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SPECIAL TOPIC
Peripheral Nerve

Meralgia Paresthetica: An Anatomical Review and Surgical Case Presentation Utilizing a Robotic Exoscope

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Background: Meralgia paresthetica (MP) is a neuropathic condition marked by pain, tingling, and numbness in the anterolateral thigh, primarily caused by compression of the lateral femoral cutaneous nerve (LFCN). Although compression often occurs beneath the inguinal ligament, anatomical variations can lead to different entrapment sites. Treatments range from conservative measures to surgical decompression, depending on symptom severity. This study provides an anatomical review of the LFCN and presents a unique case of MP where the LFCN was compressed by the sartorius fascia rather than the typical site beneath the inguinal ligament. The study also explores the use of the Synaptive Modus X robotic exoscope for surgical decompression.

Methods: This article presents a case study of a man in his 40s with a 15-year history of chronic MP symptoms, where the LFCN was atypically compressed by the sartorius fascia. Surgical decompression was performed using the robotic exoscope, a device offering high-definition, 3-dimensional visualization.

Results: At 13 weeks postoperatively, the patient experienced improvement in thigh sensation and no pain. He returned to baseline ambulation with no complications. The exoscope allowed precise identification of the LFCN's anatomy and compression site, proving effective in enhancing surgical precision.

Conclusions: This is the first report of primary LFCN decompression using the Synaptive Modus X exoscope. The device provides excellent visualization, ergonomic benefits, and educational advantages, making it a valuable alternative to traditional microscopes and loupes in nerve decompression and other microsurgical procedures. Further studies are needed to assess its cost-effectiveness and broader applications in plastic surgery. *(Plast Reconstr Surg Glob Open 2024; 12:e6352; doi: 10.1097/GOX.0000000000006352; Published online 13 December 2024.)*

INTRODUCTION

Meralgia paresthetica (MP) is a neuropathic condition characterized by pain, tingling, and numbness in the anterolateral thigh, typically resulting from the compression of the lateral femoral cutaneous nerve (LFCN).[1] This condition was first described and published by Bernhardt and Roth, separately in the 1880s.[1,2] MP arises from the compression or entrapment of the LFCN, leading to sensory disturbances in the anterolateral thigh. The most commonly cited area of compression is where the nerve passes beneath the inguinal ligament.[3] MP presentation is variable and can occur at any age; however, it most often occurs in 50- to 60-year-old men.[1,4] Factors contributing to this compression include tight clothing, obesity, pregnancy, and local trauma. Additionally, anatomical variations of the LFCN have been well-documented in the literature. Specific patterns, such as an anterior or posterior positioning relative to the ASIS, are associated with a higher incidence of MP.[1] It is estimated that around 25% of individuals exhibit an anatomical variant of the LFCN, which may predispose them to developing MP.[1,5] The duration of MP symptoms can vary widely, ranging from as short as 0.5 months to as long as 20 years.[6] On average, the duration is about 34 months, with 36% of cases experiencing symptoms that last between 12 months and 5 years.[6]

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Although most patients exhibit unilateral symptoms, bilateral presentation has been reported.[1]

The diagnosis of MP is primarily clinical, supported by imaging such as ultrasound or magnetic resonance imaging and nerve conduction studies. Management of MP ranges from conservative measures to surgical intervention. Conservative interventions include lifestyle modifications such as weight loss, avoiding tight clothing, over the counter analgesics, and tricyclic antidepressants.[1] Interventional treatments include nerve blocks, steroid injections, or surgery for neurolysis or neurectomy. Studies show that surgical decompression can provide significant symptom relief for patients with refractory MP.[7] The choice of treatment depends on symptom severity, underlying cause, and patient-specific factors. In this article, the authors provide an anatomical review of the LFCN and discuss a case involving an atypical presentation of MP. They also detail the surgical treatment of MP using the innovative Synaptive Modus X robotic exoscope (Synaptive Medical, Inc, Toronto, Canada) technology.

Takeaways

Question: The study addresses anatomical variations and atypical presentations of meralgia paresthetica (MP) due to lateral femoral cutaneous nerve (LFCN) entrapment and evaluates the efficacy of the exoscope in decompression of the LFCN.

