

Endoscopic Interdigital Neurectomy of the Foot



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Abstract: Morton's neuroma is a compressive neuropathy resulting in perineural fibrosis rather than a neuroma of the plantar digital nerve. Surgical treatment is indicated for patients with a clear diagnosis of Morton's neuroma and no improvement with nonsurgical treatment. The surgical options include isolated intermetatarsal ligament division, isolated interdigital nerve excision, and interdigital nerve excision with intermetatarsal ligament division, with or without submuscular transposition. This can be performed via dorsal or plantar approach. The open approaches require long incisions and extensive soft-tissue dissection. The purpose of this Technical Note is to describe the surgical details of endoscopic interdigital neurectomy. This is an endoscopic approach involving interdigital nerve excision with intermetatarsal ligament division and submuscular transposition.

Morton's neuroma is one of the most frequent causes of forefoot pain. It is a compressive neuropathy resulting in perineural fibrosis rather than a neuroma of the plantar digital nerve. It is caused by entrapment of the interdigital nerve near the distal edge of the transverse intermetatarsal ligament and most commonly affects the third interdigital nerve in the third web space between the third and fourth toes.^{1,2} Typically, women between the ages of 45 and 50 years old are affected. However, men may also be affected.³ The patients often complain of a burning, sharp pain located in between the third and fourth toes. This pain is often plantar at the metatarsal heads and radiates distally on either side of the toes; it can also radiate from the forefoot up the leg proximally.⁴ Differential diagnosis for Morton's neuroma should include local causes of intermetatarsal bursitis; metatarsophalangeal joint instability; stress fracture of metatarsals; metatarsalgia; Freiberg's infarction; painful callosities associated with toe deformities, local infection, and tumors; and distant causes of lumbar

radiculopathy, tarsal tunnel syndrome, and peripheral neuropathy.¹

In symptomatic patients, treatment is first based on conservative measures with shoe wear modification, plantar pad placement, nonsteroidal anti-inflammatory drugs, and Achilles stretching.^{2,5} If these measures fail to relieve the symptoms, local injection of corticosteroids, phenol, or alcohol or radiofrequency ablation can be considered.^{2,5} Surgical treatment should be reserved for patients with a clear diagnosis of Morton's neuroma who have experienced temporary improvement with a local nerve block and who have not improved with nonsurgical treatment.² The surgical options include isolated intermetatarsal ligament division, isolated interdigital nerve excision, and interdigital nerve excision with intermetatarsal ligament division, with or without submuscular transposition.^{1,3,6} The surgical aims include decompression of the entrapped interdigital nerve by transecting the intermetatarsal ligament, release or resection of the interdigital nerve itself, and/or release of any nerve branches causing tethering, thereby allowing the nerve to move more proximally away from the weight-bearing portion of the forefoot.² Three surgical approaches have been proposed for interdigital neurectomy: plantar longitudinal approach,⁷ the plantar transverse approach,⁶ and the dorsal approach.^{8,9} Each approach requires a 3- to 4-cm incision and extensive soft-tissue dissection. The purpose of this Technical Note is to describe the details of endoscopic interdigital neurectomy of the foot, which can reduce the size of surgical wounds and minimize the soft-tissue dissection. It is an endoscopic approach of interdigital nerve excision with intermetatarsal ligament division and

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submuscular transposition. This is indicated for symptomatic Morton's neuroma recalcitrant to nonoperative measures. It is contraindicated in cases of poor response from a well-placed diagnostic lidocaine injection about the common digital nerve, other causes of the forefoot symptoms, distal neuropathy with nonfocal nerve tenderness, complex regional pain syndrome, recurrent neuroma with extensive fibrosis of surrounding tissue, and concomitant neuromas at adjacent web spaces (Table 1).

