International Orthopaedics (SICOT) (2013) 37:1857–1861
DOI 10.1007/s00264-013-2002-6

ORIGINAL PAPER

Surgical treatment of Morton's neuroma: clinical results after open excision

Maximilian Kasparek · Wolfgang Schneider

Received: 24 May 2013 / Accepted: 22 June 2013 / Published online: 13 July 2013

Abstract
Purpose Long-term results following surgical treatment of Morton neuroma are rare. The purpose of the present study was to evaluate patients after excision of Morton's neuroma at least ten years following surgery.
Methods We performed a retrospective review of the patients' records who underwent excision of an interdigital neuroma with the clinical diagnosis of Morton's neuroma. Eighty-one patients who had undergone surgery on 98 feet were analysed at an average of 15.3 years postoperatively. In total 111 neuromas were excised, because in 13 feet more than one neuroma was identified clinically. Follow-up evaluation included physical examination and a radiographic evaluation. The interdigital neuroma clinical evaluation score and the AOFAS score were assessed.
Results An excellent result was reported for 44 feet (44.9 %), a good result for 31 feet (31.6 %) and a fair one for 15 feet (15,3 %). Eight feet had a poor result (8.2 %), in all of them an amputation neuroma was diagnosed. The average neuroma score was 62 points (range 20–80) and the AOFAS score 75 points (range 29–100). Sixty-one feet (62.2 %) had concomitant foot and ankle disorders not related to the primary diagnosis of Morton's neuroma. Numbness was assessed in 72 % (72 feet), a normal sensibility in 26 % (26 feet) and dyaesthesia in 1 % (one foot). The clinical outcome was not influenced by existence of sensory deficits (p=0.646); analysis of location of neuroma showed best results for those in the third webspace. A significantly worse outcome was found in patients operated on multiple neuromas compared to single neuroma (p=0.038).
Conclusion Surgical excision of a Morton's neuroma results in good clinical results and high overall patient's satisfaction in the long term. Multiple neuromas have worse outcome than single neuromas. Sensory deficits and concomitant foot and ankles disorders are common, but do not have an influence on patient's satisfaction.

M. Kasparek (✉) · W. Schneider
Department Orthopaedics, Herz Jesu Krankenhaus, Vienna, Austria
e-mail: max.kasparek@hotmail.com

Introduction

Interdigital neuroma, named after Thomas George Morton [1], is a clinical syndrome of the forefoot and has often been described in the last two centuries. It was first reported by Civinini [2] in 1835 and later by Durlacher in 1845 [3], who described the clinical complex of symptoms. The aetiology and treatment still are matter of controversy. Today, the pathomechanic principle is seen as entrapment neuropathy due to compression by the deep transverse ligament [4–7]. Histologically, the nerve is characterised by fibrosis of the soft tissue and demyelination and endoneural fibrosis of the nerve [6, 8, 9]. The demographics of interdigital neuromas show a higher prevalence in women [7, 10–12] and most commonly present in the third and second webspace [10, 13–16]. Diagnosis is mainly based on clinical assessment, which is based on the patient's history and the clinical examination [9, 17, 18]. Ultrasound and MRI are not essential for the diagnosis of Morton's neuroma, because asymptomatic interdigital nerve enlargement is common [8, 19, 20]. Occurrence of a neuroma remains unreliable unless it is clinically symptomatic [19, 20]. Radiological assessment is necessary to exclude other causes of metatarsalgia [12, 21, 22]. Clinical assessment has proven to be the most sensitive and specific modality to correctly diagnose Morton's neuroma [19]; therefore, the gold standard for diagnosis still is clinical examination [20].

Conservative treatment is not seen as effective curative treatment [23, 24], but is used to confirm diagnosis. Since the middle of the 20th century the most commonly used surgical treatment has been excision of the interdigital nerve [25, 26] through a dorsal [10, 11, 15, 27, 28] or plantar [9, 13, 29]

approach. The success rate ranges from 51 % to 85 % in long-term follow up [9, 10, 13, 15].

