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Clinical results of surgical neurectomy of Morton's neuroma

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ARTICLE INFO

Keywords:
Forefoot
Morton
Neurectomy

Received: May 19, 2024
Accepted: Jul 23, 2024
Available Online: 26.07.2024

DOI:
10.5455/annalsmedres.2024.05.095

Abstract

Aim: Morton's neuroma (MN), specifically with its forefoot placement, sometimes significantly impacting patients' quality of life. The aim of this study is to present the outcomes of neurectomy surgeries performed for MN disease. Investigating the impact of this surgery, which has a complication such as hypoesthesia, on postoperative patient satisfaction, is the targeted objective.

Materials and Methods: Seventeen masses of 16 patients were studied. In patients diagnosed with MN mass through physical examination and imaging techniques, a 3 cm incision was made to excise the nerve mass either dorsally or plantar under spinal anesthesia. During routine outpatient follow-ups, the American Orthopedic Foot and Ankle Society (AOFAS) score, Visual Analog Scale (VAS) score, and Coughlin's criteria were assessed both preoperatively and postoperatively. The effects of conservative treatments such as preoperative orthoses and steroid injections on pain scores were recorded and evaluated. Recurrence of mass development and wound issues were investigated to evaluate the outcomes.

Results: The mean age at the time of surgery was 46.75 years (26-58 years). The mean follow-up period was 23.12 (6-75 weeks) weeks. After surgery, excellent results were achieved in 9 patients (64.3%), and good results were obtained in 4 patients (28.6%). Recurrent mass development occurred in two patients (12.5%). Two patients (12.5%) were operated on with a plantar approach, and one patient with recurrent massbelonged to this group. Hypoesthesia was described in 15 out of 16 patients. There were significant improvements between patients' preoperative VAS and AOFAS scores and postoperative VAS and AOFAS scores, which were statistically significant ($p < 0.001$).

Conclusion: Numerous studies have been conducted on the diagnosis and treatment of MN disease, yet a common procedure has not been developed. Among existing treatments, excision of the mass with some healthy nerve tissue and a dorsal approach to the foot are commonly employed methods. Dorsal neurectomy surgeries demonstrate a success rate exceeding 80%. Informing patients about the possibility hypoesthesia before surgery and establishing realistic expectations can make this procedure safely applicable.

Introduction

Morton's neuroma (MN) is a mass lesion that podiatrists occasionally encounter, causing symptoms such as pain and paresthesia on the plantar surface of the forefoot. In fact, rather than a true nerve mass, it is a fusiform benign swelling of the common digital nerve characterized by perineural fibrosis, local vascular proliferation, and axonal degeneration [1,2]. Due to its typical location in the forefoot, synovitis involving the metatarsophalangeal joint can be confused with the clinical presentation of Morton's neuroma. Once a mass is detected, it is necessary to differentiate between benign lesions such as forefoot ganglion cysts, epidermal inclusion cysts, and giant cell tumors of the tendon sheath, as well as relatively more prominent malignant masses in the forefoot, such as synovial sarcoma. Although the etiology of this condition remains a subject of debate, various theories have been proposed to explain it. These include the ischemic theory, which involves thrombosis developing in the common digital artery that supplies the nerve, degeneration occurring with thickening of the arterial wall, and secondary fibrotic changes in the nerve; pressure from the deep transverse metatarsal ligament; pressure from intermetatarsal bursitis; and the theory of chronic pressure following repeated microtrau-

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mas [2]. Based on the underlying cause, these theories guide treatments. Considering the theory of chronic pressure from repeated microtraumas, wearing pads to reduce metatarsal pressure and wearing low-heeled, wide-toed shoes are recommended [3]. Corticosteroid injections into the intermetatarsal bursa have been developed as a treatment for intermetatarsal bursitis, aiming to reduce inflammation and alleviate [4]. There are cases of MN approached as a nerve entrapment clinic, and treatment planning, primarily considering the theory of pressure from the deep transverse ligament, involves cutting the ligament [5]. There is not a single cause for the development of MN; rather, various pathological processes are at play. Therefore, despite excluding deficiencies and inadequacies in treatments, outcomes such as recurrence of mass development and unresponsiveness to conservative treatments are observed regardless of the treatment applied.