Technique

Preoperative Assessment and Patient Positioning

Diagnosis of Morton's neuroma is usually based on clinical assessment.² Careful palpation along the interdigital nerves is helpful in determining the location of compression and whether additional nerves are symptomatic.² Other pathologies in the differential diagnoses should be excluded clinically.⁴ Imaging may be necessary to rule out the differential diagnoses. Occasionally, an x-ray may show a faint radiopaque mass and lateral toe deviation.¹⁰ Magnetic resonance imaging and ultrasonography may also confirm a Morton's neuroma. T2-weighted magnetic resonance imaging will show inflammation surrounding the neuroma. Ultrasound study will show a noncompressible hypoechoic interdigital mass with or without a bursal effusion.

The patient is in the supine position with the legs spread. A thigh tourniquet is applied to provide a bloodless operative field. A 2.7-mm, 30° arthroscope (Henke Sass Wolf, Tuttlingen, Germany) is used for this procedure. Fluid inflow is by gravity, and arthropump is not used.

The illustrated case demonstrates endoscopic neurectomy of the third interdigital nerve at the web space between the third and fourth toes, which is the most common site of Morton's neuroma.

Portal Placement

Toe web, proximal dorsal, and proximal plantar portals are used for this procedure. The toe web portal is at the dorsal skin fold of the third toe web. The proximal plantar portal is at the sole between the third and fourth

metatarsal bones and at the level of tarsometatarsal joint. This portal is created with Wissinger rod technique from the toe web portal.¹¹ The proximal dorsal portal is at the foot dorsum between the third and fourth metatarsal bones and about 4 cm proximal to the toe web portal (Fig 1).

Endoscopic Release of the Intermetatarsal Ligament

Endoscopic release of the intermetatarsal ligament is performed via the toe web and proximal plantar portals.¹¹ A 3- to 4-mm skin incision is made at the toe web portal site. The subcutaneous tissue is bluntly dissected with a hemostat down to the undersurface of the intermetatarsal ligament. This gives a washboard feeling when the tip of the mosquito hemostat scratches the undersurface of the ligament.¹¹ A 2.7-mm arthroscopic trocar (Henke Sass Wolf) is inserted via the toe web portal and is advanced gently along the undersurface of the intermetatarsal ligament till the plantar aponeurosis is reached at the level of the tarsometatarsal joint.¹⁰ The plantar aponeurosis is penetrated by the trocar, and a 3- to 4-mm incision is made at this point. This forms the proximal plantar portal. The trocar passes through both the toe web and proximal plantar portals, and the arthroscopic cannula (Henke Sass Wolf) is inserted along the trocar in reciprocal manner via the proximal plantar portal. The trocar is removed, and the 2.7-mm, 30° arthroscope (Henke Sass Wolf) is incorporated into the cannula. In this way, the scope passes through both the proximal plantar and toe web portals. A retrograde knife (Smith and Nephew, Andover, MA) is inserted via the toe web portal and advanced along the undersurface of the intermetatarsal ligament under arthroscopic guide as the scope is retrieved in pace with advancement of the knife. The blunt tip of the retrograde knife acts as a probe, and the undersurface of the tough intermetatarsal ligament is probed during advancement of the retrograde knife. The proximal edge of the ligament is identified by change of feeling of probing from the tough ligament to the yieldable thin fascia covering the interosseous muscles. Moreover, the muscles can be seen through the fascia (Fig 2). The fascia is easily cut open by the

Table 1. Indications and Contraindications of Endoscopic Interdigital Neurectomy of the Foot

Indications	Contraindications
1. Symptomatic Morton's neuroma recalcitrant to nonoperative measures	1. Poor response from a well-placed diagnostic lidocaine injection about the common digital nerve
	2. Other causes of the forefoot symptoms
	3. Distal neuropathy with nonfocal nerve tenderness
	4. Complex regional pain syndrome
	5. Recurrent neuroma with extensive fibrosis of surrounding tissue
	6. Concomitant neuromas at adjacent web spaces
	7. Lack of expertise
	8. Active infection at the planned portal site or operative field

