

ORIGINAL PAPERS

Adv Clin Exp Med 2016, 25, 2, 295–302
DOI: 10.17219/acem/60249

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ISSN 1899–5276

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Long-Term Results of Neurectomy Through a Dorsal Approach in the Treatment of Morton's Neuroma

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation;
D – writing the article; E – critical revision of the article; F – final approval of article

Abstract

Background. Morton's neuroma, a painful enlargement of the plantar digital nerve between the metatarsal heads, is a common cause of metatarsalgia. The etiology and treatment are still a controversial matter.

Objectives. The objective of this study was to evaluate the long-term follow-up results of neurectomy through a dorsal approach and to identify prognostic factors that can affect the final outcome.

Material and Methods. The study included 41 patients who were treated for Morton's neuroma. Their average age was 44 years (range: 25–69 years). The average follow-up time was 7.4 years (range: 5–12 years). Surgery was performed through a dorsal approach. The clinical evaluations, visual analog scale (VAS) scores and American Orthopedic Foot and Ankle Society (AOFAS) scores were assessed.

Results. The mean preoperative AOFAS score was 39.4 ± 7.84 and the mean postoperative AOFAS score was 83.4 ± 12.1 . The mean preoperative VAS scale was 7.04 ± 1.4 and the mean postoperative VAS scale was 1.4 ± 0.8 . There were 31 patients (76%) with very good results in the subjective and objective patient assessments; six (15%) had good results; one (2%) had satisfactory results and three (7%) had poor results. Statistically significant differences in the results between single and multiple neuromas were found, depending on the size of the neuromas and the duration of the symptoms. There were no statistically significant differences depending on the time between surgery and assessment, on steroid injections before operation or on the duration of preoperative conservative treatment.

Conclusions. Despite the development of less invasive techniques and very good outcomes in a short period of time, long-term results have shown that neurectomy is still useful in the treatment of Morton's neuroma. The results of the study show that the outcome does not change during the postoperative follow-up period. The best results were achieved in the case of single neuromas larger than 3 mm that were resected within 12 months of the onset of symptoms (*Adv Clin Exp Med* 2016, 25, 2, 295–302).

Key words: Morton's neuroma, metatarsalgia, neurectomia.

Morton's neuroma a painful enlargement of the plantar digital nerve between the metatarsal heads, is a common cause of metatarsalgia [1]. There are many discrepancies in the literature regarding the prevalence of this syndrome, ranging from 5% to 36% [1–3]. The etiology and treatment are still controversial matters. Today, Morton's neuroma is classified as an entrapment neuropathy [4, 5].

The nerve is compressed between the anterior edge of the deep transverse ligament and the plan-

tar soft tissue as well as the intermetatarsal bursa, causing an inflammatory process [1]. Compression of the nerve is mostly formed about 5 mm proximal to the metatarsophalangeal joint (MPJ). The pressure occurs where the digital nerve goes through the tunnel between the deep transverse intermetatarsal ligament and superficial transverse ligament [6]. Other proposed etiological theories involve chronic repetitive trauma and ischemia [7].

The most commonly affected digital nerve is located in the 2nd and the 3rd intermetatarsal spac-

es (between the 2nd–3rd and 3rd–4th metatarsal heads) [2]. Morton's syndrome is characterized by pain and numbness which increase when walking or overburdening of the limb, and decrease after resting or taking off the shoes.

A diagnosis of Morton's neuroma requires a careful clinical history correlated with the condition's unique set of characteristics found on examination [8]. Clinical examination is still the gold standard for diagnosing Morton's neuroma [9]. Mulder's sign [3, 10], as well as Gauthier's [11] and Bratkowski's [12] tests, are recognized as highly useful. Care must be taken to rule out other possible etiologies of symptoms in this area of the forefoot, including stress fracture, neoplasm, rheumatoid nodule, bursitis, MPJ disorders, metabolic neuropathy, fibromyalgia, and other chronic pain syndromes. For this purpose an X-ray is performed [13]. Ultrasonography or MRI are recommended to confirm the diagnosis [14–16]; however, due to the common occurrence of asymptomatic intermetatarsal nerve enlargement, they are of limited relevance. On the other hand, diagnostic tests have shown no correlation between the size of the lesion, clinical examinations and histopathological examinations.