This study aims to present the outcomes of neurectomy surgeries performed for patients diagnosed with MN, thereby shedding light on the efficacy of surgical intervention in managing this condition. Additionally, it seeks to demonstrate the effectiveness of neurectomy surgeries in managing MN and to offer insights into the optimal surgical approach for achieving satisfactory outcomes.

Materials and Methods

Our study is a retrospective study involving 16 patients with a confirmed diagnosis of MN based on pathology, who presented with complaints of pain and paresthesia in the forefoot and were surgically treated at the orthopedics and traumatology outpatient clinic of Inonu University. The study was approved by the Inonu University Ethics Committee (2024/5912). Patients with complete medical records, regular follow-ups, and surgical treatment for MN were included in the study. Patients with incomplete medical records, irregular follow-ups, or a post-surgery change in diagnosis were excluded.

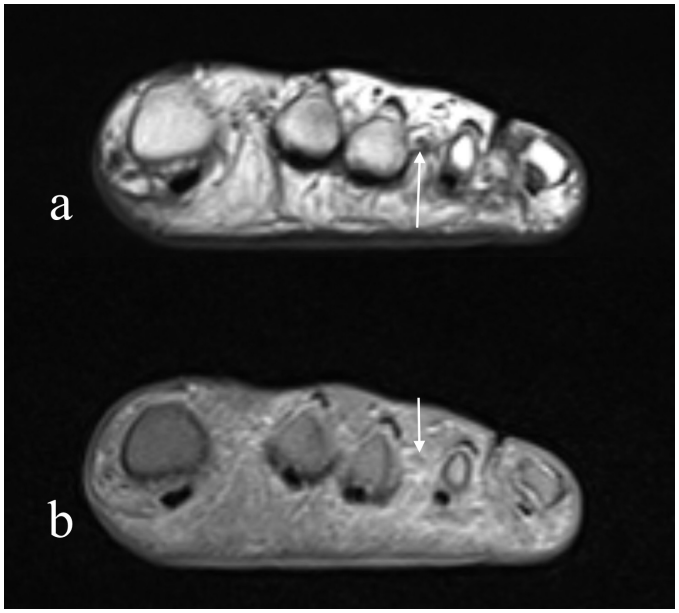

Figure 1. T1(a) and T2(b) MRI images of Morton's neuroma (arrow) in the third web space of a 56-year-old male patient.

Figure 2. Incision over the 3th web space between metatarsal heads.

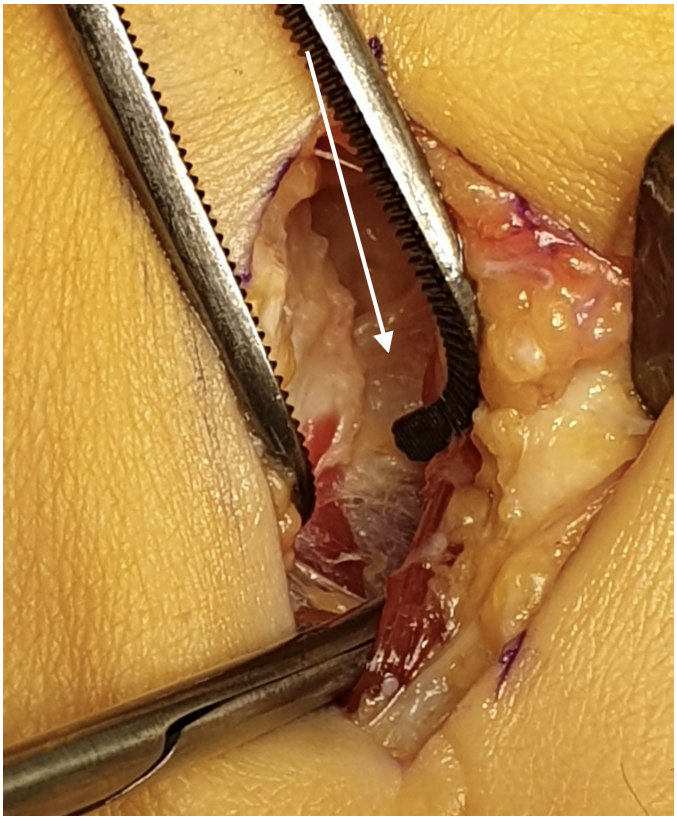

Figure 3. Appearance of the transverse ligament the between 2 and 3 intermetatarsal heads (arrow).The retractor (or clamp) facilitates exposure.