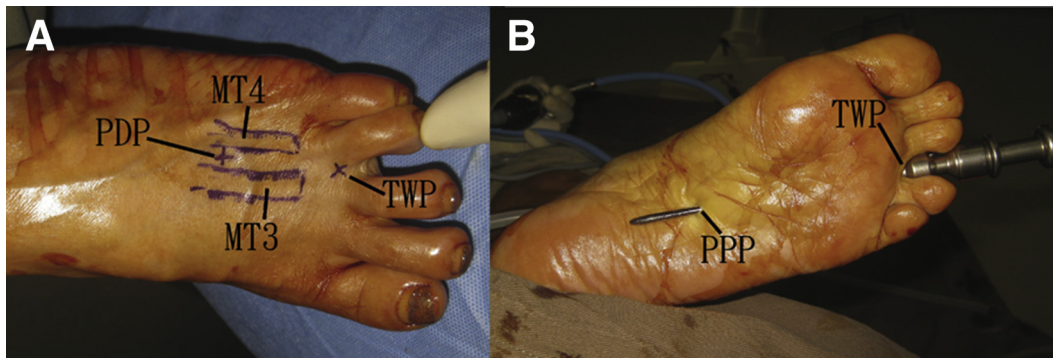


Fig 1. Endoscopic interdigital neurectomy of the third interdigital nerve of the left foot. The patient is in supine position with the legs spread. (A) The toe web portal (TWP) is at the dorsal skin fold of the third toe web. The proximal dorsal portal (PDP) is at the foot dorsum between the third and fourth metatarsal bones and about 4 cm from the TWP. (B) The proximal plantar portal (PPP) is at the sole between the third and fourth metatarsal bones and at the level of tarsometatarsal joint. This portal is created with Wissinger rod technique from the TWP.

knife, and the proximal edge of the ligament is hooked by the retrograde knife. The ligament is then released from the proximal edge distally under endoscopic visualization as the arthroscope is advanced in pace with the retrieval of the knife.

Proximal Tracing of the Interdigital Nerve

The toe web portal is the viewing portal; a needle is inserted through the proximal dorsal portal to confirm correct placement of the portal. A 3- to 4-mm skin incision is made at the proximal dorsal portal, and the

