Intraneural ganglion cysts are rare benign lesions affecting the peripheral nerves. They are more commonly associated with the peroneal nerve at the superior tibiofibular joint. The incidence of tibial nerve intraneural ganglia is restricted to the occasional case report, and there are no reported cases of these lesions in children. While evidence of the unifying theory for intraneural ganglia of the common peroneal nerve is strong, there are only a few reports describing the application of the theory in the tibial nerve. In this report the authors examine tibial nerve intraneural ganglia at the ankle and knee in an adult and a child, respectively, and describe the clinical utility of incorporating the unifying (articular) theory in the management of tibial intraneural ganglia in adults and children.

Methods. Cases of tibial intraneural ganglion cysts were examined clinically, radiologically, operatively, and histologically to demonstrate the application of the unified (articular) theory for the development of these cysts in adults and children.

Results. Two patients with intraneural ganglion cysts of the tibial nerve were identified: an adult with an intraneural ganglion cyst of the tibial nerve at the tarsal tunnel and a child with an intraneural ganglion cyst of the tibial nerve at the knee. In each case, preoperative MR imaging demonstrated the intraneural cyst and its connection to the adjacent joint via the articular branch to the subtalar joint and superior tibiofibular joint. At surgery the articular branch was identified and resected, thus disconnecting the tibial nerve intraneural cyst from the joint of origin.

Conclusions. These cases detail the important features of intraneural ganglion cysts of the tibial nerve and document the clinical utility of incorporating the unifying (articular) theory for the surgical management of tibial intraneural ganglia in adults and children. (DOI: 10.3171/2010.3.JNS10427)

Key Words • articular theory • children • ganglion cyst • intraneural ganglion • tibial nerve • unifying theory

Case Reports

Case 1

History and Examination. This 14-year-old boy presented with a 3-month history of pain in the right popliteal fossa. Walking exacerbated his symptoms. Treatment with ice packs and physiotherapy provided no relief. The pain became more bothersome and easily worsened with walking, sitting, and running. Sharp pain then developed, radiating into the toes of the right foot (medial more so than lateral) especially when sitting, and paresthesias manifested down the right leg when the boy attempted to kick a football. There was no history of knee trauma, and no significant medical history. Examination revealed normal neurological findings in the leg, and the Tinel sign at the knee was negative.

Nerve conduction studies demonstrated a mild, partial, right tibial neuropathy affecting the sensory fibers. Magnetic resonance imaging (1.5 T) of the right knee showed a cystic lesion within the tibial nerve at the popliteal fossa (Fig. 1A and B). The cyst extended along the articular branch to the superior tibiofibular joint, thus demonstrating a cystic connection from the superior tibiofibular joint to the tibial nerve in the popliteal fossa (Fig. 1C). The popliteus muscle showed denervation change. The tibial nerve demonstrated the signet ring sign, with the intraneural cyst displacing the intraepineural nerve.
fibers (Fig. 1D). The cyst was located predominantly in the lateral aspect of the tibial nerve.

Operation. At surgery the tibial nerve in the popliteal fossa was grossly expanded by the intraneural cyst (Fig. 2A). The tibial nerve distal to the takeoff of the articular branch was of normal caliber (Fig. 2B). The articular branch to the superior tibiofibular joint was distended by the cyst (Fig. 2C). The articular branch was resected, and the gelatinous contents of the cyst were evacuated, resulting in decompression of the tibial nerve.

Postoperative Course. The resected articular branch cyst was examined histologically and demonstrated fibrous connective tissue with a central small focus of myxomatous change consistent with a ganglion cyst.

At 3 months postoperatively the patient reported marked improvement in his right foot pain. Numbness in the right foot was unchanged.

Case 2

History and Examination. This 45-year-old man presented with a 4-week history of pain, numbness, and tingling in the right foot. The symptoms were particularly localized to the medial aspect of the foot and the great toe. Prolonged standing exacerbated his symptoms. Neurological examination demonstrated normal motor function in the right foot, while sensory examination revealed numbness over the medial aspect of the foot and the medial 3 digits. There was a positive Tinel sign of the tibial nerve at the level of the medial malleolus. Magnetic resonance imaging of the right ankle demonstrated a ganglion cyst of the tibial nerve arising from the subtalar joint and extending into the tibial nerve within the tarsal tunnel (Fig. 3). The subtalar joint demonstrated subchondral degenerative cystic change and marrow edema.

Nerve conduction studies demonstrated attenuated motor conduction of the right tibial nerve as well as absent medial and lateral plantar nerve sensory nerve action potentials. Electromyography showed active denervation in the right flexor hallucis brevis and abductor hallucis muscles. These results were consistent with a mild to moderate right tibial neuropathy.

Operation. At surgery the tibial nerve within the tarsal tunnel was grossly distended by the intraneural ganglion cyst. The articular branch to the subtalar joint was grossly distended by the cyst. The articular branch was resected, thus disconnecting the tibial nerve from the subtalar joint. The gelatinous contents of the tibial nerve cyst were evacuated, resulting in complete decompression of the tibial nerve within the tarsal tunnel (Fig. 4).