Findings: The study reviewed LFCN anatomy and presented a case of MP with LFCN entrapment within the sartorius fascia. Surgical decompression using the Synaptive Modus X robotic exoscope was successful, offering excellent visualization and precise delineation of anatomical details. The study concluded that the exoscope could be a viable alternative to traditional microscopes in nerve decompression and microsurgery.

Meaning: This study highlights the exoscope's potential as an effective alternative for LFCN decompression.

ANATOMICAL REVIEW

Understanding the anatomical course and variations of the LFCN is essential for diagnosing and managing MP. The LFCN originates from the lumbar plexus, specifically from the posterior divisions of the L2 and L3 spinal nerves.[1] After emerging from the lumbar plexus, the LFCN follows a path that can exhibit several anatomical variations but generally adheres to a predictable course:

1. Lumbar plexus: The nerve originates from the ventral rami of the L2 and L3 nerve roots within the lumbar plexus.
2. Pelvic passage: The nerve traverses the psoas major muscle and then crosses obliquely over the iliacus muscle toward the anterior superior iliac spine (ASIS).
3. Inguinal ligament: The nerve typically passes under or through the inguinal ligament near the ASIS, which is thought to be the most common site of compression leading to MP.

ANATOMICAL VARIATIONS (TYPES A–E)

Various studies have classified the anatomical variations of the LFCN into types based on its course relative to the inguinal ligament and surrounding structures. Aszmann et al[8] introduced a classification system (A–E) to describe the specific pathways of the LFCN from its origin to its innervation territory based on a cadaveric study of 52 specimens.[8] In this system:

- Type A: The nerve travels posterior to the ASIS across the iliac spine.
- Type B: The nerve runs anterior to the ASIS and superficial to the origin of the sartorius muscle but within the inguinal ligament.
- Type C: The nerve runs medial to the ASIS, ensheathed in the tendinous origin of the sartorius.
- Type D: The nerve runs medial to the tendinous origin of the sartorius and courses beneath the inguinal ligament, between the sartorius and iliopsoas muscles.
- Type E: The nerve is in the most medial position, travels on top of the iliopsoas muscle beneath the inguinal ligament, and contributes to the femoral branch of the genitofemoral nerve.

Additionally, a classification system by Murata et al[9] describes 4 different types (A–D).

- Type A: The nerve crosses over the iliac crest more than 2cm posterior to the ASIS.
- Type B: The nerve crosses over the iliac crest within 2 cm posterior to the ASIS.
- Type C: The nerve crosses at the ASIS.
- Type D: The nerve crosses beneath the inguinal ligament and anterior to the ASIS.

These variations are crucial for understanding different entrapment mechanisms and for planning surgical interventions.

CASE PRESENTATION

A man in his 40s with a medical history of type II diabetes and obesity presented with a 15-year history of chronic right lateral thigh numbness and tingling. The patient also endorsed "icy" lateral thigh pain exacerbated by activity. Pain had not been alleviated despite the use of conservative modalities including physical therapy and an LFCN block. On neurological examination, the patient had decreased sensation in the distribution of the right LFCN, with intact strength in the upper and lower extremities. Electromyography demonstrated decreased activity of the right LFCN. Magnetic resonance imaging of the abdomen and lumbar spine were unremarkable. Given the patient's refractory pain and discomfort, surgical release of the LFCN was planned for treatment of chronic, refractory MP.

This surgery was planned and executed with the Synaptive Modus X robotic exoscope (Synaptive Medical, Inc). The exoscope is an advanced optical device that enhances surgical visualization by providing high-definition, 3-dimensional (3D) images of the surgical field.[10] This technology integrates high-resolution cameras and optics to capture detailed images, which are then displayed on a 3D monitor.[10] This setup allows the surgical team to view the operative area in real-time with excellent clarity. The exoscope displays high magnification and optimal lighting, which is helpful for detailed and delicate surgical tasks.[10] Initially popular in neurosurgery and spine surgery, the exoscope is now being increasingly adopted in other fields, including plastic surgery.

At 13 weeks postoperatively, the patient reported a reduction in numbness and improvement in sensation in his right thigh. Additionally, he denied pain in the right thigh and at the incision site. The patient was able to ambulate at his baseline level and did not experience any postoperative complications.