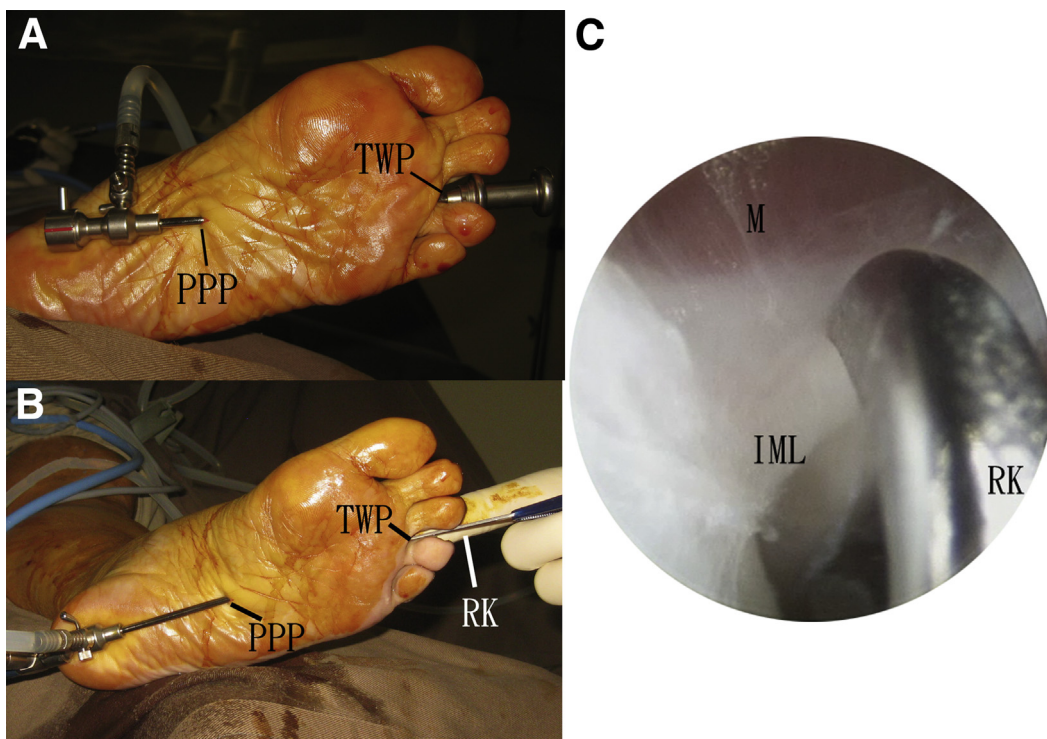


Fig 2. Endoscopic interdigital neurectomy of the third interdigital nerve of the left foot. The patient is in supine position with the legs spread. (A) The 2.7-mm arthroscopic trocar is inserted via the toe web portal (TWP) and is advanced gently along the undersurface of the intermetatarsal ligament and passed through the proximal plantar portal (PPP). The arthroscopic cannula is inserted along the trocar in reciprocal manner via the PPP. (B) The trocar is removed, and the 2.7-mm, 30° arthroscope is incorporated into the cannula. In this way, the scope passes through both the proximal plantar and TWPs. A retrograde knife (RK) is inserted via the TWP and advanced along the undersurface of the intermetatarsal ligament under arthroscopic guide as the scope is retrieved in phase with advancement of the knife. (C) PPP is the viewing portal, and the TWP is the working portal. Arthroscopic view shows the interface between the intermetatarsal ligament (IML) and thin fascia covering the interosseous muscles (M).

subcutaneous tissue is bluntly dissected with a hemostat. The deep fascia is perforated by the tip of the hemostat. The interdigital nerve is bluntly dissected out by the hemostat. The frequently identifiable landmarks in the working space include the cut intermetatarsal ligament and the lumbrical tendon of the fourth toe. The lumbrical tendon should not be mistaken as the interdigital nerve. Otherwise, transection of the lumbrical and not the nerve would lead to failure of the procedure and potential toe deviation.² The tendon can be differentiated from the nerve as the tendon is shiny and moves with dorsiflexion of the fourth toe. Moreover, when the tendon is traced distally, it is found to adhere to the medial capsule of the fourth metatarsophalangeal joint. The interdigital nerve is plantar to the tendon. Moreover, the nerve is also plantar to the intermetatarsal ligament and is readily visualized through cut ends of the ligament.

Once the interdigital nerve is identified, it is traced proximally to the native muscles of the sole. An arthroscopic shaver (Dyonics, Smith and Nephew) is inserted via the proximal dorsal portal. The shaver can serve as a blunt-tip dissector, and the native muscles can be bluntly split along the nerve. Sometimes, small fibrous arcades are encountered and can be released by the shaver or a SuperCut scissors (Stille, Lombard, IL) (Fig 3). This should be performed carefully under arthroscopic visualization in order to avoid premature transection of the nerve. Whenever the shaver is used for cutting the arcades, the suction should be kept to a minimum and the shaver blade should face away from the nerve. The nerve should be traced as proximal into the muscle as possible. This ensures submuscular placement of the proximal nerve stump after subsequent nerve transection. Sometimes, proximal bifurcation of the nerve can be encountered as the third interdigital nerve can be a confluence of the terminal branches of the medial and lateral plantar nerves. The

terminal branches of the medial and lateral plantar nerves should be individually traced proximally.

Circumferential Release of the Interdigital Nerve

The toe web portal is the viewing portal, and the proximal dorsal portal is the working portal. The interdigital nerve is carefully dissected from the surrounding fascial tissue by a hemostat. Sometimes sharp dissection of the nerve with a Supercut scissors is needed if the surrounding tissue is fibrotic. The plantar branches of the nerve are also transected by the scissors (Fig 4). This allows adequate mobilization of the nerve.

