Peroneal intraneural ganglia

Part I. Techniques for successful diagnosis and treatment

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✓The common peroneal nerve is the peripheral nerve most often affected by intraneural ganglion cysts. Although the pathogenesis of these cysts has been the subject of controversy in the literature, it is becoming increasingly evident that they are of articular origin. Recent recognition of this fact has proven to be significant in reducing recurrences and improving treatment outcomes for patients. The authors present a stepwise method of assessing and treating peroneal intraneural ganglion cysts.

KEY WORDS • cyst • intraneural ganglion • peroneal nerve • superior tibiofibular joint

INTRANEURAL GANGLIA are nonneoplastic cysts that are contained within the epineurium of peripheral nerves. Many nerves have been affected by these lesions, but the CPN at the fibular neck is by far the most frequent site. Because of the rarity of these intraneural cysts, their pathogenesis has been controversial. Treatment recommendations have been based largely on anecdote rather than a comprehensive understanding of the mechanism of cyst formation. Reported recurrence rates have been as high as 30%, and we believe these rates are underestimated because the postoperative MR imaging studies that would confirm complete treatment and document recurrent or persistent cysts have typically not been performed.

Our review of a large cohort of our own patients with intraneural ganglia¹⁶ and a detailed analysis of the world's literature allowed us to initially propose,¹⁷ subsequently challenge, and finally substantiate a unified articular theory that would support a joint connection. This theory, which would apply directly to the peroneal nerve but could be extrapolated to other nerves at other sites,^{11,13,18} has been corroborated by others.^{9,10} This articular theory differs from the more commonly held belief of de novo cyst formation.

The Unified Articular Theory

We believe that the point of exit of cyst fluid and the path of propagation is predictable based on the articular (synovial) theory. Ejected synovial fluid exits from a neigh-

boring joint. The capsular defect is probably due to a rent in a degenerative joint, which similarly can lead to coexisting or sequential extraneural ganglion cysts.²³ Fluid tracks along the articular branch of a nerve intraepineurially via a path of least resistance along tissue planes. Pressure fluxes determine the extent of dissection.^{12,15}

For the peroneal nerve at the fibular neck region, cyst fluid, derived from the anterior portion of the superior tibiofibular joint, dissects along a U-shaped articular branch and then tracks along the deep peroneal portion of the common peroneal nerve.^{4,19} With greater intraarticular pressures, the cyst may track further proximally and extend to the sciatic nerve.^{12,15} Predictably, we have demonstrated that analogous findings can be shown to affect the tibial nerve at the knee region; these tibial intraneural cysts arise from the posterior aspect of the superior tibiofibular joint and dissect up a tibial articular branch into the parent tibial nerve, on rare occasions, as proximal as the sciatic nerve.^{15,22}

Understanding these principles has allowed us to identify characteristic clinical, MR imaging, and surgical findings that would elucidate the pathoanatomy and predict recurrences. For the peroneal intraneural ganglia, this theory explains the preferential clinical finding of patients with DPN (rather than SPN) dysfunction presenting with foot drop. High resolution MR imaging allows the demonstration of joint connections (which can be small) in these paraarticular cysts and the application of imaging signs to assist with the preoperative diagnosis¹⁹ because of the stereotypic pattern of dissection. At operation, dissection along the articular branch can be reliably demonstrated, even though in some cases cystic involvement can be "occult." Operated cases in which the pathological joint and articular branch were both addressed had no evi-

Abbreviations used in this paper: CPN = common peroneal nerve; CT = computed tomography; DPN = deep peroneal nerve; FSE = fast spin echo; MR = magnetic resonance; SPN = superficial peroneal nerve; VIPR = vastly undersampled isotropic projection reconstruction.

FIG. 1. Illustration of the normal anatomy and pathoanatomy of the right knee in a flexed position. The normal anatomy of the CPN is shown with its terminal (articular, deep peroneal, and superficial peroneal) branches. Note the branch to the tibialis anterior that is derived from the articular branch. A characteristic pathoanatomy for peroneal intraneural ganglia is encountered with tubular extension along the course of the peroneal nerve. The more striking expanded cyst within the CPN is easily identified proximal to the region of the fibular tunnel. The cystic articular branch component derived from the anterior portion of the superior tibiofibular joint is far more subtle, seemingly occult, and frequently missed. This articular joint connection is beneath the peroneus longus. Note the relationship of the insertions of the biceps femoris tendon and lateral collateral ligament to the superior tibiofibular joint. *Inset* shows surgical anatomy.