When patients were initially evaluated at the outpatient clinic due to pain in the forefoot, a detailed medical history was taken, and a physical examination focused on their pain symptoms was performed. The medical history included the presence of any additional diseases, regular medication use for any reason, smoking history, history of previous fractures or dislocations, previous visits

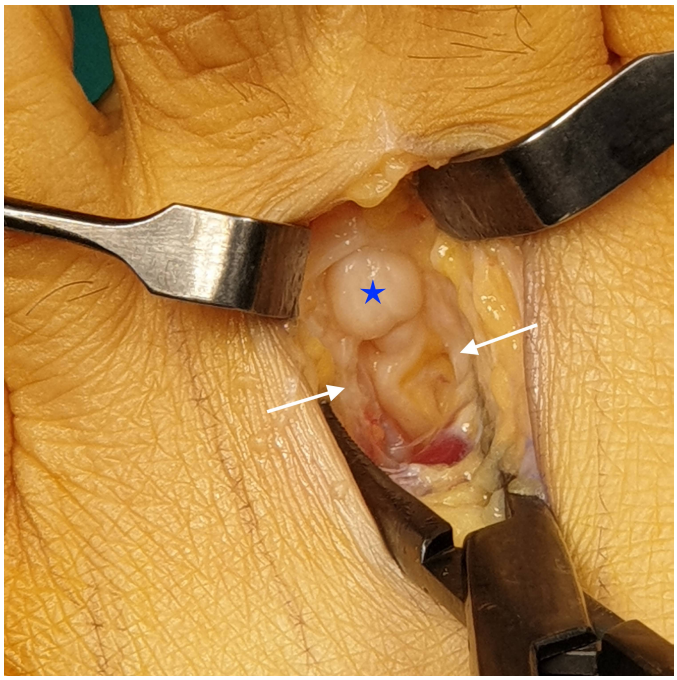

Figure 4. The transverse ligament was released (arrows) and the 2–3 intermetatarsal neuroma (asterisk) was seen before excision.

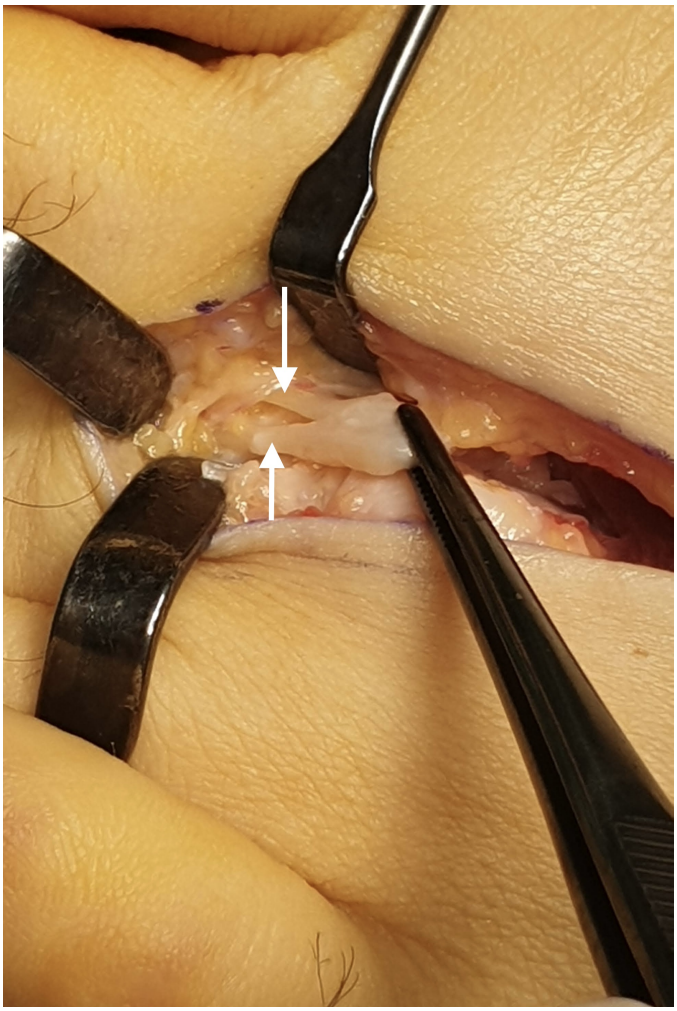

Figure 5. The nerve and neuroma tissue are exposed in a manner that included 1 cm distal (arrows) and approximately 2 cm proximal.