Despite using the name neuroma, in the histopathological examination, its features have not always been found. As Pace et al. wrote, "The lesion consists of perineural fibrosis, local vascular proliferation, edema of the endoneurium and axonal degeneration. Macroscopically it has a typically fusiform configuration, a glistening and white to yellowish-white appearance and a relatively soft consistency" [1].

The primary treatment for metatarsalgia is conservative [10, 17]: The patients use orthopedic devices, undergo rehabilitation and are given anesthetic and corticosteroid injections. If conservative methods fail, surgery should be performed, in which case there is a choice between neurolysis [18, 19] and neurectomy through a dorsal approach [8, 20, 21] or a plantar approach [22–24].

Many new noninvasive and effective methods for treating Morton's neuroma, such as ultrasound alcohol injection [25, 26] and ultrasound radiofrequency ablation [27], raise the question of the usefulness of and the indications for surgical excision of the intermetatarsal nerve. The objective of this study was to evaluate the long-term follow-up results of neurectomy through a dorsal approach and to identify prognostic factors that can affect the final outcome.

Material and Methods

Between 2004 and 2010, 41 patients (35 women and 6 men) were surgically treated for Morton's neuroma at Wrocław Medical University's Clinic of Traumatology and Hand Surgery (Wrocław, Poland). The average age was 44 years (range: 25–69 years) (Table 1). The average follow-up period was 7.4 years (range: 5–12 years), with examinations after six and 12 months, as well as after 5+ years. Before surgery, the patients had complained about pain lasting from 6 to 18 months. In doubtful cases, the diagnosis was expanded in order to include ultrasound and MRI. All the patients were initially treated conservatively with pads, orthopedic shoes and steroid injections, without satisfactory results. Patients were qualified for surgery procedure after a minimum three-month period of conservative treatment. Each of them underwent a diagnostic examination (Mulder's sign, Gauthier's test) and was given an injection of an anesthetic in the appropriate intermetatarsal space. Surgery was then performed through a dorsal approach. After protecting the sensory branches extending from the superficial peroneal nerve, the interosseous fascia was incised. After unveiling the interosseous muscles, the superficial and deep ligaments were reached. The nerve was resected for a minimum of 2 cm proximal to and 1 cm distal from the neuroma (Fig. 1–2). The neuroma was then removed (Fig. 3). The collected material was sent for histopathological examination (Fig. 4).

Outcomes were evaluated on the basis of the patients' subjective assessment and objectified us-

Table 1. Patients' characteristics

Sex, n (%)	female	35 (85%)
	male	6 (15%)
Age [y]	X ± SD	44.9 ± 10.1
	Me (range)	44 (25–69)
Morton's neuroma, n (%)	single	33 (80.5%)
	multiple	8 (19.5%)
Size of neuroma, n (%)	< 3 mm	21 (51%)
	> 3 mm	20 (49%)
Morton's neuroma localization – intermetatarsal space, n (%)	2 nd	7 (17%)
	3 rd	20 (49%)
	4 th	6 (15%)
	multiple locations	8 (19%)

X – mean; Me – median, SD – standard deviation.

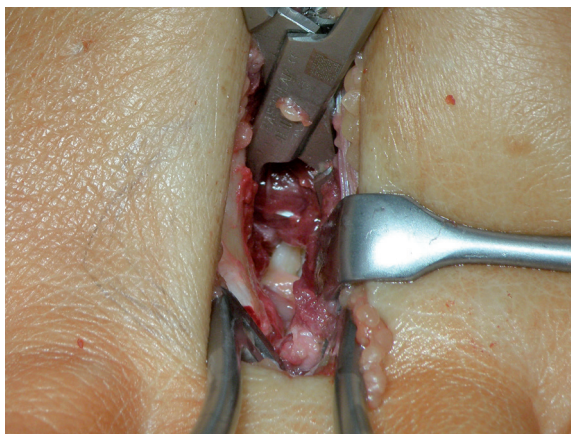


Fig. 1. Intrasurgical image showing an interdigital neuroma of the plantar nerve in the 3rd interdigital space

