**Tarlov cysts: a controversial lesion of the sacral spine**

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The primary aim of our study was to provide a comprehensive review of the clinical, imaging, and histopathological features of Tarlov cysts (TCs) and to report operative and nonoperative management strategies in patients with sacral TCs. A literature review was performed to identify articles that reported surgical and nonsurgical management of TCs over the last 10 years. Tarlov cysts are often incidental lesions found in the spine and do not require surgical intervention in the great majority of cases. When TCs are symptomatic, the typical clinical presentation includes back pain, coccyx pain, low radicular pain, bowel/bladder dysfunction, leg weakness, and sexual dysfunction. Tarlov cysts may be revealed by MR and CT imaging of the lumbosacral spine and must be meticulously differentiated from other overlapping spinal pathological entities. They are typically benign, asymptomatic lesions that can simply be monitored. To date, no consensus exists about the best surgical strategy to use when indicated. The authors report and discuss various surgical strategies including posterior decompression, cyst wall resection, CT-guided needle aspiration with intralesional fibrin injection, and shunting. In operative patients, the rates of short-term and long-term improvement in clinical symptoms are not clear. Although neurological deficit frequently improves after surgical treatment of TC, pain is less likely to do so. (DOI: 10.3171/2011.9.FOCUS11221)

**Key Words**
- Tarlov cyst
- sacral perineural cyst
- spine
- incidental finding
- surgery

Due to the wide availability of imaging, incidental lesions are increasingly found in patients undergoing neuroimaging studies. Tarlov cysts frequently present as multiple cystic lesions of the nerve root sheath in the lower spine. The first report of a TC was made by Tarlov in 1938 as an incidental finding at autopsy, and the lesion was subsequently classified as a Type II meningeal cyst by Nabors et al. Tarlov cysts are typically located at the junction of the dorsal ganglion and the posterior nerve root and usually develop between the endoneurium and perineurium of the nerve root. Although the etiology is still unclear, microcommunication with the subarachnoid space at the dural sleeve of the nerve root may function as a valve, allowing CSF influx and restricting CSF efflux, causing formation of the cysts.

We focus on a particular incidental lesion of the lumbosacral spine: sacral perineural (Tarlov) cysts. Tarlov cysts are rare lesions. According to the findings of previous studies, the lesions occur in about 1%–5% of patients. Depending on their location, size, and relationship to the nerve roots, a subset of cysts may become symptomatic and cause sensory disturbances, motor deficits, or bowel/bladder dysfunction. This occurs in approximately 1% of patients. The clinical significance of this lesion must be meticulously assessed before planning surgical treatment. There is no consensus on the best treatment of symptomatic sacral cysts, although various surgical strategies have been proposed.

Our goal is to provide a review focusing on the more commonly located sacral TC. The definition of a TC, as well as the clinical and operative management of this small subset of symptomatic cysts, is analyzed.

**Methods**

A thorough search of the PubMed database for English-language literature concerning sacral perineural cysts was conducted for the years 2000–2011. Studies were limited to this time period to emphasize the most current data. Search terms used were Tarlov cyst(s), perineural cyst(s), and sacral nerve root cyst(s). The bibliography of each article was reviewed for additional relevant articles. Each article was carefully analyzed and included in our study if details of treatment and outcome were reported. Pathogenesis, pathology, clinical presentation, neuroimaging, treatment options, and surgical indications were reviewed. In addition, case reports were included in this study to describe as many different treatment options as possible.

**Results**

Twelve studies published in the last 10 years were...
identified, each reporting treatment of more than 1 patient with a TC. After review of these 12 articles, 1 other relevant study was identified and included in the analysis. From these studies, a combined total of 251 patients were treated for symptomatic TCs. Data related to these series (>2 patients/series) are summarized in Table 1. Table 2 summarizes the 11 single case reports of TC treatment to provide further insight into the surgical management of these lesions.