to other centers for pain, and conservative treatments applied based on secondary diagnoses. Among the conservative treatments, inquiries were made about shoe modifications, orthotic use, and the use of steroids or other injections. The duration of patients' preoperative complaints was recorded and evaluated postoperatively. Body mass index (BMI) was measured during the physical examination of each patient. Pain in the affected area was assessed by palpation, and Mulder's sign was investigated in patients suspected of having MN.

Patients were routinely evaluated for traumatic bone lesions and bone pathologies in the forefoot joints (arthritis, hallux valgus, etc.) by taking antero-posterior and lateral biplanar foot radiographs. Rapid imaging modalities such as ultrasound (USG) were performed in 4 patients (25%) for soft tissue lesions and space-occupying lesions suspected to be MN. Magnetic resonance imaging (MRI) was performed in all patients with suspected masses (Figure1). Following physical examination and review of medical history, open surgery was performed in patients with suspected to have MN after confirming the presence of a mass through imaging modalities.

The surgery was performed by two different surgeons using the same procedures. The plantar approach was applied in 2 cases (11.7%). In 15 cases (88.2%), excision was performed via a dorsal approach. In the dorsal approach, under spinal anesthesia, a tourniquet was inflated, and a 3 cm longitudinal incision was made dorsally on the forefoot at the location of the lesion (Figure 2). Interosseous fascia and muscle tissue were dissected, reaching the deep transverse ligament between the metatarsal heads. The deep transverse ligament was cut, and the common digital nerve and neuroma tissue were explored (Figure 3-4). The nerve and neuroma tissue were excised in a manner that included 1 cm distal and approximately 2 cm proximal to the intact portion of the common digital nerve, along with the neuroma tissue, in a single piece (Figure 5-6). The excised intraoperative material was sent to the pathology laboratory for examination as a specimen. The tourniquet was deflated, bleeding control was performed, and the skin and subcutaneous tissues were primarily closed. Weight-bearing postoperative shoes for three weeks were given the patients. The patient was seen at the outpatient clinic in the 2nd week for suture removal.

Patients were evaluated preoperatively and postoperatively using the American Orthopedic Foot and Ankle Society (AOFAS) score [6] and the Visual Analog Scale (VAS) score. The AOFAS score (1-100) was used to assess foot joint motion, pain, anatomical alignment, and gait analysis. The VAS score (0-10) was used solely to evaluate pain. Additionally, postoperative follow-ups utilized Coughlin's criteria to assess patient satisfaction [7]. Complications such as postoperative wound infection, wound dehiscence, and scar formation were monitored. Follow-ups were also conducted to observe the recurrence of mass development and to track patients' return to work, time to resume wearing shoes, and other aspects of returning to daily life (Table 1).

Figure 6. The nerve and neuroma tissue appearance that were excised in a manner that included 1 cm distal and approximately 2 cm proximal to the intact portion of the common digital nerve, along with the neuroma tissue, in a single piece.

Table 1. Scores used in the evaluation of patients.

	Pain	Gait function	Anatomical alignment
AOFAS	+	+	+
VAS	+	-	-
Coughlin's criterias	+	+	-

AOFAS: (100-90 excellent, 89-80 good, 79-70 fair, below 70 poor) VAS: (0=no pain, 0-3 mild pain, 4-6 moderate pain, 6-9 severe pain, 10= constant pain) Coughlin'scriteria: (excellent, good, fair, poor).

Statistical analysis

Statistical analyses were performed using the SPSS version 26.0 package program. Descriptive statistics were expressed as number (percentage) and median (interquartile range). The normal distribution of variables was examined using the analytical method Shapiro-Wilk test. Categorical variables were evaluated using the Pearson chi-square test. Preoperative and postoperative scores were compared using the Wilcoxon test. In the statistical analysis of the study, comparisons with a p value below 0.05 were considered statistically significant.