The purpose of this study was to document the postoperative long-term results of excision of interdigital neuromas and to assess possible adverse events and complications.

Material and methods

From January 1985 to 1997, 81 patients underwent surgical excision of an interdigital neuroma. All patients typically complained about pain in the forefoot and were refractory to conservative treatments. Reasons for exclusion from the current follow-up study were surgery for recurrent neuroma (four patients) and rheumatoid arthritis (two patients). In total 98 feet underwent surgery and 111 Morton neuromas were excised, because 17 feet were operated on both sides and 13 feet had excision in the second and third webspace on the same side. The average age of patients at time of surgery was 50.6 years (range 19–73 years), and at time of follow-up it was 65.4 years (range 35–85 years). Gender distribution was 69 female and 12 male patients. The average follow-up time was 15.3 years (range ten to 20 years). The left foot was involved in 51 cases and the right one in 47 cases. The dorsal approach (Fig. 1) was used in 95 feet and only in three feet a plantar approach. The most common location of a neuroma was the third webspace in 73/111 (66 %) cases, and the second in 36/111 (32 %) cases. The fourth web space was only involved in two cases. Surgical records of all patients were analysed to identify those patients where transection of the deep intermetatarsal transverse ligament was done concomitantly with neuroma excision: we found 55 cases with transection and 56 cases without transection of the deep transverse ligament (optional transection of the deep transverse ligament was left to the surgeons' estimation during surgery).

At time of follow-up patients were asked to characterize their level of pain and their footwear restrictions. Pain description was scaled in none, mild, moderate and severe and they were asked about satisfaction with the result of surgery. The interdigital neuroma clinical evaluation score [9] and the AOFAS score [30] were used for assessment (Table 1). The neuroma score incorporates the categories pain, walking distance, sensitivity and footwear requirements into a numerical scale from zero to 80 points. The classification of outcome is defined as follows: < 50 points poor, 50–59 fair, 60–69 good and 70–80 excellent. The AOFAS score is a standardized score with a maximum of 100 points. In this investigation the AOFAS lesser toe metatarsophalangeal–interphalangeal score was used.

Physical examination included assessment in terms of attention of sensory deficits in the supplying area of the resected nerve. Sensibility was tested on light touch with brush and pinprick. The presence of a positive Mulder sign [18] and other foot and ankle disorders, such as Hallux valgus or hammer/claw toes, were evaluated as well. A standardized weight-bearing radiograph was evaluated for evidence of abnormalities within the osseous structure and subluxation or dislocation of the MTP joint.

Statistical analysis was performed with Microsoft Excel and SPSS. T-test for unpaired data and Fischer's exact test were used. Level of statistical significance was set at $p<0.05$.

Results

An excellent result according the neuroma score was reported in 44 cases (44.9 %), good in 31 cases (31.6 %) and fair in 15 cases (15.3 %). Eight cases reported a poor result (8.2 %), all of them had similar pain prior to surgery and had a positive Mulder sign on examination. They were referred to revision surgery. All patients who underwent revision