**Discussion**

In the practice of medicine, it is common to discover an incidental lesion, which is an asymptomatic lesion found while examining the patient for reasons unrelated to the incidentally found lesion. In many hospitals, the introduction of the picture archiving and communication system has led to an increasing number of incidental lesion discoveries. Patients now undergo MR imaging of the lumbar spine for various symptoms including back pain, sciatica, and neurological dysfunction. These MR imaging studies of the lumbosacral spine often result in pain, sciatica, and neurological dysfunction. These MR imaging studies of the lumbosacral spine often result in the discovery of benign lesions. The most common incidental lumbar lesions are vertebral hemangiomas, perineural cysts, fibrolipommas, synovial cysts, and sacral meningoceles.

One recent report indicates an 8.4% rate of incidental findings on lumbar spine MR imaging for suspected disc herniation or lumbar stenosis. The prevalence of different incidental findings in the lumbosacral spine seems to vary significantly for age and sex. Some authors describe a 1%–5% incidence of TCs (Table 3). The incidence does not significantly differ between sexes but is more prevalent in younger people: 4.0% in people less than 50 years of age old versus 1.3% in people greater than 50 years of age.

**Definition, Anatomy, Pathophysiology, and Histology**

After the first report by Tarlov in 1938 as an incidental finding at autopsy, several authors described different types of spinal cysts. Spinal meningeal cysts have been recently classified by Nabors et al. into 3 different types: Type I (extradural meningeal cysts without spinal nerve root fibers); Type II (extradural meningeal cysts with spinal nerve root fibers [that is, TCs]); and Type III (spinal intradural meningeal cysts).

Regardless of the classification system, the definition of a TC is histopathological, because it requires the presence of spinal nerve root fibers in the wall of the cyst or in its cavity. Tarlov cysts are defined as CSF-filled sacular lesions located in the extradural space of the sacral spinal canal and are formed within the nerve root sheath at the dorsal root ganglion. Cyst walls are composed of perineurium and neural tissue. The cysts show membranous tissue walls, with peripheral nerve fibers and ganglionic cells embedded into connective tissue. Voyadzis et al. found nerve fibers in the walls of the cysts in 75% of their cases.

Cysts created by the dilated sheaths usually have microconnections to the subarachnoid space. However, when pulsatile and hydrodynamic forces of CSF, through a ball-valve mechanism, cause these perineural cysts to fill and expand in size, they can begin to compress neighboring nerve fibers, resulting in neurological symptoms. The ball-valve theory has been previously postulated as the reason why some large TCs cause symptoms that progress, whereas others cause only mild symptoms. The so-called un-valved cysts (that is, those in which

**TABLE 1: Literature review of series in which patient were surgically treated for TCs**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Patients</th>
<th>Follow-Up (mos)</th>
<th>Surgical Technique</th>
<th>% w/ Symptom Improvement</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caspar et al., 2003</td>
<td>15</td>
<td>6–108</td>
<td>SL + CR</td>
<td>87</td>
<td>none</td>
</tr>
<tr>
<td>Guo et al., 2007</td>
<td>11</td>
<td>3–156</td>
<td>SL + CR + CI + FG + MP + Gelfoam</td>
<td>82</td>
<td>CSF leak, bladder dysfunction</td>
</tr>
<tr>
<td>Kunz et al., 1999</td>
<td>8</td>
<td>24–96</td>
<td>NA</td>
<td>38</td>
<td>NA</td>
</tr>
<tr>
<td>Langdown et al., 2005</td>
<td>3</td>
<td>6–12</td>
<td>SL + CR + MP</td>
<td>100</td>
<td>CSF leak, cauda syndrome by MP displacement</td>
</tr>
<tr>
<td>Lee et al., 2004</td>
<td>2</td>
<td>6</td>
<td>1) CT-NA; 2) SL + CR + NL + CI</td>
<td>100</td>
<td>none</td>
</tr>
<tr>
<td>Mummaneni et al., 2000</td>
<td>8</td>
<td>1–73</td>
<td>SL + CF + CI</td>
<td>88</td>
<td>none</td>
</tr>
<tr>
<td>Murphy et al., 2011</td>
<td>122</td>
<td>NA</td>
<td>1) CT-NA &amp; FI; 2) SL + CF + FP</td>
<td>1) 65†; 2) 63</td>
<td>transient urticaria</td>
</tr>
<tr>
<td>Neulen et al., 2011</td>
<td>13</td>
<td>2.5–20</td>
<td>SL + CF + CR</td>
<td>54‡</td>
<td>CSF leak</td>
</tr>
<tr>
<td>Park et al., 2008</td>
<td>2</td>
<td>NA</td>
<td>SL + CR + FG + Gelfoam</td>
<td>100</td>
<td>none</td>
</tr>
<tr>
<td>Sajko et al., 2006</td>
<td>3</td>
<td>NA</td>
<td>CF + FG</td>
<td>100</td>
<td>none</td>
</tr>
<tr>
<td>Tanaka et al., 2006</td>
<td>12</td>
<td>6–52</td>
<td>SL + CR + CI</td>
<td>71</td>
<td>prostatitis, PF bleeding</td>
</tr>
<tr>
<td>Voyadzis et al., 2001</td>
<td>10</td>
<td>3–136</td>
<td>SL + CR + NL + FG + Gelfoam</td>
<td>70</td>
<td>urinary incontinence</td>
</tr>
<tr>
<td>Zhang et al., 2007</td>
<td>31</td>
<td>10–28</td>
<td>CT-NA &amp; FI</td>
<td>80</td>
<td>fever, headache</td>
</tr>
</tbody>
</table>