SURGERY

The exoscope was positioned above the patient, and oriented and focused on the incision site. To expose the LFCN in the leg, the ASIS was marked, the skin was infiltrated with 1% lidocaine with epinephrine solution in a 1:100,000 concentration, and a 7-cm incision was made parallel and inferior to the inguinal ligament. The skin and subcutaneous skin were divided, and with blunt dissection, the subcutaneous fat was swept off the lateral portion of the inguinal ligament and its junction with the sartorius muscle (Fig. 1). The fascia lata was then incised and retracted to reveal the surface of the sartorius muscle (Fig. 2). Medial to the sartorius, the nerve was identified traveling in the correct anatomic orientation (Fig. 3). The inguinal ligament was partially divided to release the nerve proximally (Fig. 4). The fascia was then released inferiorly to free the nerve from constriction (Fig. 5). In this case, the etiology of the nerve compression and distortion was constriction by the fascia overlying the sartorius muscle. This contrasts with the most commonly described point of constriction at the inguinal ligament.[11] After hemostasis was achieved and the wound was irrigated, the incision was closed in layers with deep PDS and subcuticular Monocryl.

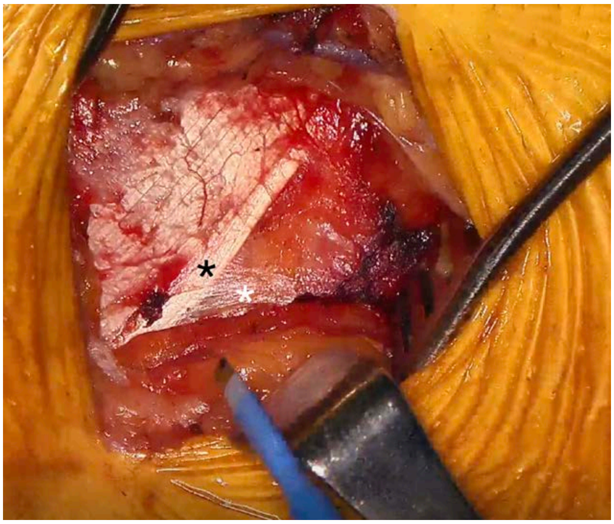

Fig. 1. The lateral portion of the inguinal ligament (black asterisk) and its junction with the sartorius muscle (white asterisk).

The patient tolerated the procedure well and was discharged to the recovery room under stable condition.

DISCUSSION

LFCN release is a reliable option for MP refractory to conservative treatment. The anatomical course of the LFCN is well described and is subject to distinct variants. Several classification systems have been published, which describe these known variants. According to the classification system developed by Aszmann et al, the patient in this case report had a type C LFCN pathway, in which the nerve ran medial to the ASIS and was ensheathed in the tendinous origin of the sartorius.[8] According to the system developed by Murata et al, this patient's anatomy was consistent with type D, as the LCFN crossed beneath the inguinal ligament and anterior to the ASIS.[9] Studies by de Ridder et al[11] and Zhao et al[12] further classified the branching types of the LFCN and passage types of the LCFN through the inguinal

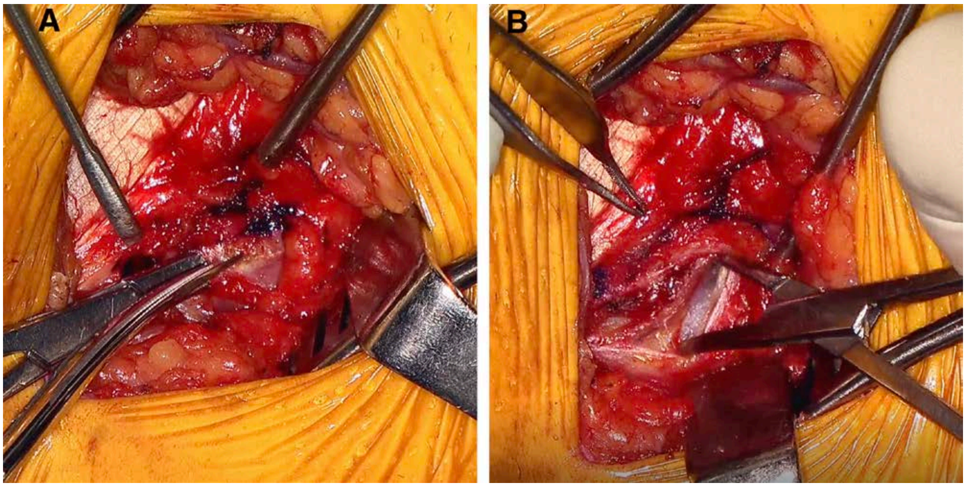

Fig. 2. The fascia lata was incised and retracted to reveal the surface of the sartorius muscle (A–B).