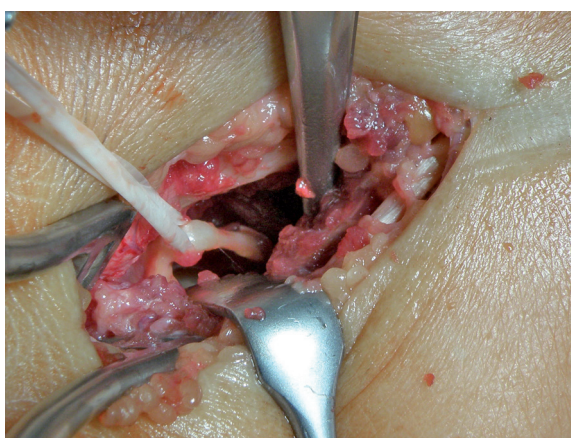


Fig. 2. Intrasurgical image showing a dissected neuroma in the 3rd interdigital space

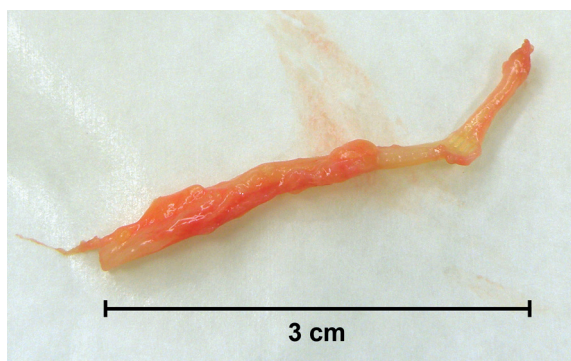


Fig. 3. Intrasurgical image showing an excised neuroma from the 3rd interdigital space

ing a visual analogue scale (VAS) and the American Orthopedic Foot Ankle Society (AOFAS) questionnaire. Patients were asked whether the symptoms had been relieved or not, and if they would agree to undergo surgery again. The results were classified as “very good” when at least two of the three following criteria were fulfilled: pain relief, VAS 0-1 points, and more than 40 points of progress on the AOFAS scale. The criteria for the

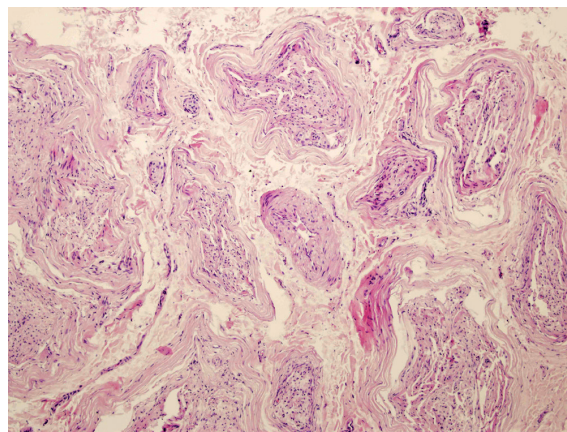


Fig. 4. Histologic appearance of a neuroma (magnification 200, hematoxylin-eosin staining)

results to be classified as “good” were as follows: significant pain relief, VAS 0-1 points, more than 30 points of progress on the AOFAS scale. Results were considered “poor” when a patient required a second operation. The results were “satisfactory” when they were classified as neither very good, nor good, nor poor.

The statistical analysis was conducted using STATISTICA v.10 software (StatSoft Inc., Tulsa, OK, USA). The associations between two categorical variables were tested using the chi-square test. To compare the distribution of two independent samples, the Mann-Whitney U test was used; for more than two, the Kruskal-Wallis test was used. More than two dependent samples were tested by Friedman’s two-way analysis of variance by ranks. Significant test results of the Kruskal-Wallis test and Friedman’s two-way analysis of variance by ranks were followed up with pairwise comparisons. Nonparametric methods were used because the Shapiro-Wilk test showed the data were not normally distributed. The likelihood of committing a type 1 error was set to 0.05.