* CF = cyst fenestration; CI = cyst imbrication; CR = cyst resection; CT-NA & FI = CT-guided needle aspiration and fibrin injection; FG = fibrin glue; FP = fat packing; MP = muscle patch; NA = not available; NL = (cyst) neck ligation; PF = posterior fossa; SL = sacral laminectomy.
† In 23% of improved patients, symptoms returned on average 7.3 months following the initial procedure.
‡ Includes 1 patient with initial improvement and pain relapse 2 months after surgery.
**Tarlov cysts**

CSF can freely circulate in and out are unlikely to cause symptoms. On the other hand, lesions in which CSF accumulates under gravitational pressure within the cyst in a valve-like way enlarge over time and can cause neural structure compression. The cysts are often multiple and can erode surrounding sacral bone structures, causing irritation of the periosteal pain fibers and insufficiency fractures.1,6

Several hypotheses have been proposed to explain the etiologies of perineural cysts in the sacral region. The most important ones include inflammation of nerve root cysts followed by inoculation of fluid, arachnoidal proliferation along and around the sacral nerve root, breakage of venous drainage in the perineurium and epineurium secondary to hemosiderin deposition after trauma, and developmental or congenital origin.6,18,33 Some authors have reported a 40% rate of association with trauma.22 The presence of nerve fibers, ganglionic cells, or signs of old microhemorrhages in the form of hemosiderin has been related to fact that TCs may be in different stages of evolution.23,33

Based on their observations of 2 surgically treated cases of symptomatic sacral TCs in one family, Park et al.24 suggested that a genetic origin could be an important factor involved in the pathogenesis of TCs.

**Clinical Presentation**

Most people with TCs are asymptomatic. The reported incidence of symptomatic TCs is approximately 1% or less (Table 3).14,22,26 The clinical presentation of symptomatic cysts is nonspecific and similar to other disc or lumbar spine pathological entities. Symptoms that can be correlated to TCs include low-back pain, sacroccygeal pain, perineal pain, sacral nerve root pain (sciatic pain), leg weakness, neurogenic claudication, bowel and bladder dysfunction, and sexual dysfunction.1,6,35 The onset of symptoms can be sudden or gradual. Usually, patients report that their symptoms are exacerbated by coughing, standing, and change of position. This can be explained by the increase in CSF pressure, leading to an activation of the aforementioned ball-valve mechanism. Symptomatic relief can usually be achieved by recumbent positioning.