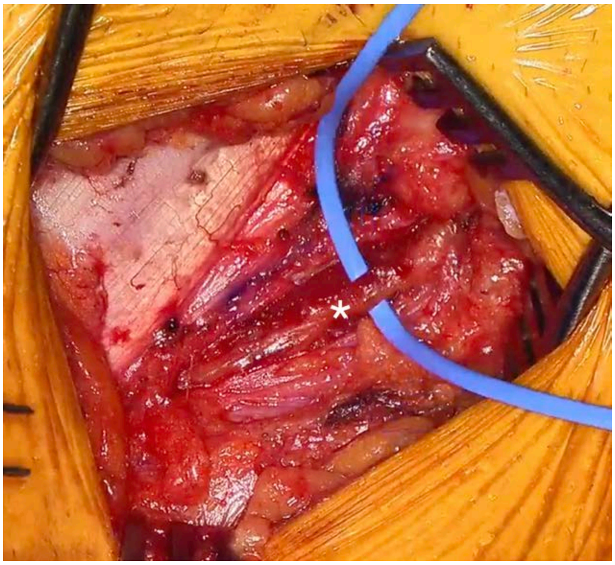

Fig. 3. Medial to the sartorius muscle, the nerve (white asterisk) was identified traveling in the correct anatomic orientation.

ligament, respectively. More recently, in 2022, Mandal et al[3] conducted a cadaveric study and found that in 95% of cases, the LFCN passes under the inguinal ligament in a narrow area of 0.6 cm (ASIS to LFCN, 1.6–2.2 cm). This is consistent with pathogenesis of MP, which is well described as entrapment of the LFCN at the inguinal ligament.[13] In this area, the nerve runs superficially and is easily compressed during hip extension. For this reason, Aszmann types A, B, and C are most susceptible to MP.[8] Less commonly, the LFCN can become entrapped at the point where it pierces the fascia lata.[13]

In the present patient, the LFCN was compressed tightly within the fascia of the sartorius muscle, distal to the inguinal ligament. This is unlike previously described points of compression of the LCFN in relation to MP. As we released the fascial compartment superficial to the nerve, an atrophic, discolored LFCN was revealed. In chronic peripheral nerve compression, nerves exhibit thickening of the walls of the microvasculature within the endoneurium and perineurium, accompanied by epineurial and perineurial edema and fibrosis.[14] Increased extraneural pressures can rapidly disrupt intraneural microvascular blood flow, hinder axonal transport, and impair nerve function within minutes to hours.[14] This can result in endoneurial edema, elevated intrafascicular pressure, and displacement of myelin, with the severity of these effects escalating in a dose-dependent manner.[14] In this report, our patient had MP for 15 years before undergoing definitive surgical treatment. This extended time period undoubtedly led to the aforementioned histopathologic changes which were apparent upon dissection of the overlying sartorius fascia.

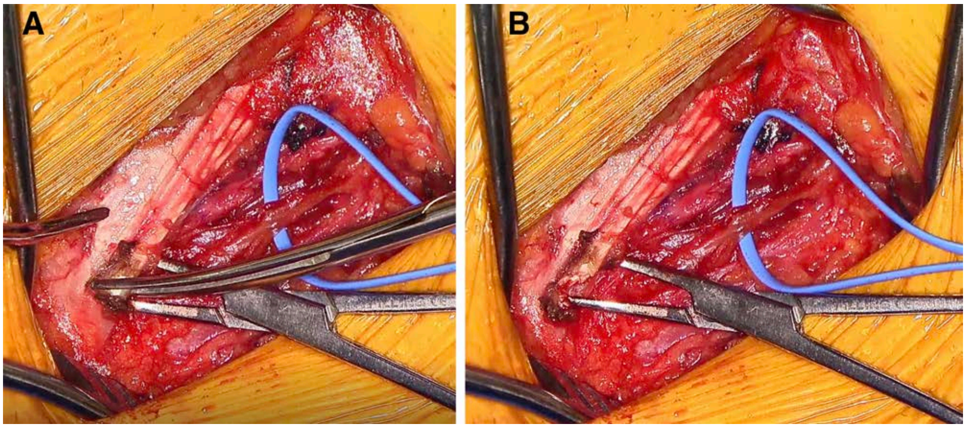

Fig. 4. The inguinal ligament was partially divided to trace and release the nerve proximally (A–B).

