Although rare, intraneural ganglion cysts have received disproportionate attention over the past century, largely due to the controversy over their pathogenesis. Some researchers believe in the synovial theory, which propounds that ganglia are derived from an articular or pararticular origin. Approximately 40% of previous cases have demonstrated a connection between an intraneural cyst and a joint space through an articular peduncle. Other researchers believe that, despite their typical proximity to joint spaces, intraneural cysts arise within the nerve. Supportive theories have included: expansion of extraarticular embryonic rests, cystic degeneration of tumors, traumatic intraneural hemorrhage and metaplastic change, and focal degeneration of epineural or perineural connective tissue within the nerve secondary to chronic mechanical irritation.

We report the case of an intraneural ganglion cyst occurring in an unusual location—the tibial nerve within the popliteal fossa—in which a connection to the proximal tibiofibular joint was demonstrated on magnetic resonance (MR) images and at surgery. Surgical ligation of the articular branch and evacuation of the cyst led to symptomatic relief, and an MR image obtained 1 year after surgery documented no recurrence. This case reinforces the fact that surgeons need to consider and search for an articular connection in all cases of intraneural ganglia, especially in those that have recurred.

**Case Report**

**History.** This previously healthy 40-year-old man was asymptomatic until 1 year before evaluation. While working as a manual laborer, he slipped and felt a stretching sensation in the posterior aspect of his right leg, which was accompanied by immediate pain in the upper calf region and the lateral sole of his foot. The steady intense pain diminished over the next several days; however, a burning pain in the upper calf and sole of the foot was elicited with exertional maneuvers, such as squatting, bending, or prolonged ambulation. The patient sought medical attention because of the persistent symptoms.

**Examination.** On examination the patient exhibited severe weakness of the toe flexors and moderate weakness of the posterior tibial muscle of the right leg. There was no weakness or appreciated atrophy of the sural triceps muscle or musculature of the lateral and anterior compartments. The sciatic nerve–innervated posterior thigh musculature exhibited normal strength and muscle bulk. Objective sensory loss was noted in the distribution of the sural and lateral plantar nerves. Reflexes were normal in the patient’s affected leg.

Results of nerve conduction studies recorded over the abductor of the great toe muscle from the tibial nerve revealed a low-amplitude compound-muscle action potential. The medial plantar sensory response was absent. Electromyographic studies revealed chronic denervation with renervation (fibrillations and large motor unit potentials) in muscles innervated by the tibial nerve distal to the branch supplying the gastrocnemius muscle.

Magnetic resonance imaging revealed a multiloculated soft-tissue mass extending along the course of the right tibial nerve for a length of approximately 19 cm (Fig. 1). The mass measured 1.5 cm at its maximum diameter; it began where the tibial nerve originated from the sciatic bifurcation and extended inferiorly to a level just distal to...
the tibial plateau. No evidence of a communication with a joint space was seen. The gradient-echo imaging sequence confirmed the absence of flow within the mass. Gadolinium-enhanced images demonstrated that the mass was composed of multiple small nonenhancing cystic spaces, which only showed enhancement of a thin peripheral rim and scattered internal septations. Radiographic findings were most consistent with a diagnosis of ganglion cyst. However, the differential diagnosis also included a nerve sheath myxoma or a benign peripheral nerve tumor with cystic degeneration, such as a schwannoma or neurofibroma. There was also an abnormal signal within the musculature of the lower leg, which was compatible with the denervation seen in these muscles on electromyograms.

First Operation. The entire length of the lesion was exposed at surgery. No communication with the tibiofibular or knee joint was identified. The lesion appeared to be located completely within the epineurium. The vasa nervorum were distended around the lesion (Fig. 2). The lesion tapered gradually to nerve that appeared normal at both ends. Characteristics of a pathological specimen were consistent with a diagnosis of an intraneural ganglion cyst. While the patient was monitored by electromyography, the lesion was resected and found to contain multiple communicating compartments of a clear or yellow-reddish, gelatinous material within fibrous septa that dissected the tibial nerve at multiple levels. No macroscopic or microscopic evidence of hemorrhage was identified. The functioning component of the nerve, as delineated by intraoperative electrical stimulation with intra-muscular wire recordings, was left undisturbed. The remaining nonfunctioning nerve with a densely adherent, multiloculated fibrous capsule was resected.