Proximal Cut of the Interdigital Nerve

The toe web portal is the viewing portal, and the proximal dorsal portal is the working portal for the Supercut scissors. The nerve can be grasped by an arthroscopic grasper (Acufex, Smith and Nephew) via the proximal plantar portal and retracted distally. This facilitates identification of the proximal aberrant branches of the nerve, which should also be resected in order to allow proximal retraction of the proximal nerve stump after nerve transection. The nerve retraction also facilitates more proximal nerve transection. The native muscle can be retracted proximally with the blades of the Supercut scissors, and the nerve is transected proximally (Fig 5). If the terminal branches of the medial and lateral plantar nerves are identified, both should be traced and transected proximally.

Retraction of the Distal Stump of the Interdigital Nerve to the Toe Web Portal

The toe web portal is the viewing portal, and the proximal dorsal portal is the working portal. The distal stump of the transected nerve is grasped by a hemostat. The arthroscope is removed, and the distal stump is retrieved to the toe web portal (Fig 6).

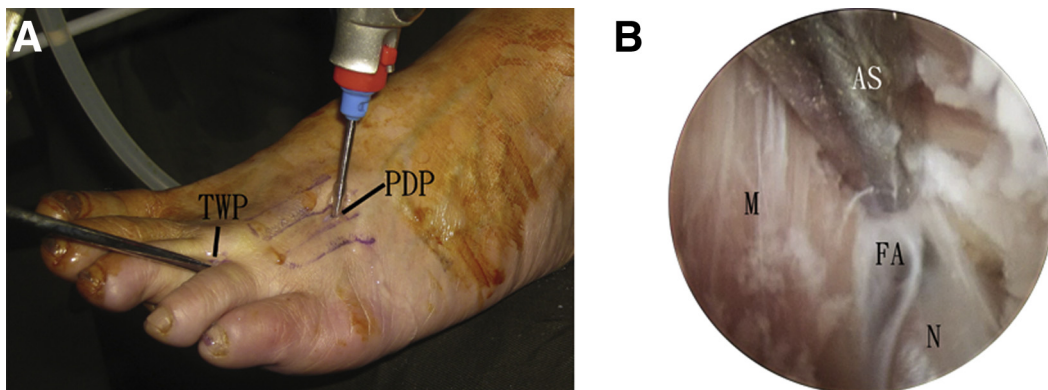


Fig 3. Endoscopic interdigital neurectomy of the third interdigital nerve of the left foot. The patient is in supine position with the legs spread. (A) The toe web portal (TWP) is the viewing portal, and the proximal dorsal portal (PDP) is the working portal. (B) Arthroscopic view shows proximal retraction of muscle (M) by the arthroscopic shaver (AS) exposing the interdigital nerve (N) and the fibrous arcade (FA).

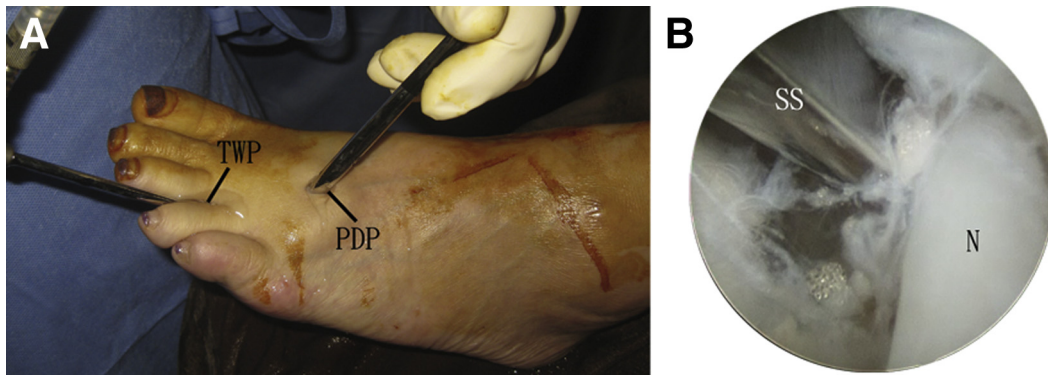


Fig 4. Endoscopic interdigital neurectomy of the third interdigital nerve of the left foot. (A) The patient is in supine position with the legs spread. The toe web portal (TWP) is the viewing portal, and the proximal dorsal portal (PDP) is the working portal. (B) Arthroscopic view shows transection of plantar branches of the interdigital nerve (N) by the Supercut scissors (SS).

