozoa showing Grade I and Grade II motility. More than 40% of the spermatozoa displayed normal forms. He further underwent a complete battery of studies to find the cause of his retrograde ejaculations. All possible causes were excluded, including diabetes mellitus, multiple sclerosis, drug side effects, etc. Pelvic magnetic resonance imaging (MRI) including the lumbosacral spine showed the presence of large cystic lesions in the sacral region. The patient was referred to the neurosurgical unit for further assessment.

An MRI showed 2 large cystic areas in the spinal canal of the S2 to S4 vertebrae (Figure 1a and b). The cysts were hypointense in T1-weighted images and hyperintense in T2-weighted sequences. The case was further discussed in a multidisciplinary meeting with neuroradiologists and spinal surgeons, and a diagnosis of perineurial cysts of the sacral nerve roots was made. Because of the presence of progressive signs and symptoms, it was decided to undertake microsurgical excision of the cysts. A wide decompressive laminectomy was performed from L1 to S4, and a cystic lesion in the area of the S2 to S4 vertebrae was identified (Figure 2). The cyst wall was opened and excised after dissection of the sacral nerve roots, which were displaced to one side by the cyst. Finally, the dural rent was repaired by primary closure. Histopathologic examination of the cyst wall showed the presence of peripheral nerve fibers confirming the diagnosis of Tarlov cysts.

After surgery, the back pain improved dramatically in a matter of 4 weeks. Follow-up in the fertility clinic at 6 months, however, showed no significant improvement in ejaculate volume, and sperm count and semen quality remained far below the optimal values required for natural conception. The couple successfully conceived after 1 year with the help of artificial insemination with sperm derived from the centrifugation of postmasturbatory urine. A follow-up MRI at 1 year after surgery showed no recurrence of cysts.

DISCUSSION

The first methodical description of perineurial cysts of the spinal region is credited to Isadore M. Tarlov during his postmortem study of filum terminale. At the time of initial discovery, the main differential diagnosis of these cysts remained meningeal diverticula and long arachnoid prolongations. Tarlov (1,4,5) distinguished among these lesions on the basis of 3 main features: (a) communication with the spinal subarachnoid space, (b) location in relation with dorsal root ganglion, and (c) histopathologic composition. Whereas meningeal diverticula and long arachnoid diverticula communicate freely with the spinal subarachnoid space, Tarlov cysts have only a potential communication. This difference in communication explains the delayed filling of Tarlov cysts in myelograms contrary to the rapid filling of the other 2 lesions. The second differentiating point was the location of these cysts (4). Tarlov cysts are mostly found at/or distal to the junction of the posterior nerve root and dorsal root ganglion in the sacral region. Meningeal diverticula, on the other hand, develop proximal to the dorsal root ganglion throughout the vertebral column. The third distinguishing feature was the histologic composition of these cysts. The wall of Tarlov cyst contains nerve fibers, whereas the meningeal diverticula have a wall lined by arachnoid mater with no evidence of a neural element. Most authors including Tarlov himself (1,4–9) agreed that the most important distinguishing feature of the perineurial cyst is the presence of nerve root fibers in the cyst wall.

In an attempt to clarify the matter further, Goyal et al (7) and Nabros et al (8) presented 2 simplified classification systems of spinal cysts. According to Goyal et al (7), Tarlov cysts or perineurial cysts are defined as cysts formed within the nerve root sheath at dorsal root ganglion. Nabros et al (8) classified spinal cysts in 3 types. Type I are extradural meningeal cysts without nerve root fibers. Type II lesions correspond to Tarlov cysts and are defined as extradural meningeal cysts with nerve fibers. Type III contains intradural meningeal cysts.

The exact etiology of sacral perineurial cysts remains a matter of debate, and different theories have been proposed. Tarlov himself believed that hemosiderin deposition caused by blockage of venous drainage of the perineurium and epineurium after local trauma leads to the development of these cysts (5). Fortura et al (10)

Figure 1. (a) T2-weighted sagittal section clearly showing the presence of 2 large cystic lesions at the level of the S2 to S4 vertebrae. The cysts are similar in intensity to CSF. (b) T2-weighted transverse section confirming the presence of Tarlov cysts in the sacral region.

proposed congenital arachnoid proliferation along the exiting nerve roots resulting in the formation of sacral perineurial cysts. Paulson et al (3) suggested the ball-valve mechanism whereby the cerebrospinal fluid (CSF) enters the cyst with systolic pulsations but is unable to exit through the same portal during diastole. The same theory is supported by Tanaka et al (6) and is thought to be the basis of positive filling defects in computed tomography (CT) myelograms and the increase in size of Tarlov cysts with time. The cyst wall is usually

composed of dense, paucicellular collagenous bundles along with well-vascularized loose fibrous tissues. The cysts are often multiple, extending around the circumference of the nerve root. Because of inherent tendency to enlarge with time, the cysts may compress the neighboring nerve roots and may cause bony erosion (6).