Results

In the study group, 31 patients (76%) had very good results; six (15%) had good results; one (2%) had satisfactory results; and three (7%) had poor results in the subjective and objective patient assessments. In four cases superficial wound infections occurred, but did not require additional treatment. Many of the patients complained of numbness (68%), tingling (80%) and tenderness (61%). The patient data, localization and size of neuromas are presented in Table 1.

When the results were analyzed in relation to the time after surgery, the results observed after six months, 12 months and five years were signif-

Table 2. AOFAS score and VAS scale before surgery and at follow-up points

		Before surgery	After 6 months	After 12 months	After 5 yrs	p*
AOFAS	X ± SD	39.4 ± 7.8	87.4 ± 8.6	84.8 ± 11.0	83.4 ± 12.1	< 0.001
	Me (range)	40 (25–55) ^{a,b,c}	90 (60–100) ^a	85 (50–100) ^b	85 (45–100) ^c	
VAS	X ± SD	7.0 ± 1.4	1.1 ± 0.6	1.2 ± 0.5	1.4 ± 0.8	< 0.001
	Me (range)	7 (4–9) ^{a,b,c}	1 (0–2) ^a	1 (0–2) ^b	1 (0–3) ^c	

X – mean, Me – median, SD – standard deviation; * – Friedman two-way analysis of variance by ranks; a, b, c – pairwise comparison with $p < 0.005$ following Friedman two-way analysis of variance by ranks.

Table 3. Post-treatment AOFAS and VAS scores in relation to single and multiple neuromas, the time between the first symptoms and the surgery, the size and the location of the neuroma

		AOFAS after 5 years		VAS after 5 years	
		x ± SD Me (range)	p	x ± SD Me (range)	p
Morton's neuroma	single	85.8 ± 9.5 85 (50–100)	0.020*	1.2 ± 0.7 1 (0–2)	< 0.001*
	multiple	73.8 ± 16.9 80 (45–90)		2.4 ± 0.5 2 (2–3)	
Time between the first symptoms and surgery	< 12 mths	86.7 ± 6.6 85 (75–100)	0.098*	1.2 ± 0.8 1 (0–3)	0.030*
	> 12 mths	74.5 ± 18.4 85 (45–95)		1.7 ± 0.7 2 (0–3)	
Size of neuroma	< 3 mm	78.6 ± 14.2 85 (45–95)	0.013*	1.8 ± 0.7 2 (1–3)	0.004*
	> 3 mm	88.5 ± 6.3 90 (80–100)		1.0 ± 0.7 1 (0–2)	
Morton's neuroma location – intermetatarsal space	2 nd	78.6 ± 14.1 80 (50–95) ^a	0.018**	1.3 ± 0.5 1 (1–2)	0.162**
	3 rd	86.3 ± 7.0 85 (65–100)		1.3 ± 0.7 1 (0–2)	
	4 th	92.5 ± 5.2 92.5 (85–100) ^a		0.7 ± 0.8 0.5 (0–2)	

X – mean, Me – median, SD – standard deviation; * Mann-Whitney *U* test; ** Kruskal-Wallis test; a – pairwise comparison with $p < 0.005$ following Kruskal-Wallis test.

icantly better than the results noted before treatment (Table 2). The best results were reported six months after surgery. However, the results evaluated after surgery did not differ substantially from each other.

According to the AOFAS and VAS scores, the outcomes of treatment in patients with a single neuroma were significantly better than in the group with multiple neuromas. On the other hand, when the differences in the results before and after the surgery were compared in single-neuroma cases versus those with multiple neuromas, there were no statistically significant differences in AOFAS scores (median increase 50 vs. 35; Mann-Whitney

U test $p = 0.344$) or VAS scores (median decrease 6 vs. 6; Mann-Whitney *U* test $p = 0.671$). This means that the improvement was similar in both groups, but the final result in the single- neuroma group was better because the initial complaints were lesser (Table 3).