**Neuroimaging**

Magnetic resonance imaging is the gold-standard modality to detect sacral perineural cysts, to study their relationship with surrounding structures, and to plan surgical treatment (when indicated). On MR imaging, the cyst is a fluid-filled lesion showing a low signal on T1-weighted images and high signal on T2-weighted images (that is, CSF signal) (Fig. 1). Scalloping of the sacral vertebral body or posterior arches, caused by a slow increase in size of the cysts, can be seen on both MR and CT images. Computed tomography scans can also be useful for the treatment of the cysts by percutaneous aspiration, as has been reported.15,19,26 Plain radiographs usually appear normal, but they may reveal characteristic bone erosion of the spinal canal or neural foramina.

Myelography is a more invasive imaging modality that can have a role in detecting communication of the TC with the subarachnoid space. The communication between the thecal sac and cysts functions as a valve. Thus, a delayed filling after intrathecal contrast administration helps to determine the “valved cysts,” which are more likely to produce symptoms.

**Surgical Indications and Treatment Options**

Because TCs are often incidental, the finding can lead to 3 different diagnostic options: 1) another pathology is causing symptoms (that is, the TC is not related to symptoms); 2) another pathology is probably causing symptoms, but the TC could be a secondary cause of the symptoms; or 3) the TC is the only pathological finding that can explain the symptoms. Obviously, this requires

### TABLE 2: Case reports of surgically treated TCs

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Follow-Up (mos)</th>
<th>Surgical Technique</th>
<th>Symptoms Improvement</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acosta et al., 2003</td>
<td>3</td>
<td>SL + CF + CR; FG + myofascial flap</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Chaiyabud &amp; Suwanprateep, 2006</td>
<td>9</td>
<td>SL + CF</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Hsu &amp; Kuo, 2010</td>
<td>0.3</td>
<td>NL + FG + fat</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Ishi et al., 2007</td>
<td>NA</td>
<td>SL + NL + root section</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Kayali et al., 2003</td>
<td>3</td>
<td>SL + CF + CI</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Jain et al., 2002</td>
<td>NA</td>
<td>SL + CR</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Ju et al., 2009</td>
<td>6</td>
<td>cyst-subarachnoid shunt</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Landers &amp; Seex, 2002</td>
<td>6</td>
<td>CT-NA + SL + CI + FG</td>
<td>yes</td>
<td>meningocoele</td>
</tr>
<tr>
<td>Morio et al., 2001</td>
<td>24</td>
<td>cyst-subarachnoid shunt</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Prashad et al., 2007</td>
<td>9</td>
<td>SL + CR + CF</td>
<td>yes</td>
<td>none</td>
</tr>
<tr>
<td>Singh et al., 2009</td>
<td>12</td>
<td>SL + CR</td>
<td>yes</td>
<td>none</td>
</tr>
</tbody>
</table>

### TABLE 3: Incidence of TCs in patients undergoing MR imaging for lumbosacral symptoms

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Patients</th>
<th>Incidence of TC (%)</th>
<th>Incidence of Symptomatic TC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paulsen et al., 1994</td>
<td>500</td>
<td>23 (4.6)</td>
<td>5 (1.0)</td>
</tr>
<tr>
<td>Langdown et al., 2005</td>
<td>3535</td>
<td>54 (1.5)</td>
<td>7 (0.2)</td>
</tr>
<tr>
<td>Park et al., 2011</td>
<td>1268</td>
<td>27 (2.1)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>
one to carefully evaluate the correlation between clinical and radiological findings.

In Option 1, the main goal is treatment of the primary cause. Some authors have reported cases related to Option 2, in which TCs can contribute to symptoms by virtue of their anatomical location, but they cannot be considered the primary cause because patients have other identified pathology. In those cases, surgical treatment of the associated problem (for example, disc prolapse or foraminal stenosis) can lead to symptomatic improvement.

If the first 2 options can be excluded and the TC is considered the cause of patient’s symptoms, treatment of the cyst is indicated. However, no consensus has been reached on the ideal treatment modality. There are very little published data regarding the natural history of TCs. Moreover, none of the available studies report significant numbers, and there seems to be no clearly defined criteria for surgical or conservative management of symptomatic TCs.