Postoperative Course. The resected articular branch cyst was examined histologically and demonstrated fibrous connective tissue with a central small focus of myxomatous change consistent with a ganglion cyst.

At 3 months postoperatively the patient reported marked improvement in his right foot pain. Numbness in the right foot was unchanged.

Discussion

Intraneural ganglion cysts are rare mucinous cysts arising from synovial joints. They occur in nerves associated with joints—more commonly the peroneal nerve in the lower limb, but they also occur in the upper limb, such as in the ulnar nerve and the suprascapular nerve. The origin of these cysts has been subject to conjecture until recently. The unified articular theory has recently been described, based on clinical, MR imaging, anatomical, and operative findings. The prototypical intraneural ganglion cyst arises from the superior tibiofibular joint and involves the articular branch of the deep peroneal nerve. The cyst then dissects along the articular branch and into the deep peroneal nerve itself. It expands the epineurium so that the nerve appears swollen and compresses the nerve fascicles. While the intraneural cyst of the peroneal nerve is the most common and well described, these cysts can arise from any synovial joint.
and reach the parent nerve via the articular branch. Very few cases of tibial nerve intraneural ganglion cysts have been published, particularly at the level of the tarsal tunnel. Furthermore, there are no reported cases of tibial intraneural ganglion cysts in children.

**Magnetic Resonance Imaging of Intraneural Ganglia**

Preoperative MR imaging provides the opportunity for a correct diagnosis if the surgeon or radiologist is aware of this condition and its typical radiological features. Some of the key features are as follows.

**Involvement of the Articular Branch.** Figures 1C and 3 right show the cystic communication via the articular branch in the reported cases. It can be seen that the articular branch is involved by the extension of the cyst and that the branch indeed provides communication between the joint capsule and the parent tibial nerve.

**Extension Along the Parent Nerve.** In both cases extension of the cyst longitudinally in the tibial nerve is appreciated. The typical MR imaging signal characteristics of the cystic contents are demonstrated along the course of the tibial nerve (Fig. 1A and B).

**Compression of the Nerve Within its Epineurium.** Within the epineurial coverings of the nerve, the tibial nerve fascicles are compressed by the expanding cyst. The nerve fascicles are placed eccentrically within the epineurium, resulting in the classic “signet ring” sign (Fig. 1D).

**Denervation Changes in the Appropriate Muscles.** In the case of the tibial nerve at the knee, the articular branch arises from the oblique descending branch to the popliteus muscle. Therefore, changes demonstrated within the popliteus muscle are sensitive markers of intraneural ganglia at this location (Fig. 1C). As the compression neuropathy continues, denervation changes develop in muscles innervated by the parent nerve.

**Joint Changes.** The joint of origin may demonstrate degenerative, inflammatory, or traumatic changes.

**Operative Findings**

In both cases a cystic articular branch was identified, providing a visible conduit between the joint and the tibial nerve. In Case 1 the articular branch from the tibial nerve to the superior tibiofibular joint was identified, while in Case 2 the articular branch from the tibial nerve to the subtalar joint was identified (Figs. 2C and 4). In both cases the articular branch was involved longitudinally by cystic expansion, and the cyst extension into the parent tibial nerve was confirmed. Via this cystic connection, the parent tibial nerve cyst was decompressed.

**Outcome**

The operative treatment in both cases resulted in a resolution of symptoms. Equally important is the fact that disconnection of the tibial nerve cyst from the joint by excision of the articular branch will provide long-term benefit by eliminating the risk of recurrent intraneural cyst formation. Hitherto, recurrence has been common if
the articular branch was not identified and disconnected. By disconnecting the articular branch, the conduit from joint to nerve is eliminated, and recurrent intraneural cyst formation is prevented. Incorporating the unified theory into the operative management, it is apparent that resection of the tibial nerve cyst is not required and is actually contraindicated because of the risk of injury to the tibial nerve. Operative management requires treatment of the underlying pathological mechanism, namely, the articular cystic connection between the joint and the tibial nerve. Therefore, disconnection of the articular branch and simple drainage of the cyst obviates the risks associated with attempted resection of the cyst from the tibial nerve.

The management of intraneural ganglion cysts has evolved since the development of the unifying theory. This theory provides a mechanistic understanding of cyst development, enabling the treating clinician to interpret the MR imaging findings correctly, and thus to perform the appropriate surgical treatment that decompresses the involved nerve and prevents recurrence by disconnecting the nerve from the articular branch. We have demonstrated that the tibial nerve may be affected at the level of the knee (superior tibiofibular joint) or the ankle (subtalar joint) and that intraneural ganglion cysts of the tibial nerve can develop in adults and children.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Conception and design: GA Davis. Acquisition of data: GA Davis. Analysis and interpretation of data: IH Cox. Drafting the article: GA Davis. Critically revising the article: GA Davis, IH Cox. Reviewed final version of the manuscript and approved it for submission: GA Davis, IH Cox.

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