Resection of the Distal Stump of the Interdigital Nerve

The proximal dorsal portal is the viewing portal, and the toe web portal is the working portal. The distal nerve stump can be visualized via the cut ends of the intermetatarsal ligaments. The distal ends of the distal nerve stump are resected with an arthroscopic shaver, and the distal stump is removed (Fig 7, Video 1, Table 2). Any inflamed intermetatarsal bursa can also be resected.

Postoperatively, a compression dressing is applied, and the patient is allowed for immediate weight-bearing with a wooden base sandal. The patient is advised on active and passive ankle and toes dorsiflexion mobilization. This can facilitate proximal retraction of the proximal nerve stump into the native muscles. Toe dorsiflexion can stretch out the native muscles of the sole, while ankle dorsiflexion allows further retraction of the nerve stump into the native

muscles. The patient is allowed to wear normal shoes once the foot swelling subsides.

Discussion

Open neurectomy of the interdigital nerve can be performed through a dorsal or plantar approach. A dorsal approach requires a 3- to 4-cm longitudinal incision and has the risk of injury to the dorsal sensory branch of the intermediate dorsal cutaneous branch of the superficial peroneal nerve that may become painful.^{1,9} In order to have adequate retraction of the proximal stump of the transected interdigital nerve into the native musculature, the plantar branches of the digital nerve should be resected and the interdigital nerve must be adequately resected at least 3 cm proximal to the intermetatarsal ligament.¹² Otherwise, recurrent neuroma remaining under the weight-bearing portion of the foot can occur. This transection can be difficult to achieve via a dorsal

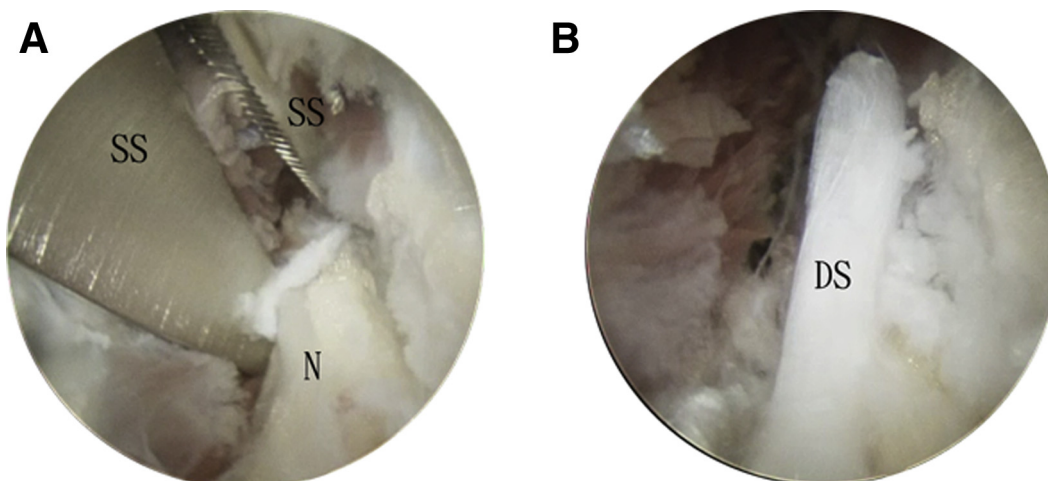


Fig 5. Endoscopic interdigital neurectomy of the third interdigital nerve of the left foot. The patient is in supine position with the legs spread. The toe web portal (TWP) is the viewing portal, and the proximal dorsal portal (PDP) is the working portal. (A) The blades of the Supercut scissors are used as retractor, the intrinsic muscle is retracted proximally, and the nerve is transected proximally. (B) Arthroscopic view shows the free end of the distal stump (DS) of the interdigital nerve.