Tarlov (1) initially thought these cysts were entirely incidental and asymptomatic, but a decade later in 1948, he realized the causal relationship between the sacral perineurial cysts and sciatica after operating on a woman

Figure 2. Intraoperative photograph after laminectomy showing the Tarlov cysts in situ. The cysts were opened and excised after carefully dissecting off the neural element. The dural rent was repaired by primary closure.

with this condition. The most common location in the spine is the sacral region, with the S2/S3 nerve roots most commonly affected (11). The symptomatic Tarlov cysts are exceedingly rare (3), and only one fifth present clinically (3). Depending on size and location, Tarlov cysts may cause a variety of symptoms ranging from backache, perineal pain or sciatica (6), to frank cauda equina syndrome (12). Symptoms are mostly exacerbated by maneuvers that elevate CSF pressure, such as coughing, walking, changing posture, and the Valsalva maneuver (13). Exacerbation of symptoms after these maneuvers can be explained on the basis of CSF being forced into the cysts with increased spinal subarachnoid pressure (13). Because of close proximity to the dorsal root ganglion, they mostly produce sensory sign symptoms with normal motor nerve conduction (6). A

number of urologic symptoms are also described including dysuria, incontinence, and neurogenic bladder (2,6,14).

Retrograde ejaculation and infertility, never described before in relation to Tarlov cysts, nonetheless can be viewed in conjunction with the urologic symptoms. Normal antegrade ejaculation (15) requires coordinated contractions of the vas deferens and seminal vesicles to propel the semen into the prostatic urethra and closure of bladder neck to prevent backflow of semen. These 2 events occur under sympathetic control. Ejaculation is further assisted by parasympathetically (S2–S4) induced rhythmic contractions of the bulbospongiosus and ischiocavernosus muscles, which expel the semen through the urethral meatus. Common causes of retrograde ejaculation include prostatic surgeries and neuropathies in the elderly and retroperitoneal lymph node dissection (RLND) and spinal cord injury in young fertile men (15) (Table 1). Apparently, successful antegrade ejaculation is largely dependent on both sympathetic and parasympathetic drives. Sympathetic efferent nerves, which are responsible for maintaining the integrity of bladder neck, emerge from the T12 to T13 segments and pass to the bladder neck through the inferior hypogastric plexus (15). Any space-occupying lesion in the sacral region that involves this plexus may impair the bladder neck mechanism. The most common cause of retrograde ejaculation in RPLD is damage to these sympathetic efferent nerves (15). The parasympathetic component, which is responsible for contractions of the bulbospongiosus and ischiocavernosus muscles, stems from the S2 to S4 segments (15).

The absence of urinary incontinence in this patient can be explained on the basis of normal bladder anatomy and physiology. Urinary continence depends on a functioning of bladder neck, as well as the external urinary sphincter. The bladder neck is under sympathetic control delivered through the inferior hypogastric plexus,

Table 1. Different Etiologies for Retrograde Ejaculation

Common Causes			
Transurethral resection of prostate (TURP): overall most common cause (75%)			
Retroperitoneal lymph node dissection (RLND): most common cause in young fertile men			
Diabetes mellitus			
Idiopathic			
Bladder neck surgery (Y-V plasties)			
Other Causes			
Surgical	Drugs/toxins	Neuropathic	Congenital
Sympathectomy	Alcohol	Multiple sclerosis	Bladder neck incompetence
Aortoiliac surgery	Cocaine	Guillain-Barré syndrome	Congenital wide bladder neck
Abdomino-perineal resection of rectum	α blockers		Urethral strictures (traumatic)
Other prostatic surgeries	Antihypertensives		Posterior urethral valves
	Antipsychotics		Spina bifida
	Antidepressants		