Results

Seventeen MN's of 16 patients were operated. One patient had bilateral morton neuroma mass. The mean age of the patients at the time of surgery was 46.75 years (26-58 years). The mean follow-up period was 23.12 (6-75 weeks) weeks. The average body mass index of the patients was 27,73 (24,1-31,05kg/m^2). Demographic data, including the side of the MN and its location in the foot, are provided in (Table 2). Before surgery, corticosteroid injections targeting the mass were administered to only one patient (6.25%), while conservative treatments such as shoes and orthotics were attempted for at least 3 months in eight patients (50%). Sclerosing agent injection and other conservative treatment methods were not applied.

Table 2. Demographic data of the patients and localization of the masses.

	n	%
Gender		
Female	13	81.3
Male	3	18.8
Smoking		
Never	9	56.3
Intermittent	3	18.8
Permanent	4	25
Side		
Right	10	58.8
Left	6	35.29
Bilateral	1	5.88
Location		
2.web	5	29.41
3.web	12	70.59
Preoperative		
X ray	15	93.8
USG	4	25
MR	16	100
Mulder's sign		
Yes	8	50
No	4	25
Undetectable	4	25

When giving the location and side information of the neuromas, the number of masses has taken into consideration, not the number of patients.

Table 3. Analysis of surgical approach choice in terms of Coughlin's criterias.

	Dorsal Approach	Plantar Approach	p*
Excellent	9 (64.3)	0 (0.0)	0.025
Good	4 (28.6)	0 (0.0)	
Fair	0 (0.0)	1 (50.0)	
Poor	1 (7.1)	1 (50.0)	

*: Pearson chi-square test.

Table 4. Functional outcomes of the patients.

	Median (IQR)	95% CI	p*
VAS score			
Pre-op	8.5 (1)	(8-9)	<0.001
Post-op	1 (3)	(46-50)	
AOFAS score			
Pre-op	46 (5)	(1-4)	<0.001
Post-op	90 (13.5)	(90-100)	

IQR: Interquartile range; CI: Confidence Intervals *: Wilcoxon test.

Additionally, postoperative steroid injections were administered to 2 patients (12.5%). One of these two patients experienced complete pain relief after the injection, while the pain persisted in the other patient. There was no significant relationship between preoperative AOFAS and VAS scores and the conservative treatments administered to the patients (p =0.136).

There was no difference in postoperative pain scores between smokers and non-smokers when evaluating postoperative smoking status. Statistically, no significant relationship was found between smoking status and pain scores (postoperative VAS p>0.37, postoperative AOFAS p> 0.39). Additionally, there was a positive correlation between an increase in BMI and postoperative pain complaints. There was a significant positive relationship between BMI increase and decrease in AOFAS score (p <0.05).

After the operation, intermittent pain was reported in 3 patients (18.75%) out of 17 masses. Two patients (12.50%) experienced persistent pain similar to pre-surgery levels. Pain completely disappeared in 11 patients (68.75%). According to the Coughlincriteria, outcomes were rated as excellent in 9 patients (56.3%), good in 4 patients (25%), fair in 1 patient (6.3%), and poor in 2 patients (12.5%).Mass recurrence was observed in two patients (12.5%). While complaints persisted in one patient, mass recurrence occurred in another patient who underwent MN excision with a plantar approach. Following mass excision with a dorsal approach, only one patient experienced mass recurrence. There was a statistically significant difference in patient satisfaction according to the surgical approach. It was observed that patient satisfaction was higher with the dorsal approach (p=0.025) (Table 3).

The mean preoperative AOFAS score for the patients was 46, with a range of 39-56. The postoperative AOFAS score was found to be 90 (range: 66-100). Preoperative VAS score was 8.5 (range: 7-9), while postoperative VAS score was 1 (range: 0-8). Statistically significant improvements were observed in patients' functional outcomes both before and after surgery (p<0.001) (Table 4). Postoperatively, scar formation was observed in one patient (6.25%), but none of the patients experienced wound dehiscence, wound infection, or any complications related to the incision site. Except for one patient, hipoesthesia in the incision area and toe was reported in 15 patients (93.75%). The average time for patients to return to work after surgery was 8.12 weeks (range: 3-17 weeks). The time to resume wearing shoes paralleled the time to return to work, with an average of 8.31 weeks (range: 4-20 weeks). Despite continuing complaints without recurrence, the patient with the lowest postoperative AOFAS score showed improvement, increasing from 39 to 66.