dences of recurrences (confirmed with postoperative imaging studies); in contrast, in cases in which these were not identified or treated by previous surgeons, subclinical or frank recurrences could invariably be demonstrated. In consecutive published cases reported by others in which a joint connection had not been observed, reinterpretation of the initial imaging studies revealed a joint connection.¹⁶

In this two-part review, we demonstrate our systematic approach to cases of peroneal intraneural ganglia and illustrate lessons learned from our comprehensive review. In Part I, we provide a step-by-step diagnostic and management protocol. In Part II,²⁰ we present common modes of failure in assessing and treating these lesions, which can be avoided by adherence to the principles outlined in Part I. We are unaware of such reports in the literature and believe that application of these techniques can improve outcomes in the future. Understanding the anatomy of the peroneal nerve and its terminal branches is necessary to become knowledgeable and gain experience with the pathoanatomy of these peroneal intraneural cysts (Fig. 1).

Illustrative Case

History and Presentation. This 38-year-old female veterinary radiologist presented to us with a recurrent right peroneal intraneural ganglion cyst in December 2005. She had first become symptomatic in June 2004, when she noticed paresthesias and dysesthesias in the dorsolateral aspect of the right foot. Her symptoms were exacerbated by exercise. By January 2005, she had developed weakness that resulted in a foot drop associated with more persistent pain 1 day after a strenuous volleyball game. She became aware of a mass in the proximal leg. Electromyography demonstrated a moderately severe lesion affect-

ing the CPN. An MR imaging study performed in March of 2005 revealed a cystic mass that was thought to be an extraneural cyst. In May 2005 she underwent decompression of a peroneal intraneural cyst. A joint connection, which was evident on MR images (Fig. 2), was not treated during this operation. The immediate clinical and electrophysiological improvement was reported by another group.³ The patient's initial symptoms recurred 6 weeks later. She also noted recurrent enlargement of the mass, which was confirmed by ultrasonography and MR imaging.^{25,26}

Her symptoms of foot drop, dorsal foot numbness, anterior compartment muscle cramping, and pain (all of which were worse after exertion) in the face of a recurrent mass (which was larger than the mass had been prior to the initial surgery) led to our evaluation of her.

Examination. On physical examination, a well-healed scar was noted over the fibular neck region along with a palpable fullness in that area. Strength of the tibialis anterior and extensor hallucis longus was Medical Research Council Grade 4 and that of the extensor digitorum communis Grade 2+. The peronei were of normal strength. She was unable to walk on her heels. She had abnormal sensation in the distribution of the DPN, but normal sensation in the SPN distribution. A Tinel sign was present at the fibular neck and radiated to the first dorsal web space.

Magnetic resonance imaging revealed a classic presentation of a recurrent peroneal intraneural ganglion cyst (Fig. 3).

Operation and Postoperative Course. Surgery revealed a 4-cm cystic enlargement of the CPN representing a peroneal intraneural ganglion cyst. The cyst followed the course of the articular branch with a connection to the

FIG. 2. Preoperative MR images from an imaging study performed at another institution. Our reinterpretation of these images showed features that are classic for a peroneal intraneural cyst. A: Axial T2-weighted FSE image with fat suppression showing an intraneural cyst (*asterisk*) within the CPN displacing the nerve fascicles into a crescent shape (*arrow*, the “signet ring” sign). B: Axial T1-weighted image at the same level showing the nerve fascicles displaced (*arrow*) by the intraneural cyst (*asterisk*). C: Axial T2-weighted FSE image with fat suppression showing the cyst (*asterisk*) extending along the transverse portion of the articular branch (*arrows*) of the peroneal nerve arising from the anterior superior tibiofibular joint as it crosses over the fibular neck (the “transverse limb” sign). Note denervation changes in the lateral (*plus sign*) and anterior compartments (also evident in D). D: Axial T2-weighted FSE image with fat suppression slightly proximal to C shows the cyst (*asterisk*) and its origin from the superior tibiofibular joint (*arrow*, the “tail” sign).

superior tibiofibular joint (Fig. 4). The superior tibiofibular joint was resected (Fig. 5), the cyst was decompressed (Fig. 6), and the articular branch was disconnected (Fig. 7). These steps are summarized in Fig. 8 and elaborated upon later in this paper. Histopathological analysis demonstrated an intraneural ganglion cyst (Fig. 9).