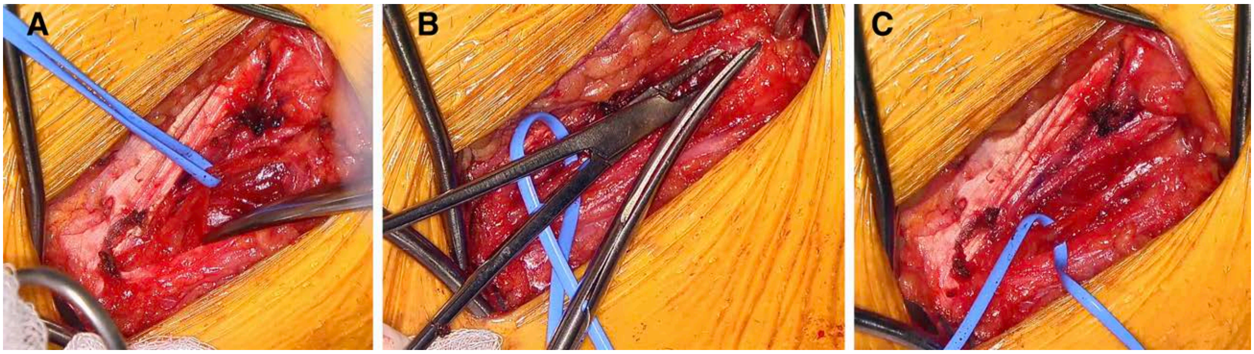

Fig. 5. The fascia was released inferiorly to free the nerve from constriction (A–C).

To date, there have been no published cases of primary LFCN release in the setting of MP using the exoscope. Few peripheral nerve procedures using the exoscope have been described in the literature. Carpal tunnel release using the exoscope was published by Rodriguez-Unda et al,[15] and the authors noted excellent visualization to delineate the normal fascicles of the median nerve, epineurium, and scar tissue as well as ergonomic benefit to the surgeon. Findlay et al[16] described a secondary LFCN release revision procedure using the exoscope, which helped distinguish pale scar tissue and pale nervous tissue due to previous surgery. In our case, the use of the Synaptive Modus X robotic exoscope as opposed to a traditional microscope or loupes facilitated a unique and efficient procedure. The 3D visualization device has gained popularity in neurosurgical spine procedures, as it has many ergonomic benefits, high magnification, ideal lighting, and the ability to share the 3D view with every person in the operating room. With this device, our team was able to effectively and efficiently perform all aspects of the operation while allowing for all team members including attendings, residents, medical students, and nurses to observe the entire operation in real time and in the same orientation as the surgeon.

Although the exoscope offers advanced visualization, superior ergonomics, and enhanced educational value, these benefits must be weighed against its higher cost compared with loupes. The exoscope requires a substantial initial investment ranging from $250,000 to $1,500,000.[17] In contrast, loupes are significantly more affordable, typically costing between $500 and $3000. For straightforward peripheral nerve decompression cases that do not require extensive visualization or intricate dissection, loupes remain a cost-effective and practical option. However, in complex cases where detailed anatomy must be visualized, or in settings where prolonged surgery is common, the ergonomic advantages and reduced surgeon fatigue provided by the exoscope could justify the higher cost. Additionally, in academic centers where training and education are a priority, the exoscope's ability to provide a shared 3D view for all team members may offer added value that offsets its initial expense. Interestingly, a systematic review by Iqbal et al[18] found that the exoscope is associated with lower costs compared with an operative microscope. Although the cost of the exoscope may not be justified for all peripheral nerve decompression procedures, its benefits in select scenarios, such as in teaching hospitals, high-volume centers, or complex surgical cases, could make it a valuable investment. Future studies directly comparing costs, surgical outcomes, and long-term benefits of exoscope versus loupe use in peripheral nerve surgery are needed to better inform these decisions.