Conservative treatment, including medical therapy (with analgesic and nonsteroidal antiinflammatory medications) and physical therapy, is suggested as a first option. Mitra et al. described 2 cases of symptomatic perineural cysts treated with conservative management.

Symptomatic relief was obtained with oral steroids in a patient with a cervical (C-6) perineural cyst and in a patient with an L-5 perineural cyst, also obtaining in the latter case shrinkage of the cyst after epidural steroid injections. Langdown et al. reported on 3 patients with symptomatic TCs who refused surgery and were able to tolerate their fluctuating symptoms. They did not describe the alternative treatment recommended to these patients, but in a median radiological follow-up of 3.3 years, no changes in cyst features were documented.

Reports in the literature thus far on different surgical options for TC can be divided in 2 subgroups: 1) diversion of CSF flow (CT-guided percutaneous aspiration and modifications, lumboperitoneal shunt, or cysto/subarachnoid shunt); or 2) direct microsurgical approach.

The first reports on a percutaneous CT-guided sacral meningeal cyst aspiration described this technique as a potential treatment to alleviate symptoms, but complications such as the tendency of the cysts to reaccumulate fluid and cause symptoms were noted. Subsequently, some authors suggested the use of percutaneous CT-guided fibrin glue injections in sacral meningeal cysts, reporting no recurrence of the cyst after 6 months, but there were 3 (of 4) cases of postprocedural aseptic meningitis. In a more recent study of 31 patients treated with CT-guided percutaneous fibrin glue injections with or without previous cyst aspiration, the authors described an 80% symptom improvement. There was statistically significant back and leg pain reduction and no recurrence of the treated cysts for during a mean follow-up of 23 months. Two cases of transitory aseptic meningitis were reported. Murphy et al. retrospectively described a larger series of 122 patients treated by CT-guided fibrin glue cyst injection. This group showed symptomatic improvement in 65% of patients, 23% experienced symptom recurrence after 7 months. The authors recommended percutaneous CT-guided aspiration of the cyst and fibrin glue injection as a first treatment option, reserving open surgery only for patients not candidates for aspiration or for patients in whom this technique was unable to improve symptoms.

Assuming that a slit-like communication exists between the subarachnoid space and the cyst, functioning as a valve, pressure waves can enhance enlargement of the cyst. Thus, surgical strategies have been proposed with the aim of decreasing CSF pressure of the cephalad thecal sac. Lumboperitoneal shunt implant after a CSF lumbar drainage test has been proposed as a surgical option to lessen the hydrostatic pressure and dampen the CSF pressure waves, decreasing the pressure within the sacral nerve root cyst, as well as compression of the adjacent nerve root. Bartels and van Overbeeke reported on 2 patients suffering from back/leg pain treated with a lumboperitoneal shunt. Symptom relief was achieved at a median of 10 months after shunt insertion. This option has been suggested for patients with multiple TCs, when it is difficult to determine which one is symptomatic. Its advantage is also that it avoids direct manipulation of the cyst by requiring a more technically demanding surgical procedure; however, the risks of every shunt procedure, such as malfunction or infection, are present. In 2 single case reports, the patients underwent placement of cys-
Tarlov cysts

tosubarachnoid shunts. These systems were implanted following a direct surgical approach, aiming to equalize the pressure between the thecal sac and the cyst but avoiding the risk of cyst wall resection and potential neurological sequelae. The authors reported relief of symptoms without complication (Table 2).

Although some authors have not described good results in association with direct surgical treatment, several authors have recommended it for selected symptomatic patients. Numerous strategies of direct surgical approaches have been proposed (Table 1). Simple posterior sacral bony decompression has low success rates and can have serious complications, such as dural or nerve lesions. Microsurgical excision consists of a sacral laminectomy or laminoplasty followed by microsurgical resection of the wall of the cyst(s). Care must be taken in preserving nervous fibers of the parental nerve roots, which lie directly on the walls of the cyst. Procedures including cyst imbrication by suturing the walls of the cyst, neck ligation to close communication of the cyst with the subarachnoid space; and cyst fenestration allowing free communication of the CSF between the thecal sac and the cyst have been suggested as different technical options. Some authors have proposed excising the cyst and sacrificing the parental root without significant neurological deficit.