By the next day, she had regained full dorsiflexion, and toe extension and sensation had improved. A postoperative MR imaging study performed 6 months later (Fig. 10) demonstrated no cyst persistence or recurrence. At 15 months postoperatively, she had no neurological symptoms or deficits (Fig. 11). She had returned to an active lifestyle, including volleyball playing.

Peroneal Intraneural Ganglia

Diagnostic Technique

Patients typically present with neural symptoms, such as pain, motor weakness, or sensory abnormalities within the distribution of the CPN (especially the DPN) and/or a palpable mass on the anterolateral aspect of the knee in proximity to the superior tibiofibular joint. Trauma around the affected area is also often part of the history. Symptoms may be insidious or acute in nature. Symptoms and findings (including the size of the mass) may fluctuate with exertion, as exemplified in the illustrative case described in this paper.

FIG. 3. Magnetic resonance images obtained at our institution using a 3-tesla unit after early clinical recurrence. A: Coronal oblique 3D maximum intensity projection (MIP) from a VIPR data set showing the intraneural cyst (*asterisk*) extending from the superior tibiofibular joint (*arrow*) along the articular branch to the CPN. B: Coronal oblique MIP from a VIPR data set showing the connection of the intraneural cyst to the joint (*arrow*) with extension along the articular branch (*asterisk*). C: A 3D rendering of a T2-weighted MR imaging data set with fat suppression shows the full extent of the peroneal cyst arising from the anterior portion of the superior tibiofibular joint extending along the articular branch to the CPN. The DPN and SPN branches and the tibial nerve are seen.

Physical examination includes palpation for a mass, and testing of motor and sensory function in the common peroneal, tibial, and sciatic nerve distributions. Typically patients present with a predominant DPN lesion, though broader deficit in the CPN, even at times affecting the tibial division of the sciatic nerve itself, may be encountered. These findings can be confirmed by electromyography or nerve conduction studies.

The diagnosis of peroneal intraneural ganglia should be suspected in patients with peroneal nerve compression, especially those with preferential involvement of the DPN and/or those with mass lesion.^{5,24} We believe that imaging studies (CT, ultrasonography, and—our preference—MR imaging) can help establish the diagnosis preoperatively and should be performed in all patients with this clinical presentation.

Imaging Technique

Close attention to imaging technique is critical for characterizing the origin and nature of peroneal intraneural ganglia. The structures that have to be visualized are small and the joint connections and other associated findings are often subtle, requiring the highest possible spatial and contrast resolution for effective prospective identification. The modality of choice for evaluating peroneal intraneural ganglia is MR imaging. Optimum technique requires at least a full field (1.5-tesla) scanner; if possible, a high-field (3-tesla) magnet should be used to capitalize on the improved signal-to noise ratio available at the higher field strength. For any type of MR imaging the use of dedicated surface coils is necessary. Attempts at imaging this small area of interest without an appropriate surface coil will seriously compromise image quality. A transmit/receive knee coil with adequate coverage is the first choice both for image quality and energy management, especially at a high field strength.

The joint of interest should be positioned at the center

of the coil, which should itself be at the center of the magnet for the best possible imaging and to minimize artifacts and poor fat saturation off isocenter. The area covered should include all of the soft tissues of the knee and proximal calf in order to not only assess the cyst and joint but also to evaluate the musculature of the anterior compartment of the calf, which often has denervation changes secondary to the nerve involvement. A small field of view should be used, usually no greater than 16 cm in the axial plane. Slice thickness should also be as small as possible in order to identify subtle joint connections without problems related to volume averaging with thicker slices. The acquisition matrix should also be as high as possible with the available signal-to-noise ratio, usually at least 384×256 . The basic imaging sequence used is a T1-weighted sequence for anatomy; an FSE pulse sequence may be used in place of conventional T1-weighted imaging to save time with appropriate imaging parameters. The most critical and often most difficult sequence to obtain is a uniform T2-weighted image with good signal-to-noise resolution and robust chemical fat suppression. Inversion recovery imaging is often used for this purpose but should be avoided unless it is absolutely not possible to obtain good fat suppression using a saturation pulse. Inversion recovery sequences (FSE inversion recovery, short-tau inversion recovery [STIR], and so forth) are fraught with artifacts including hyperintensity in normal nerves. The preferred T2-weighted sequence is a heavily T2-weighted FSE sequence (TR ≥ 3500 msec, TE > 60 msec) with uniform chemical fat suppression. Images should be obtained in at least orthogonal planes along the entire area of interest, including visualizing the full extent of the cyst and changes in the nerve (peroneal and sciatic where appropriate) and the inferior extent of the superior tibiofibular joint, usually to the level of the metadiaphysis of the proximal fibula. Generally speaking high-resolution 2D images may be reformatted on a clinical workstation to identify small joint connections, but in some cases 3D