The time from the onset of symptoms to surgery was analyzed up to 12 months and more than 12 months. The best results were achieved in the group that had the surgery within 12 months of the first symptoms. There were statistically significant differences in the VAS scores and a statistical trend in the AOFAS scores depending on the time between the surgery and the assessment (Table 3).

Regarding the size of neuroma, better results were observed in cases of excision of neuromas bigger than 3 mm than in cases of neuromas smaller than 3 mm. These differences were statistically significant in the AOFAS and VAS scores (Table 3).

The results of treatment were better when Morton's neuroma was localized in the 4th intermetatarsal space than in the 3rd or 2nd intermetatarsal spaces, but the only statistically significant difference in the AOFAS score was between the 2nd and 4th intermetatarsal spaces (Table 3).

Before surgery the patients had had from one to five corticosteroid injections. A comparison of these groups did not show any statistically significant differences in the AOFAS and VAS scores. Similarly, the outcome for patients who had less than six months of conservative treatment before the operation did not show statistically significant differences from those who had more than six months of conservative treatment, according to the VAS and AOFAS scores.

The histological results revealed macroscopically visible intermetatarsal neuromas in 11 cases (27%) (Fig. 4). In six cases (14.5%), the nerves were regular, without any pathological changes. Changed nerves with features of fibrosis and inflammatory infiltrates were observed in 24 cases (58.5%). The results of the histopathological examination did not correlate with the final outcome of the treatment. There were no statistically significant differences between inflammatory processes and true neuromas.

In summary, it was been found that there are statistically significant differences in the results depending on the number of lesions, the intermetatarsal space, the size of the neuroma, and the time between the first symptoms and the surgery. There were no statistically significant differences depending on the time between the surgery and the assessment, the number of steroid injections before operation and the duration of preoperative conservative treatment.

Discussion

In the literature there are many studies about the treatment of Morton's neuroma, but only a few of them deal with the long-term results and factors that can affect them. The results of the present study are similar to those presented in many other studies. Pace et al. presented more than 80% very good results [1], while Keh and Ballew [23] reported 93% long-term subjective relief from neurectomy. The present study has highlighted the fact that the results do not change throughout the observation period. Problems with numbness and scarring

have been reported, but these inconveniences do not affect the final assessment of the results.

One interesting issue is the assessment of the incidence of the disease and the basis for qualifying patients for treatment, which can influence the final results. In the introductory sections of their publications, the majority of authors state that Morton's syndrome is a common cause of metatarsalgia [1–3]. A few publications estimate the incidence of metatarsalgia from 5% to 36% [2]. The differences in these assessments may be due to an overlap between Morton's syndrome and other diseases. It has been reported that over 70% of cases of neuroma were associated with some other pathologies of the forefoot [28]. In the present study, the patient inclusion criteria were primarily based on clinical examination, and ultrasound and MRI were additional examinations. Any other foot disease was excluded from this evaluation. As noted above, clinical examination is still the gold standard for diagnosing Morton's syndrome [9].

The basic question is whether very good results achieved with non-invasive treatment methods justify treatment by neurectomy. Assessing complaints about recurrences of the symptoms measured in a long-term follow-up may provide the answer to this question. The initial treatment of metatarsalgia is mainly conservative [1–3, 18] and includes the use of pads and orthopedic shoes, rehabilitation, and steroid and anesthetic injections [27, 29–31]. Makki et al. [32] concluded that a single ultrasound-guided corticosteroid injection results in generally short-term pain relief for symptomatic Morton's neuromas. The effectiveness of the injection appears to be more significant and long-lasting for lesions smaller than 5 mm. The effectiveness of this treatment is greater than 80%, and according to some authors over 90%, but the risk of recurrences is high. Greater effectiveness is achieved by alcohol injections or radiofrequency ablation. Dockery reports 89% efficiency after a 4% alcohol injection (alcohol sclerosing solution) with a follow-up after 12 months [30]. Musson et al. describe alcohol ablation under ultrasound control with 66% efficiency (pain relief) in the 14th month of the observation period [33]. In a study by Pasquali et al., 74% of over 500 patients achieved satisfactory results within a one-year follow-up period [25]. While the majority of these studies are characterized by a short follow-up period, Gurdezi et al. followed up the study participants for five years and concluded that alcohol injections provided results comparable to surgical excision [26]. Another interesting method of treatment was presented by Chuter et al. involving ultrasound-guided radiofrequency ablation with more than 85% effectiveness over a six-month fol-

low-up [27]. Greenfield et al. reported on a study where 95% of the patients treated by local injections relapsed within two years [29]. In the present study at a surgical referral center, the effectiveness of conservative treatment was not evaluated.