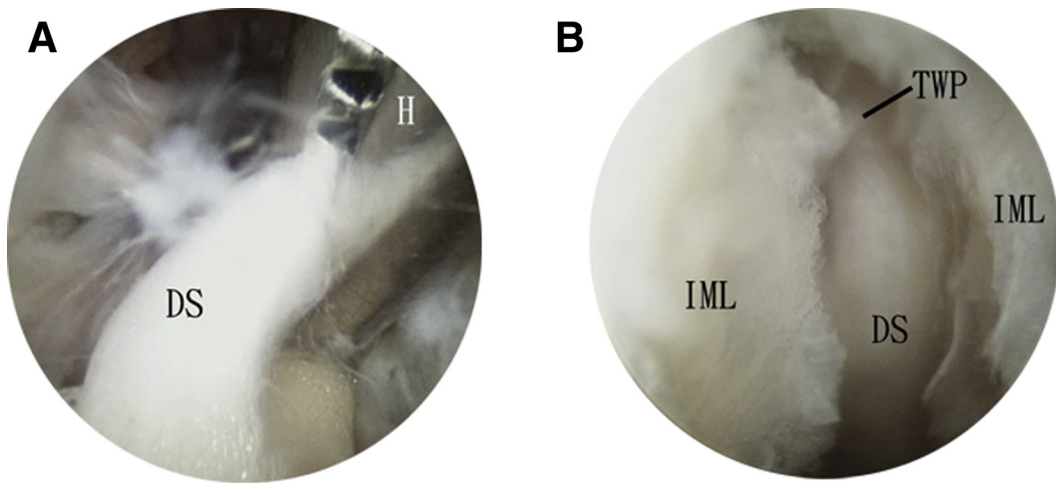


Fig 6. Endoscopic interdigital neurectomy of the third interdigital nerve of the left foot. The patient is in supine position with the legs spread. (A) The toe web portal (TWP) is the viewing portal, and the proximal dorsal portal is the working portal. Arthroscopic view shows grasping of the distal stump (DS) of the interdigital nerve by a hemostat. (B) The proximal dorsal portal is the viewing portal. The DS of the interdigital nerve is transposed to the TWP and can be seen through the cut ends of the intermetatarsal ligament (IMP).

approach, as the proximal dissection can be limited.⁹ In contrast, this reported endoscopic technique requires a much smaller dorsal incision and reduces the risk of cutaneous nerve injury. Moreover, proximal dissection, transection of the plantar branches, and proximal transection of the nerve are possible by small instruments through the intermetatarsal space under magnified arthroscopic view.

The plantar approach also requires a 3- to 4-cm incision. The strands of the fibrous plantar tissue and the plantar aponeurosis are disrupted. This increases the risk of painful hypertrophic scar formation or keloid formation on the plantar surface of the foot. Dissection performed medially or laterally can also create scarring of the fatty tissue; as a result, the scar may become inverted, or the fat pad beneath a metatarsal head may become atrophic.^{9,13} In this endoscopic approach, the

small proximal plantar portal placed at the non-weight-bearing portion of the sole without dissection of the fatty tissue can avoid these complications.

In contrast to the open approaches, phenol treatment of the nerve trunk is not possible in the endoscopic approach. This may increase the risk of amputation neuroma formation. Therefore, it is important to make sure that the proximal nerve stump is buried in the native musculature.