FIG. 4. Photographs illustrating dissection. A: The patient's right leg showing the previous incision. The palpable recurrent mass is outlined. B: The previous wound has been incorporated into a slightly more extensile exposure allowing safe identification and mobilization of the nerves and the cystic elements. The expansile peroneal intraneural ganglion (asterisk) has been identified within the CPN. Note that its expansion is proximal to the trifurcation of the nerve, which occurs beneath the peroneus longus. C: The fascia over the peroneus longus has been incised. D: A portion of the peroneus longus origin has been divided. E: Identification of the terminal branches of the CPN—the articular branch (AB), the DPN, and the SPN—has been accomplished. F: The articular branch (in red vasoloops) has been traced to the level of the anterior portion of the superior tibiofibular joint.

imaging is preferable.²¹ In those cases, sequences such as VIPR¹ or parallel imaging accelerated 3D FSE imaging may be helpful, but high-quality 2D imaging remains the mainstay of diagnosis. Contrast should be used in every instance to confirm the cystic nature of the lesion, which may otherwise mimic solid lesions such as a benign neurogenic tumor or even a malignant tumor such as a synovial sarcoma.

Several consistent imaging features have been described to characterize peroneal intraneural ganglia.^{12,19} These signs, including the “signet ring” sign, the “transverse limb” sign, and the “tail” sign, are illustrated in Fig. 2. In those cases in which the cyst is actually extraneural, MR imaging is also useful in identifying the joint of origin and the relationship to the nerve, which may be compressed due to extrinsic mass effect. Distinguishing between these entities is helpful for planning treatment.

Using these basic techniques, degenerative joint disease, joint effusions, denervation in the muscles, and other associated findings may all be identified and correlated with the clinical scenario. In many cases, other intraarticular pathological conditions of the knee will also be visualized, and these lesions may need to be addressed separately or concurrently with the intraneural ganglion cyst. Radiography will show degenerative joint disease but lacks the soft-tissue contrast required for visualizing cysts. Computed tomography may be used in cases involving patients who cannot undergo MR imaging, but CT scans lack the exquisite soft tissue differentiation of MR images.

Specialized techniques such as MR¹⁴ or CT arthrography⁶⁻⁸ may be helpful in identifying occult joint connections but should not be used before conventional, noninvasive imaging is performed. Ultrasonography may have a role in the hands of an experienced examiner due to its highly operator-dependent nature. The use of high-frequency (17.5-MHz small footprint [“hockey stick”] transducers is necessary to achieve the appropriate resolution required to see small joint connections,² but it unfortunately results in a limited field of view, which may preclude visualization of the full extent of the cyst. Unless very specialized expertise in musculoskeletal ultrasonography is available, we find that intraneural cysts are best imaged with MR imaging.

Operative Technique

We believe that this condition deserves operative intervention to promote effective nerve (cyst) decompression and to decrease the risk of further proximal cyst dissection (and the potential for involvement of unaffected portions of the sciatic nerve).¹⁵ In order to treat peroneal intraneural ganglia effectively, surgeons must understand the pathoanatomy of the process and address systematically each of the separate structures: the peroneal nerve and its branches (particularly, the articular branch), the cyst, and the superior tibiofibular joint (Fig. 8). Based on our broad experience, we have introduced and employed a focused operative strategy that addresses these principles. With some modifications, this approach can be extrapolated to the treatment of other rarer cysts occurring in other nerves or at other joints.

Dissection. Under tourniquet control, the CPN can be exposed through a curved incision over the posterolateral

FIG. 5. Photographs demonstrating disarticulation. The joint resection is performed using a combination of an oscillating saw (A), osteotome (B), and a rasp (C). The intraneural cyst is indicated by an asterisk in each image. The CPN and its branches are protected.

aspect of the proximal leg. Typically the incision extends from the popliteal crease posteriorly, the fibular neck laterally, and then as far distally as the anterior compartment. More proximal exposure may be necessary for cysts extending further up the CPN. The enlarged CPN can be easily identified, protected, and mobilized. If possible, the integrity of the cyst should be maintained. The lateral sural cutaneous nerve can often be identified more proximally. The cyst, which expands proximal to the fibular tunnel, tends to taper toward the joint within the articular branch. As the nerve is traced more distally, it courses over the fibular neck beneath the peroneus longus muscle. Three branches of the nerve need to be identified and mobilized: the articular branch, the DPN and the SPN. The fascia over the peroneus longus muscle is incised. With more distal dissection of the articular branch, a portion of the peroneus longus is divided over the articular branch. The articular branch should then be exposed in its U-shaped

course towards the superior tibiofibular joint. Dissection is facilitated by use of loupe magnification or a surgical microscope.