First Postoperative Course. Initially, the patient exhibited no change in his neurological status and his pain was improved. However, over the ensuing months, the pain returned primarily in response to exertion. At the 3-month follow-up examination, imaging revealed a small residual cyst component in the distal tibial nerve. By the 1-year follow-up visit, the patient’s pain was as severe as it had ever been. Physical examination revealed a new mild weakness in his gastrocnemius muscle and a 1.5-cm size discrepancy in the circumference of his calf muscles; sen-

Recurrent intraneural tibial ganglion cyst

Fig. 1. Magnetic resonance images revealing an intraneural ganglion cyst of the tibial nerve. Left: Transaxial T₂-weighted (TR 2350 msec, TE 50 msec) image demonstrating a small, well-circumscribed multiloculated mass situated adjacent to the popliteal artery and vein. The lesion measures approximately 1.5 cm at its maximum transverse diameter. Center: Gadolinium-enhanced T₂-weighted image with fat saturation (TR 583 msec, TE 14 msec), demonstrating that the mass is composed of multiple, nonenhancing lobulated cystic spaces that display enhancement of only a thin peripheral rim and scattered internal septations. Right: Sagittal T₂-weighted fast spin-echo images demonstrating the longitudinal course of the ganglion cyst (arrowhead), which is seen extending along the course of the tibial nerve for a length of approximately 19 cm (TR 3516 msec, TE 84 msec).

Fig. 2. Intraoperative photograph obtained during the initial surgery showing the tibial nerve with the intraneural ganglion cyst. The two heads of the gastrocnemius muscle are at the low numerical end of the ruler and the relationship of the nerve to the sural triceps group is depicted at the 2-in mark. Note the multiloculated cystic dilation.
sory examination revealed no change from his preoperative status. Electromyographic studies demonstrated new evidence of denervation changes in the medial gastrocnemius muscle, which was suggestive of additional tibial nerve fascicle involvement. Repeated MR imaging (Fig. 3) revealed a massive recurrence of the cyst involving the proximal component of the tibial nerve near the sciatic origin of both the tibial and common peroneal nerves. A tail of the ganglion cyst could be traced directly to the level of the proximal tibiofibular joint. In fact, a similar finding was present on a retrospective review of the patient’s previous MR images.

Second Operation. In view of the painful recurrence of the cyst and to prevent involvement of the common peroneal component of the sciatic nerve, surgical reexploration was performed. A large intraneural ganglion cyst was identified and resected. Following the tibial nerve distally, we found that the cyst emanated from the posterior aspect of the proximal tibiofibular joint by invagination into an articular branch of the tibial nerve (Fig. 4). Contrast medium injected into this branch filled the joint space. This branch was disconnected, and the joint space was oversewn and obliterated. Interpositional nerve grafting was not used because of the significant atrophy of the affected musculature, the minimal symptoms resulting from the motor deficit, and the presence of protective sensation on the plantar aspect of the foot.

Second Postoperative Course. At the patient’s 1-year postoperative follow-up examination, neurological and electrodiagnostic findings were unchanged from those obtained preoperatively and his pain had resolved. Repeated MR imaging performed at 6 and 12 months postoperatively confirmed no cyst recurrence.

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Fig. 3. Magnetic resonance images revealing a recurrent intraneural ganglion cyst of the tibial nerve. A: Transaxial T2-weighted image (TR 4000 msec; TE 88 msec) demonstrating the tail of the recurrent cyst in direct apposition to the proximal tibiofibular joint. B–D: Sagittal T2-weighted images (TR 2000 msec; TE 60 msec) revealing massive recurrence of the intraneural ganglion cyst.