Discussion

MN is also referred to by names such as interdigital neuroma, interdigital neuritis, or Morton's metatarsalgia [8]. This is because it is not a true peripheral nerve tumor, but rather a lesion within the nerve tissue. The etiology of this condition, changes observed in the nerve, and the mechanism of formation are currently under intense research, and debates continue. However, diagnosing the disease, with its specific location in the forefoot and advancements in imaging techniques, is relatively simpler than determining its cause, which remains a subject of debate. Although there is no consensus among foot surgeons regarding treatment, conservative treatments have limited efficacy in terms of cure [9]. Surgical treatments include nerve excisions performed through various approaches such as plantar, dorsal, or direct web space, as well as open, endoscopic, or minimally invasive neurolysis techniques aimed at eliminating compression [10]. The goal of different techniques is to improve surgical outcomes and minimize complications [11]. With the dorsal approach we applied, we achieved both high patient satisfaction and satisfactory functional results through neurectomy.

MN is more commonly observed in middle-aged women compared to men. The third interdigital space is the most common location, followed by the second interdigital space [2,12]. Although side predominance is not mentioned, bilateral mass presence is also possible. Recent study have reported case of multiple neuromas within the same foot, highlighting the importance of considering this possibility [13]. Additionally, a case presentation of an interdigital neuroma with an atypical location in the first interdigital space has been shared recently [14]. In our study, neuromas are more common in female patients and most frequently located in the third interdigital space. Bilateral masses were also observed in one of our patients. Knowing such demographic data facilitates early and rapid diagnosis. However, it should be kept in mind that masses may rarely have atypical locations and may be present in significant numbers.

Mechanical metatarsalgia is characterized by pain at the metatarsophalangeal joint and develops secondary to anatomical and functional abnormalities in the metatarsals. In a study, alcohol injection was administered for MN in patients who also had a clinic that would cause mechanical metatarsalgia. Resistant symptoms were observed in a limited number of patients [15]. Only 2 cases among our sex hibited arthritic changes in the joint, and these patients did not experience recurrence, achieving satisfactory results. Additionally when examining risk factors for MN, running on hard surfaces and wearing narrow and pointed-toe shoes are emphasized. Factors such as smoking and obesity have not been associated with resistant symptoms. However, the development of neuropathic pain in patients requiring foot and ankle surgery has been investigated [16]. Severe neuropathic pain symptoms were associated with smoking and moderate neuropathic pain symptoms were associated with increased body mass. In another study, it was reported that there was no relationship between BMI and neuroma [17].

We also questioned patients about smoking habits and recorded their BMI. Our research revealed that smoking status did not significantly impact preoperative or postoperative pain levels or functional outcomes. However, there was a significant relationship between increased BMI and decreased AOFAS scores. Although weight gain may not directly affect the development of masses, it can adversely affect surgical outcomes. It is important to carefully evaluate patients before surgery and determine the causes of pain. When patients present with additional pathologies

alongside MN, factors such as smoking and weight gain can have clinical implications and influence surgical outcomes.

Diagnosis for MN disease is primarily clinical. Burning pain in the areawhere the mass is located is essential. Intensification of pain with tight shoes, alleviation of complaints with shoe changes and massage are typical [8]. During clinical examination, specific tests such as the toes queeze test, thumb-index finger test, and Mulder test are commonly used for diagnosing MN [18]. While these tests can aid in diagnosing the disease, they require skilled interpretation by an experienced physician. Additionally, the size of the mass is particularly important in the Mulder test. Because in masses smaller than 1 cm, a clicking may not occur, and the test may be interpreted as false negative. Imaging methods, such as x-ray films, play a crucial role in confirming the diagnosis and differentiating MN from osseous pathologies such as osteoarthritis and stress fractures [8]. MRI is considered the gold standard for diagnosis [18]. However, in addition to being inexpensive, ultrasound applications have been found to be equivalent to MRI for MN in terms of high diagnostic accuracy, and even better [1,19].

In half of our patients, the Mulder sign was positive. In the remaining patients, the absence of a clicking during the Mulder test may be attributed to the size of the mass. Additionally, our patients were routinely evaluated for additional diseases with X-rays, and all of them underwent an MRI for further diagnosis, revealing the mass. Although ultrasound is more accessible and cost-effective, its diagnostic accuracy for MN depends on the skill of the operator, similar to the clinical examination. Therefore, if conditions are suitable, we recommend evaluating with MRI.