Absorbable gelatin sponge and/or fibrin glue and muscle or fat patching can be used to fill the cyst cavity and cover the dural defects. Neurological worsening due to muscle patch displacement and subsequent cauda equina syndrome has been reported. Leakage of CSF has been a reported complication in 1 of 11 patients reported by Guo et al., 1 of 3 by Langdown et al., and 1 of 13 by Neulen et al. Prolonged lumbar drainage is the suggested treatment for CSF leakage. Some authors have recommended routine postoperative lumbar drainage for 3–7 days to prevent CSF leakage as well as the use of intraoperative electrophysiological monitoring to minimize damage to the sacral nerve roots during excision.

Despite low rates of cyst recurrence (range 0%–10%), different rates of symptomatic improvement have been reported in association with microsurgical treatment (Table 1), varying from 38% to 100%. These results should also be correlated to the patient’s preoperative symptoms. Caspar et al. noted an improvement in 87% of patients complaining of radicular pain, 90% of patients with sensory disturbances, and 100% of patients with a motor deficit or bowel/bladder dysfunction. Neulen et al. suggested that radicular symptoms are less likely to benefit from surgery, probably because of the permanent impairment of the nerve itself, resulting in chronic pain due to deafferentation.

In statistical terms, the numbers in the present report are too small to draw any definitive conclusions. However, several authors have suggested some indications to identify the better responder to surgical treatment. Voyadzis et al. observed that better results were achieved in patients with radicular symptoms or bladder/bowel dysfunction, and patient with cyst diameters exceeding 1.5 cm. Surgical treatment of multiple cysts, especially those larger than 1.5 cm, has been suggested. Neulen et al. suggested that a tendency to improve after surgery was present in patients with single or multiple perineural cysts > 1 cm in diameter and with delayed contrast filling on postmyelographic CT scanning. Patients who present with pain exacerbated by both postural changes and Valsalva maneuvers are also likely to benefit most from surgery.

To our knowledge, only 1 study has reported on the results of surgical treatment compared with conservative management. Kunz et al. did not observe significant differences in terms of symptomatic improvement between the 2 groups (total 16 patients). Due to unfavorable results in terms of pain relief observed after surgical treatment, they recommended surgery only for those patients with a short history and with a neurological deficit.

Unfortunately, all these recommendations are based on results obtained from a small number of patients and, overall, from retrospective reviews.

Conclusions

Tarlov cysts are usually incidental findings on radiological examination performed in the lumbosacral spine. A small percentage of these lesions may be symptomatic. Meticulous care should be taken to clearly define the patient’s symptoms and correlate them to radiological findings. What Tarlov stated in his seminal article more than 70 years ago still seems to be true today: “The clinical significance of these cysts remains to be determined.”

The results reported in the literature on the surgical treatment of symptomatic cysts, which can now be performed using different methods, have conflicting results, can be technically demanding and not without significant complications, and often do not provide lasting benefit. The best management option must be determined by the size and location of the patient’s cyst, as well as the surgeon’s skillset.

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Disclosure

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Author contributions to the study and manuscript preparation include the following. Conception and design: Park, Lucantoni, Valdivia, Maher, La Marca. Acquisition of data: Lucantoni, Than, Wang. Analysis and interpretation of data: Park, Lucantoni, Than, Wang, Valdivia. Drafting the article: Lucantoni, Than, Wang, Valdivia. Critically revising the article: Park, Lucantoni, Than, Valdivia, Maher, La Marca. Reviewed submitted version of manuscript: all authors. Study supervision: Park, Maher, La Marca.

References

1. Acosta FL Jr, Quinones–Hinojosa A, Schmidt MH, Weinstein PR: Diagnosis and management of sacral Tarlov cysts. Case...


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