Fig. 4. Artist’s drawings depicting a recurrent intraneural ganglion cyst. A: A large multiloculated tibial intraneural ganglion located in the popliteal fossa. B: The intraneural cyst can be traced to the proximal tibiofibular joint. More proximally, a close-up cross-sectional view shows the epineural cyst displacing other nerve fascicles; more distally, the articular connection to the proximal tibiofibular joint is hollow. C: The articular branch is held open with two hemostats and a probe is in its center. By permission, Mayo Foundation.
Recurrent intraneural tibial ganglion cyst

Discussion

Ganglion cysts may form from synovial joint spaces and cause peripheral nerve compression lesions either extraneurally or intraneurally. An intraneural ganglion cyst is an accumulation of mucoid material within a dense, adherent fibrous capsule that may have multiple loculations dissecting for some distance through a peripheral nerve. Approximately 100 cases of intraneural ganglia have been reported; however, their incidence is probably underreported.3 Most patients are male with a broad age range from childhood to senescence. The common peroneal nerve was affected in approximately 75% of reported cases; however, other nerves in the upper and lower extremities have been affected.

Only three cases of a tibial intraneural ganglion in the popliteal fossa have been reported;1,9,11 two involved the tibial nerve1,11 and one involved only the tibial component of the sciatic nerve in the distal thigh.9 These three patients, similar to ours, presented with pain in response to exertion (with or without neurological deficit), which improved significantly after surgery. No communication with the knee joint or a bursa was identified in any of these three cases.

In contrast, in our patient, we demonstrated an articular connection of the tibial intraneural cyst within the popliteal fossa to the proximal tibiofibular joint. Ligament of the articular branch led to resolution of the cyst, as observed on postoperative MR images. The superior tibiofibular joint receives innervation by both the peroneal and the tibial nerves.7 The articular branch of the tibial nerve is derived from the nerve to the popliteal muscle. Note that when pedicles have been described for intraneural ganglia of the peroneal nerve, the superior tibiofibular joint has also been described at the site.7 Intraneural ganglia, must be distinguished from extraneural ganglia, which also may arise from the proximal tibiofibular joint.9

Results of magnetic resonance imaging and intraoperative arthrography supported our finding of a connection with the tibial nerve and the proximal tibiofibular joint. Recently, a similar demonstration of a cyst–joint communication was reported with the peroneal nerve1 as well. Others have used ultrasonography, computerized tomography scanning, or MR imaging to identify intraneural lesions.1,3,9,10 Magnetic resonance imaging is the modality of choice because of its superior soft-tissue contrast resolution. Ganglion cysts typically present as homogeneous multilobulated, well-circumscribed, soft-tissue masses that exhibit low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. Ganglion cysts can be characterized with the aid of intravenously administered gadolinium, by exhibiting no internal enhancement within the cystic spaces. The application of the short tau inversion recovery technique is also helpful for delineating areas of abnormal signal within distally supplied musculature indicative of denervation and may assist in mapping the distribution of nerve fascicle involvement. Such modern imaging techniques may play an important role in demonstrating joint involvement and elucidating further the pathogenesis of intraneural cysts in the future.

Surgical treatment of symptomatic lesions can vary from simple decompression and evacuation of the cystic contents to more radical exenteration of the fibrous walls and adjacent densely adherent nerve. Resection of the cyst with its adherent capsule often results in fascicular disruption. Drainage without excision of the cyst walls will optimize preservation of function, but may predispose the nerve to cyst recurrence. The postoperative course is unpredictable, and although the lesion is nonneoplastic, long-term follow-up review is recommended because recurrences can occur as often as 30% of the time.2 This may be especially true of intraneural cysts associated with articular joints, if the articular pedicle has not been obliterated at the time of surgery.3

In conclusion, this case highlights the importance of searching for a joint communication in every patient with an intraneural ganglion cyst both preoperatively and intraoperatively to avoid cyst recurrences.

References