Once complete dissection of the cyst and the articular nature of the lesion has been demonstrated, the following steps can be performed in any order: disarticulation, decompression, disconnection.

Disarticulation. In our opinion, resection of the superior tibiofibular joint is an important part of the treatment. Resection of the joint's synovium is undertaken in an effort to prevent extraneural cyst recurrence. However, we recognize that extraneural cyst recurrence: 1) may occur at the superior tibiofibular joint if subtotal joint resection is performed; 2) may occur at the neighboring knee joint due to the global degenerative process; 3) does not necessarily occur if a joint procedure is not performed; 4) is often subclinical; and 5) rarely leads to extrinsic nerve compression. This portion of the procedure can be performed in collabo-

FIG. 6. Photographs demonstrating decompression. A: Incision of the cyst in its most expanded section of the CPN. Decompression of the cyst is accomplished through a small longitudinal opening in the nerve, well away from the fascicles that have been mapped. No attempt is made to resect the cyst or its wall, thereby minimizing intraneural dissection. B: Mucinous material is evident extruding from the cyst. C: The decompressed cavity within the nerve after cyst evacuation and irrigation.

FIG. 7. Intraoperative photograph illustrating disconnection. In order to eliminate intraneural recurrence, the articular branch (in red vasoloops) is disconnected from the superior tibiofibular joint (at a point just distal to the origin of the branch to the tibialis anterior [in blue vasoloops]). The distal-most portion of the articular branch is submitted for histological examination. The proximal and distal stumps are ligated whenever possible (not shown).

ration with an orthopedic surgeon trained in this technique. Preoperative plain films and CT scans or MR images show the configuration of the superior tibiofibular joint and help guide the surgeon in the angulation necessary for joint resection. The superior tibiofibular joint is typically in a degenerated condition. During the exposure of the joint, the lateral collateral ligament and the common biceps tendon insertion should be preserved. The CPN and its branches should be protected during the osteotomy. When penetrating the capsule, cyst fluid is seen. A probe is placed in the joint after capsulotomy to reaffirm the direction for the proposed osteotomy of the proximal fibula. The joint resection is done using an oscillating saw, an osteotome, a curette, and then a rasp. Care must be taken to avoid injury to the anterior tibial vessels during the joint resection. Vessels are typically below the articulation as they penetrate the intermuscular septum. The inferior aspect of the proximal fibula's articulating component is identified after capsulotomy. A small curved Bennett retractor is placed medial to the proximal medial fibula, displacing the intermuscular septum and vessels medially and protecting them.

There are no long-term sequelae associated with resection of the superior tibiofibular joint for the treatment of peroneal intraneural ganglia. Similarly, this joint can be resected when treating tibial intraneural ganglia arising from this joint.²² In contrast, complete resection of the joint in the cases of intraneural ganglia arising from other joints such as the wrist or ankle is not appropriate and should not be performed. Although fusion of the superior tibiofibular joint is another means of treating this condition, we favor joint resection where feasible because it is technically easier to perform than fusion, which can be complicated by nonunion, and joint resection does not require a period of immobilization postoperatively.

Decompression. Prior to cyst decompression, mapping of the fascicles of the CPN typically shows them to be displaced. The location of the nerve fascicles can be predicted on review of the preoperative MR images and/or visualized or confirmed with nerve stimulation intraoperatively. A longitudinal epineurial incision is made away from the fascicles, usually centered over a cystic bleb. Gelatinous material is then evacuated—usually released under some pressure. This myxoid material can be submitted for histological examination; no cyst wall or neural tissue from this level is resected or submitted for examination. Although occasionally cysts located within the outer epineurium can be excised, we still favor a limited fenestration of the cyst. This limited epineurotomy, which effectively decompresses the cyst without risking neurological injury, can be applied even in cases with longer intraneural cyst extension.