Non-surgical treatment options for MN are quite diverse. Among these are shoe modifications and orthotics, various injections (corticosteroid, alcohol, capsaicin, botox), cryoablation and radiofrequencyablation methods, extracorporeal shock wave therapy, and laser applications [20,21]. Some of these treatments are relatively new and require comprehensive studies, but corticosteroid injections are among the commonly used treatments in MN clinics. In our patients, initial conservative treatments were also applied before surgery. Despite evaluating preoperative VAS and AOFAS scores for curative treatment assessment, no significant improvement was observed. Significant clinical improvement was observed in one of our patients after postoperative corticosteroid injection. We believe that combining conservative treatments with surgery may yield better results in MN disease.

Surgical procedures for MN disease include intermetatarsal transverse ligament release performed with neurolysis, neurolysis combined with nerve transposition, and neurectomy with excision of the common digital nerve. The outcomes and postoperative satisfaction rates of patients undergoing neurectomy have been shared in the literature [22-24]. These studies frequently report clinical improvement rates and patient satisfaction levels of up to 80% following neurectomy, particularly when performed via the dorsal approach. Similar clinical outcomes have been achieved in patients undergoing neurectomy via both dorsal and plantar approaches, but dorsal approach surgeries have shown more wound-related problems and sensory loss issues in terms of postoperative complications [25]. Another study comparing the two approaches in terms of woundissues has also shared the superiority of the dorsal approach [26]. Additionally, it has been suggested that dorsal release surgeries may be more favorable in terms of complications compared to neurectomy and can serve as an alternative procedure [5]. In our cases, we performed neurectomy and achieved satisfactory results of over 80% clinically, similar to the literature. However, in one case treated with a plantar approach, we obtained poor results, while in another case, moderate results were achieved. The reason for this may be related to the negligible number of patients who underwent plantar neurectomy compared to dorsal neurectomy.

While there is not a wealth of data on this topic in the literature, the average time for returning to wearing shoes and returning to work after MN surgery ranges from 6 weeks to 3 months, serving as an indicator of clinical outcomes [27]. In our series, this period averaged 8.12 weeks (ranging from 3 to 17 weeks). Before surgery, patients should be informed of these data to establish expectations.

The most common complication is hypoesthesia secondary to neurectomy. In addition, wound infections, wound dehiscence and painful scar formation are the problems that postoperative surgeons will deal with. In addition to these complications, recurrent mass development and failure to improveclinically are also undesirable outcomes. The causes of recurrent mass development include misdiagnosis, inadequate excision, stump neuroma development and adhesions [28]. In our cases, wound infection and wound dehiscence were not observed in any patient. This can be prevented with appropriate postoperative care. Scar development is more common in surgeries performed with plantar approach [29]. In contrast to the common association of scar development with surgeries performed via the plantar approach, we applied dorsal approach neurotomy in the case of our patient who developed a scar after surgery. Despite this, the postoperative scores for this patient were quite high, and the treatment satisfaction was excellent.

The presence of hypoesthesia was reported by patients during questioning, but it did not significantly affect the overall outcomes. At present, the most significant concern lies in the development of recurrence. In a cadaver study, the extent of excision from the healthy part of the nerve has been investigated [30]. We encountered recurrent masses in two of our patients. In these patients, the functional outcomes were poor independent of recurrence. While the development of stump neuroma may not be entirely predictable, further research is warranted to elucidate the optimal extent of resection necessary to prevent recurrence.

This study has several limitations. Firstly, it is a single-center and retrospective study. Secondly, the number of patients is relatively small. Lastly, longer follow-up periods could provide more valuable results.

Conclusion

In conclusion, MN is a condition specific to the forefoot and remains a subject of significant debate regarding its etiology, the choice of diagnostic imaging modalities, and

treatment. Numerous innovations are emerging, particularly in conservative treatments, to achieve optimal results. However, surgical outcomes demonstrate success rates exceeding 80%. Despite the complexity surrounding surgical intervention, dorsal approach neurectomy appears to be the preferred initial treatment option, provided patients are adequately informed.

Ethical approval

This study was approved by the İnönü University Faculty of Medicine Scientific Research Evaluation Board with the decision numbered 2022/2542 in the 03th session of the meeting dated 08/02/2022.

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