There are no differences in the early results after conservative and surgical treatment, but according to reports from Coughlin and Pinsonneault [8] and Pace et al. [1], in longer follow-up periods surgical treatment seems to be better. The longest follow-up reported – over 10 years – was made by Lee et al. [14], who showed that the long-term results of neurectomy are slightly worse than those observed in a short period after surgery, but still very good. The majority of authors state that conservative methods were used initially and that surgery was used when other methods failed. In the present authors' opinion, noninvasive methods are a good alternative for the initial treatment, and patients should be considered for surgery after conservative treatment proves ineffective. Nonetheless, surgical procedures certainly entail greater invasiveness and a greater risk of complications. In the present study, two cases required reoperation due to neuroma recurrences; following the second operation the patients were achieved satisfactory results.

It should be mentioned that the literature provides instances of satisfactory results after both neurolysis and neurectomy. Gauthier [11] and Diebold et al. [19] describe the high effectiveness of the neurolysis procedure. Keh and Ballew [23] and Pace et al. [1] describe neurectomy as comparably good. In the available literature some authors have claimed that the neurolysis procedure could be performed for minor neuromas with intraoperative confirmation of nerve compression in the digital nerve tunnel, while for more extensive changes neurectomy is preferred [11, 23]. In the present study neurectomy was always performed because in the authors' opinion the relative size of the neuroma is often subjective.

Surgical treatment involves choosing between a dorsal or plantar approach. However, in a meta-analysis presented by Glasoe and Coughlin [31], the majority of authors recommend plantar approach rather than dorsal approach. On the other hand, in a trial comparing plantar and dor-

sal neurectomies, Akermerk et al. found showed no differences in the results, but different types of complications [34]. In the current study, in order to avoid scars on the plantar side, the dorsal approach was used as recommended by Mann and Reynolds [35]. The percentage of failures and complications was not observed to be any greater than in the plantar approach. The present study noted longer average time of surgery than Pace reported [1]: 39 min compared to 31 min.

Perhaps histopathological analysis would answer the question as to whether a given method is effective or not. In the literature there are a number of reports that what was referred to as *neuroma* was just inflammatory infiltration; for example, Vachon et al. reported 33% negative histological findings [36]. The present study did not confirm these data; i.e., there were more cases of neuromas. Perhaps cases resistant to conservative treatment tend to be real neuromas. It should be noted that in the present study differences in outcome depend on macroscopically identified changes.

The most common neuroma location reported in the literature was the 3rd intermetatarsal space [1–3]. The present study also confirmed this. This is due to anastomosis between the branches of medial and lateral plantar nerves. In the present study, there were no macroscopic differences between neuromas located in different areas. The data show statistically significant differences between neuromas in different intermetacarpal spaces, however, it should be emphasized that the number of participants analyzed was relatively small.

The type and duration of conservative treatment has no influence on the results of surgical treatment, which means that neurectomy is effective at every stage of the disease. On the other hand, the small number of patients in the analyzed groups limits the value of the study.

Despite the development of less invasive techniques offering very good outcomes in short time periods, long-term results show that neurectomy is still useful in the treatment of Morton's neuroma. Long-term results indicate that the outcome of neurectomy remains stable throughout the post-surgical follow-up. The best results were achieved in cases of single neuromas, larger than 3 mm, resected within 12 months of the onset of symptoms.

Acknowledgements. The authors would like to thank Bartosz Witkowski for providing medical writing services.

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Conflict of interest: None declared

Received: 18.04.2015

Revised: 27.07.2015

Accepted: 16.10.2015