A high chance of injury to the common digital arteries is expected during endoscopic resection of the distal ends of the distal nerve stump. This is because the arteries are in close proximity to the nerve at this region and not readily identifiable as the tourniquet is inflated to provide a bloodless operative field. However, this usually does not cause any problem due to extensive collateralization of digital vessels.¹⁴

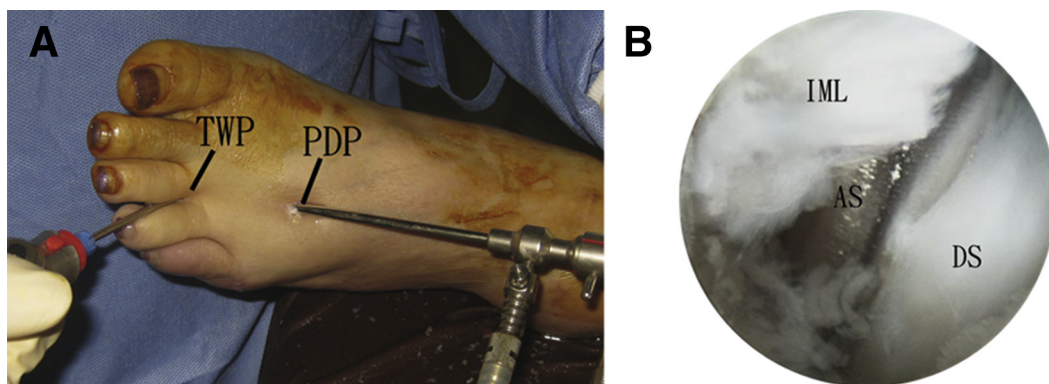


Fig 7. Endoscopic interdigital neurectomy of the third interdigital nerve of the left foot. The patient is in supine position with the legs spread. (A) The proximal dorsal portal (PDP) is the viewing portal, and the toe web portal (TWP) is the working portal. (B) Arthroscopic view shows resection of the distal ends of the distal stump (DS) of interdigital nerve by an arthroscopic shaver (AS). IML, cut end of the intermetatarsal ligament.

Table 2. Pearls and Pitfalls of Endoscopic Interdigital Neurectomy of the Foot

Pearls	Pitfalls
1. Division of the intermetatarsal ligament improves the arthroscopic view of subsequent steps.	1. The lumbrical tendon should not be mistaken as the interdigital nerve.
2. The plantar branches should be transected in order to allow for adequate mobilization of the nerve.	2. Premature transection of the interdigital nerve during mobilization of the nerve will avoid proximal retraction of the proximal nerve stump.
3. The nerve should be cut proximal enough to allow burying of the proximal nerve stump in the native musculature.	

We do not recommend simultaneous endoscopic neurectomy of the adjacent web spaces. This may result in injury of both digital arteries of the central toe and entire toe numbness.

Surgical treatment with excision of the tumor or decompression of the intermetatarsal space is associated with a considerable success rate (80% to 96%).³ In the outcome study conducted by Habashy et al., there was no statistically significant difference between the dorsal and plantar approach groups with respect to outcomes and patient satisfaction.⁹ However, it has high costs and a considerable risk of postoperative complications such as wound infection, hypersensitive scars, or keloids in up to 23% cases.¹⁵ Revision due to recurrence of the neuroma has been reported in 11% of cases after neurectomy.¹⁵ However, there is no outcome study in the literature concerning endoscopic interdigital neurectomy. Large-scale prospective study is needed to define the safety and effectiveness of this endoscopic technique.

The advantages of this technique include small incision and minimal tissue dissection, less chance of painful scar formation, early return to sport activities, reduction in the risk of injury to cutaneous nerves and veins, adequate dissection of the nerve, and burying

Table 3. Advantages and Risks of Endoscopic Interdigital Neurectomy of the Foot

Advantages	Risks
1. Small incision and better cosmetic outcome	1. Recurrent neuroma formation
2. Minimal soft-tissue trauma	2. Common digital arteries injury and postoperative hematoma
3. Less chance of painful scar formation	
4. Early return to sport activities	
5. Reducing risk of injury to cutaneous nerves and veins	
6. Adequate dissection of the nerve and bury of the proximal nerve stump	

of the proximal nerve stump. The potential risks of this technique include recurrent neuroma formation, common digital arteries injury, and postoperative hematoma formation (Table 3). This endoscopic approach is technically demanding and should be reserved for experienced foot and ankle arthroscopists.

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