Table 2. Common Causes of Oligospermia

Childhood	Past Medical Problems	Familial
Undescended testes	Diabetes mellitus	Klinefelter syndrome
Maldescended testes	Inguinoscrotal surgery	Cystic fibrosis
Testicular torsion	Pelvic trauma	Young syndrome
Mumps orchitis	Retroperitoneal surgery	Immotile-cilia syndrome (Kartagener syndrome)
Y-V plasty of bladder neck	Multiple sclerosis	Adrenal hyperplasia
Testicular trauma	Testicular tumours	Androgen-receptor deficiency (Reifenstein syndrome)
Delayed onset puberty		
Infections	Gonadotoxins/Drugs	Miscellaneous
Venereal diseases	Chemotherapy	Prolonged thermal exposure
Tuberculosis	Radiotherapy	Varicocele
HIV/AIDS	Environmental toxins	Hypopituitarism
Epididymo-orchitis	(dibromochloropropane)	Pituitary tumours
Viral	Drugs eg,	Poor sample techniques
	Sulfasalazine	Improper preservation
	Cimetidine	
	Nitrofurantoin	
	Anabolic steroids	
	Spermicidal jellies	
	Alcohol	
	Smoking	
	Cocaine	

From Ref. 17.

whereas the external urinary sphincter is parasympathetically controlled, supplied by the pudendal nerve. The ejaculatory ducts open in the prostatic urethra, lying between the bladder neck and the external sphincter (16). If pathology selectively involves the inferior hypogastric nerves interfering with the normal bladder neck integrity but leaving the external urinary sphincter intact, retrograde ejaculation can occur without urinary incontinence.

Poor semen quality or oligospermia is not a classical feature of Tarlov cysts. Even in the presence of Tarlov cysts, careful exclusion of other common causes of oligospermia is mandatory before attributing Tarlov cysts as a potential underlying etiologic factor. The common causes of oligospermia are given in Table 2 (17). However, in the absence of any other identified cause, we hypothesize that Tarlov cysts can be a potential underlying cause for retrograde ejaculation as in this case. Semen quantity and quality were severely compromised, because most of the semen was being retropulsed to the bladder at the time of ejaculation.

Spinal perineurial cysts warrant a thorough work-up to determine the exact location, size, relationship with spinal nerve roots, and multiplicity. Plain radiographs and CT scans can be useful in picking up the underlying bony erosions. Contrast-enhanced myelograms give a characteristic appearance of delayed filling of Tarlov cysts with contrast medium (5,18) and can be particularly useful in differentiating Tarlov cysts from other meningeal diver-

ticula (5). A positive filling-defect sign can also be shown as described by Tanaka et al (6). Because of better soft tissue resolution, MRI is the preferred imaging method (3). In MRI, Tarlov cysts show CSF-like characteristics and therefore are hypointense in T1-weighted images and hyperintense in T2-weighted sequences.

The natural history of symptomatic Tarlov cysts is progressive enlargement and eventually clinical deterioration. The ball-valve mechanism has been proposed as an underlying factor responsible for the enlargement of these cysts (5,19–21). Mummaneni et al (13) recommended a conservative trial in patients presenting with radicular pain alone. Medical management should consist of analgesics, anti-inflammatory medications, and physiotherapy. Surgery can be avoided in individuals who respond to conservative measures. Active management should be offered to patients who fail to respond to medical management or who develop new symptoms. The active management plan can broadly be divided into nonsurgical and surgical methods. Drainage of CSF either by a permanent lumboperitoneal shunt (19) or percutaneous CT-guided aspiration (3) have been tried with variable results but have not been approved universally. Recurrence within a few months remains the rule in most patients after CT-guided aspiration (3). Mixed results were obtained with CT-guided instillation of fibrin glue into recurrent cysts. However, because of high rates of aseptic meningitis associated with the procedure, it is not usually recommended (22).

Appropriate patient selection remains the mainstay of surgical treatment in sacral perineurial cysts. To choose the right surgical candidate, the basic approach is to decide whether the symptoms can be attributed to the cyst in the first place. The chances of cure will obviously be higher when a definitive causal relationship can be established. The neurosurgical techniques used for the treatment of Tarlov cysts include bony decompression alone, cautery of the cyst wall, complete excision of the cyst along with the nerve root involved, cyst fenestration, and imbrication or oversewing of the cyst wall (5,6,8,20,23–25). Tarlov proposed the excision of cysts along with the involved nerve root. The morbidity produced by the procedure, however, is high enough not to justify its use (24,25). Simple decompressive laminectomy has a low success rate (24).