Disconnection. In order to prevent intraneural recurrence, we recommend disconnecting the articular branch from the superior tibiofibular joint. The small articular branch is ligated and transected, preserving the branch to the anterior tibialis muscle.⁴ Disconnection eliminates the possibility of intraneural recurrence, allows representative and definitive histological evaluation, and denervates a portion of the joint. Although theoretically removal of the joint capsule and the synovium during the disarticulation phase would effectively disconnect the articular branch, we still ligate the proximal and distal stumps as a “belt and suspenders” method.

Closure. Hemostasis is achieved with the tourniquet released. The capsule is closed with 0 Vicryl (Ethicon) sutures over a drain. The wound is closed in anatomical layers with a subcuticular suture and Steri-Strips (3M Health Care). A well-padded compressive dressing is applied.

Postoperative Course

Patients typically stay overnight in the hospital for observation and pain control. The drain is removed prior to discharge. The wound is evaluated and redressed with a compressive dressing, which is kept in place for 1 week. Patients may ambulate without assistance (that is, without immobilization or protection) immediately after the surgery, though some prefer using crutches for a few days. Gentle, early motion of the knee is encouraged because it permits gliding of the peroneal nerve.

Future Applications

We anticipate that surgeons, aware of the joint connec-

FIG. 8. Composite illustration of the operative techniques displayed in Figs. 4–7. The four Ds are summarized: dissection, disarticulation, decompression, and disconnection. Inset shows skin incision and surgical anatomy.

tions and capsular condition, will devise arthroscopic or endoscopic techniques to treat these intraneural cysts. These predictions are based on the fact that some surgeons are currently applying such techniques in cases of extra-neural cysts, pathological conditions of the labra, and nerve compression at other joints, such as the shoulder. The anatomy of the superior tibiofibular joint, however, would make endoscopic or arthroscopic treatment of intraneural cysts involving this joint technically difficult.

Postoperative Follow-Up Evaluation

Serial clinical examinations are performed and typically demonstrate progressive recovery. Electromyographic examination may be helpful several months after surgery. Often, decompression of the cyst will facilitate recovery within days of surgery and steady improvement over the ensuing months. Outcomes in general can be maximized with this type of approach as described. Even in recurrent cases (such as in our case example), excellent outcomes can be achieved. We believe that outcomes will improve in the future if these principles are adhered to and surgery is performed early.

Intraneural recurrences can be eliminated and extra-

neural recurrences can be minimized with this approach. We believe that postoperative MR imaging and long-term follow-up (at least several years) are necessary to document the outcome and identify subclinical recurrent or persistent cyst. Complications from incomplete cyst and

FIG. 9. Photomicrographs illustrating histological findings. A: Section of the ganglion cyst and an associated small myelinated nerve fascicle (arrow). B: Section demonstrating the intimate apposition of the nerve fascicle (left) with the cyst wall (right). H & E, original magnifications $\times 64$ (A) and $\times 160$ (B).

FIG. 10. Postoperative MR images. A: Axial T1-weighted FSE image just distal to the knee joint shows resection of the superior tibiofibular joint. B: Axial T2-weighted FSE image with fat suppression at the same level as A shows no residual cyst material after joint resection.

joint resection are generally predictable and avoidable if these principles are adhered to.²⁰

Finally, due to the relative rarity of cases of these cysts, they are often submitted as case reports or small case series for publication in journals. To establish a consensus on this articular theory, we must collaborate to validate the

true pathogenesis of the lesions. Future publications supporting another theory must supply adequate documentation to refute the articular theory so that others may critically review the findings.¹⁰ Stringent criteria should include: 1) preoperative MR images at the superior tibiofibular joint showing no cystic joint connection, 2) intraoperative photographs demonstrating the appearance of the articular branch, 3) histological review of the distal articular branch, 4) postoperative MR images of the superior tibiofibular joint showing no persistence or recurrence, and 5) long-term follow-up.

Conclusions

We have presented a systematic approach to the management of cases of peroneal intraneural ganglia that can only be successfully undertaken with an understanding of the pathogenesis of these relatively rare lesions. Peroneal intraneural ganglia, which have been considered clinical curiosities with inexplicably high recurrence rates, can be diagnosed and treated effectively and definitively, if the basic principles for their formation and propagation are understood and followed. In the accompanying article detailing the potential pitfalls in the management of these patients,²⁰ we discuss common modes of failure when treatment is not based on the underlying pathogenesis as described in this paper.

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FIG. 11. Photograph demonstrating clinical outcome 15 months following the secondary procedure. The healed incision is seen. Full ankle dorsiflexion and toe extension are demonstrated as the patient stands on her heels.

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