Further supporting the benefits of using exoscopes in peripheral nerve surgery, a preliminary study by Vetrano et al[19] explored the use of the high-definition 4K 3D exoscope (ORBEYE) for Schwannoma surgery of the lower limbs. The study demonstrated that the exoscope provided excellent visualization of the anatomical details at the tumor-nerve interface, facilitating gross total resection in both cases. The exoscope also allowed for a comfortable ergonomic position for the surgeon. The 4K monitor enabled a realistic and nonfatiguing 3D view for the entire surgical team, suggesting that with an adequate learning curve, the exoscope is a feasible and effective tool for nerve tumor surgery. These findings further highlight the potential of exoscope technology in enhancing surgical outcomes, especially in cases where detailed anatomical visualization is crucial.[19]

In a recently published article by Nawabi et al,[20] the authors conducted a retrospective comparative study of all spinal procedures performed with an exoscope and traditional microscope and found that use of the exoscope resulted in a reduced operative time, decreased blood loss, shorter hospital stays, and improved clinical outcomes. A study by Kusyk et al[21] examined the proportion of time surgeons spent in a deviated posture using the exoscope versus a traditional microscope and found that surgeons spent significantly less time in a deviated posture when using the exoscope. Poor surgical posture is associated with work related neck and back pain in surgeons which can lead to degenerative cervical and/or lumbar spine disease, which can ultimately hasten a surgeon's career.[21,22] The exoscope has also been studied in head and neck reconstruction, including a study by Makihara et al[23] which studied the use of the exoscope in endoscopic endonasal and transcranial surgery. The authors concluded that the exoscope facilitated seamless coordination of multiple surgical interventions and suggested that this technique represents a significant advancement in managing complex oncological cases.[23]

Microsurgery plays an enormous role in plastic surgery, as it is mandatory for vessel anastomosis, flap harvest, lymphatic reconstruction, and nerve surgery. Traditional microscopes and loupes have served as staples for microsurgical reconstruction; however, new exoscope technology has the potential to revolutionize the way that reconstructive microsurgery is conducted. As previously mentioned, the exoscope has been increasingly utilized and studied in other specialties such as neurosurgery and head and neck surgery; however, it has not been widely adopted or studied in plastic surgery. Garcia et al[24] conducted a systematic review evaluating the exoscope as an alternative to the microscope in plastic surgery. The review included 12 articles with studies utilizing 5 exoscope systems and spanned from 2012 to 2022. Procedures included vessel anastomosis, free flaps harvest, pedicle dissection, and extremity lymphedema. Based on the results of the 12 studies, the authors found that exoscope systems are safe and serve as a valid alternative to traditional microscopes and advocate for further trials of the exoscope in plastic surgery.[24] Similar to the previously described benefits, Samaha and Ray[25] studied free flap procedures using an exoscope versus a microscope and found that surgeons reported less neck discomfort following procedures and comparable operative time between the 2 modalities.

Although the exoscope demonstrates tremendous promise in the field of plastic surgery, there have been reports of suboptimal ergonomics and prolonged operative times. Piatkowski et al[26] reported longer times to complete anastomoses in autologous breast reconstruction cases with the exoscope. Operative complications, however, were comparable between the two groups. This contrasts with Samaha and Ray's experience using the exoscope for DIEP flaps, in which ischemia time was on average 10 minutes less with the exoscope compared with the microscope.[25] Fiani et al[17] postulated that prolonged operative times with the exoscope may be due to a learning curve that surgeons may experience when acclimating to the new technology. In terms of ergonomics, Wang et al[27] found that ergonomic benefits of the exoscope were dependent on the tasks that the surgeon was performing, and in some instances, when performing a DIEP flap, the exoscope led to suboptimal ergonomics. Further studies comparing the exoscope to the traditional microscope and loupes are undoubtedly warranted, specifically looking at ischemia time, operative time, complication profiles, and ergonomic outcomes.

CONCLUSIONS

The authors present a distinct case of MP and LFCN entrapment in the sartorius fascia as well as the first description of primary LFCN decompression surgery using the Synaptive Modus X robotic exoscope. The exoscope provided clear, excellent visualization to delineate the anatomic details, pathway, and compression site of the LFCN. This technology can be safely used as an alternative to the microscope in nerve decompression procedures and broader plastic surgery microsurgical procedures. However, further studies are needed to comprehensively evaluate its long-term efficacy, safety, and potential benefits across various plastic surgery procedures.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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