It has been observed that some symptoms respond better to surgical excision than others. Coccydynia, dyspareunia, perineal pain, and urinary symptoms are claimed to be specifically curable by Tanaka et al (6). In contrast, they found sciatica and lumbago poorly relieved by surgery. However, quite the contrary, some authors including Tarlov himself (2,9,14) found backache and sciatica resolving quickly after surgery, whereas urinary symptoms showing only partial improvement. Voyadzis et al (26) suggested that the surgical excision of symptomatic Tarlov cysts more than 1.5 cm in diameter carries a favorable prognosis. Tanaka et al (6) also proposed large cyst size and a positive filling defect on myelography as indicators of good surgical outcome. Mummaneni et al (13) proposed that patients whose symptoms are exacerbated by postural changes or Valsalva maneuvers are more likely to benefit from microsurgery. However, there is some controversy regarding the surgical results for different symptoms. We found that, as cysts have an the inherent property of enlargement with time (5,6,19–21), it is reasonable to operate on patients presenting with progressive symptoms. Surgical indications are obviously less clear in cases such as cauda equina. Because some authors report partial resolution of urologic symptoms with time (2,14), we suggest that these cases should have a surgical consultation sooner than later. Retrograde ejaculation and infertility may be the rare presentations of sacral Tarlov cyst of the cauda equina region; it is difficult to draw conclusions regarding outcomes based on a single case. Even after surgery, the sperm count and the seminal volume remained far lower than the optimal values required for natural conception (27), ultimately necessitating assisted fertilization.

Two techniques of laminectomy have been described by Tanaka et al (6): recapping laminectomy and simple laminectomy. Mummaneni et al (13) recommended microsurgical cyst fenestration and imbrication as effective treatment. Imbrication of cyst wall is preferred over a total excision because the latter has a high risk of neural damage (6). After exposing the sacral nerve roots by

laminectomy, the cysts can be fenestrated with a scalpel to drain the fluid contents. It has been observed (13) that the nerve roots are mostly located ventrally or laterally to cyst rather than dorsally within the cyst. Microdissection should be used to push any dorsally positioned nerve root fibers into the floor of the foramen.

Intraoperative physiologic monitoring can be a useful adjunct at this stage in minimizing damage to the neural tissue (13). The nerve root sleeve can be imbricated, followed by a watertight dural closure. The need for a watertight dural closure is emphasized by most authors. It can be achieved by a primary dural closure using a fine nonabsorbable suture, as in our case, or by dural grafts. The closure can further be reinforced with epidural fat or muscle grafts and fibrin glue application (13). The muscle or fat graft can also prevent CSF reaccumulation within the cysts by creating a mechanical pressure (13). Mummaneni et al (13) recommended the use of postoperative lumbar drains in patients who showed communication between the cyst and spinal subarachnoid space in CT myelograms. Tanaka et al (6) achieved very good results with a success rate of 83% by using imbrication and resection of cysts. Radicular pain was markedly improved in 50% of the patients in the series of Mummaneni et al (13). The remainder of the patients also showed moderate symptomatic relief but still needed analgesics for pain control.

Whereas a spinal perineurial cyst predominantly remains an incidental finding, because of its tendency to enlarge with time, patients should be informed of the possibility of developing symptoms later in life. However, that does not mean that all Tarlov cysts should be monitored; if the patient becomes symptomatic, imaging should be repeated at appropriate intervals. After an MRI, a CT myelogram should be performed to confirm the communication between the cyst and subarachnoid space and the filling-defect sign. In the light of good surgical results, early microsurgical resection should be considered, especially in patients with progressive symptoms. A surgical decision should be based on symptomatic progression, cyst size of more than 1.5 cm, and a positive filling-defect sign in myelography. Patients showing exacerbation of symptoms after Valsalva maneuver are also good surgical candidates. Electrophysiologic monitoring is imperative in minimizing the damage to sacral nerve roots. Sperm retrieval from postcoital urine is an excellent and relatively inexpensive technique to assist conception in couples facing problems caused by retrograde ejaculation.

CONCLUSION

Most Tarlov cysts are discovered incidentally and are asymptomatic in nature. However, because of their natural tendency to increase in size with time, they may become symptomatic later in life. Unexplained retrograde ejaculations in an otherwise healthy man deserve detailed work-up, as shown by this case. Microsurgical

excision may benefit patients with progressive symptoms caused by Tarlov cysts.

REFERENCES

1. Tarlov IM. Perineurial cysts of the spinal nerve roots. *Arch Neurol Psychiatry*. 1938;40:1067–1074.
2. Kumpers P, Wiesemann E, Becker H, Haubitz B, Dengler R, Zermann DH. [Sacral nerve root cysts—a rare cause of bladder dysfunction. Case report and review of the literature]. (German) *Aktuelle Urol*. 2006;37:372–375.
3. Paulsen RD, Call GA, Murtagh FR. Prevalence and percutaneous drainage of cysts of the sacral nerve root sheath (Tarlov cysts). *AJNR Am J Neuroradiol*. 1994;15:293–299.
4. Tarlov IM. Cysts of the sacral nerve roots; clinical significance and pathogenesis. *AMA Arch Neurol Psychiatry*. 1952;68:94–108.
5. Tarlov IM. Spinal perineurial and meningeal cysts. *J Neurol Neurosurg Psychiatry*. 1970;33:833–843.
6. Tanaka M, Nakahara S, Ito Y, et al. Surgical results of sacral perineurial (Tarlov) cysts. *Acta Med Okayama*. 2006;60:65–70.
7. Goyal RN, Russell NA, Benoit BG, Belanger JM. Intraspinal cysts: a classification and literature review. *Spine*. 1987;12:209–213.
8. Nabors MW, Pait TG, Byrd EB, et al. Updated assessment and current classification of spinal meningeal cysts. *J Neurosurg*. 1988;68:366–377.
9. Tarlov IM. Cysts (perineural) of the sacral roots: another cause (removable) of sciatic pain. *JAMA*. 1948;138:740–744.
10. Fortuna A, La Torre E, Ciappetta P. Arachnoid diverticula: a unitary approach to spinal cysts communicating with the subarachnoid space. *Acta Neurochir (Wien)*. 1977;39:259–268.
11. Seaman WB, Furlow LT. The myelographic appearance of sacral cysts. *J Neurosurg*. 1956;13:88–94.
12. Nicpon KW, Lasek W, Chyczewska A. [Cauda equina syndrome caused by Tarlov's cysts—case report]. *Neurol Neurochir Pol*. 2002;36:181–189.
13. Mummaneni PV, Pitts LH, McCormack BM, Corroo JM, Weinstein PR. Microsurgical treatment of symptomatic sacral Tarlov cysts. *Neurosurgery*. 2000;47:74–79.
14. Shinomiya K, Mutoh N, Furuya K. Giant sacral cysts with neurogenic bladder. *J Spinal Disord*. 1994;7:444–448.
15. Kamischke A, Nieschlag E. Treatment of retrograde ejaculation and anejaculation. *Hum Reprod Update*. 1999;5:448–474.
16. Wolters JP, Hellstrom WJ. Current concepts in ejaculatory dysfunction. *Rev Urol*. 2006;8(suppl 4):S18–S25.
17. Herling R, Lee RD, Lipshultz LI. Evaluation of the infertile male. In: Proyor JP, Lipshultz LI, eds. *Andrology*. 1st ed. London, UK: Butterworths; 1987:243–246.
18. Schreiber F, Haddad B. Lumbar and sacral cysts causing pain. *J Neurosurg*. 1951;8:504–509.
19. Bartels RH, van Overbeeke JJ. Lumbar cerebrospinal fluid drainage for symptomatic sacral nerve root cysts: an adjuvant diagnostic procedure and/or alternative treatment? Technical case report. *Neurosurgery*. 1997;40:861–865.
20. Rodziewicz GS, Kaufman B, Spetzler RF. Diagnosis of sacral perineurial cysts by nuclear magnetic resonance. *Surg Neurol*. 1984;22:50–52.
21. Strully KJ. Meningeal diverticula of sacral nerve roots (perineurial cysts). *JAMA*. 1956;161:1147–1152.
22. Patel MR, Louie W, Rachlin J. Percutaneous fibrin glue therapy of meningeal cysts of the sacral spine. *AJR Am J Roentgenol*. 1997;168:367–370.
23. Siqueira EB, Schaffer L, Kranzler LI, Gan J. CT characteristics of sacral perineurial cysts. Report of two cases. *J Neurosurg*. 1984;61:596–598.
24. Caspar W, Papavero L, Nabhan A, Loew C, Ahlhelm F. Microsurgical excision of symptomatic sacral perineurial cysts: a study of 15 cases. *Surg Neurol*. 2003;59:101–106.
25. Wilkins RH. Prevalence and percutaneous drainage of cysts of the sacral nerve root sheath (Tarlov cysts). *AJNR Am J Neuroradiol*. 1994;15:298–299.
26. Voyadzis JM, Bhargava P, Henderson FC. Tarlov cysts: a study of 10 cases with review of the literature. *J Neurosurg*. 2001;95:25–32.
27. World Health Organization (WHO). *WHO Laboratory Manual for the Examination of Human Semen and Sperm-Cervical Mucus Interactions*. 3rd ed. Cambridge, UK: Cambridge University Press; 1992.