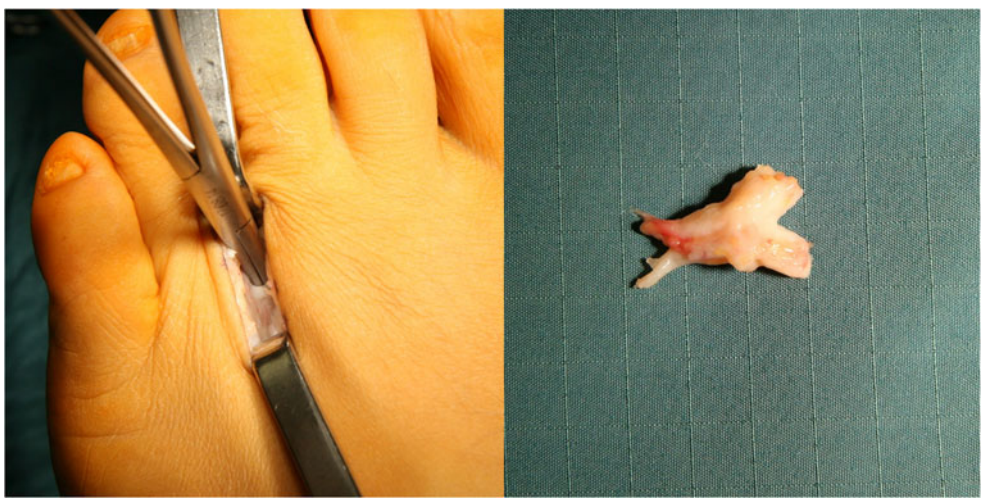

Fig. 1 *Left* Typical dorsal approach with identification of deep intermetatarsal transverse ligament. *Right* Morton's neuroma after excision

Table 1 Scoring systems used for assessment following neuroma excision

Giannini [9]		AOFAS [30]	
Description	Score	Score	Description
Pain	20	40	Pain
		10	Activity limitations
Footwear requirements	20	10	Footwear requirements
		10	MTP joint motion
		5	IP joint motion
		5	MTP-IP stability
		5	Callus related to lesser MTP-IP
		15	Alignment
Walking distance	20		
Sensitivity	20		
Total	80	100	

surgery had histological verified amputation neuroma and were satisfied after revision surgery.

In general, a high percentage (95 %) of the patients would do surgery again. This included most of the patients with a fair or poor result, because they described a pain relief compared to the situation prior to surgery.

The average neuroma score was 62 points (SD±12 points, range 20–80). The AOFAS score averaged 75 (SD±18 points, range 29–100). Forty-four of the cases had additional surgery due to hallux valgus, 37 due to hammer or claw toe of one or more toes and six had an osteotomy of the metatarsal. In general, 61 feet (62.2 %) had an additional forefoot procedure due a concomitant foot and ankle disorder. The clinical outcome of patients who had undergone additional surgical procedures of the foot and ankle was not significantly different compared to patients who had only neuroma excision (p=0.347) (Table 2).

The radiographic examination showed no evidence for pathologies in osseous structures surrounding the involved intermetatarsal space.

Thirty-one patients (38.3 %) did not have footwear restrictions, two patients (2.5 %) required an orthopaedic shoe and 48 patients (59.2 %) reported use of a shoe insert. On examination, 45 feet (45.9 %) had tenderness, such as metatarsalgia, on palpation under the metatarsal heads II–IV, and in five feet (5.1 %) painful subluxation of a metatarsophalangeal joint was detected. A mild or moderate tenderness on palpation in the involved intermetatarsal interspace was reported in 26 cases (26.5 %).

Comparing scoring results between patients who underwent neuroma excision in second and third webspaces, respectively, we found no difference using neuroma score and a slight difference using AOFAS score (p=0.044) (Table 3).

Comparing patients with surgery in one or more than one webspace, scoring results were significantly better in cases of single neuroma surgery, compared to multiple neuroma excisions. This effect was seen in both neuroma score and AOFAS score (Table 4).

A reduction of sensation or numbness in the supplying area of the resected nerve was detected in 72 % (72 feet) of the feet. A normal sensibility was observed in 26 % (26 feet) and 1 % (one foot) had a dysaesthesia. The clinical outcome was not influenced by the level of sensibility (p=0.646) (Table 5).

Comparing results of patients with or without transection of the deep intermetatarsal transverse ligament showed slightly, but not significantly, better results for cases with transection of the deep transverse ligament: AOFAS score 73 (SD±21) vs. 70 (SD±18 points) and neuroma score 63 (SD±11) vs. 58 (SD±12 points). Poor results were observed more often in cases without transection of the deep transverse ligament: two out of 55 with the deep transverse ligament transected vs. six out of 56 with intact deep transverse ligament.

Discussion

In the literature Morton's neuroma and its treatment has been extensively discussed since its first report. In particular, aetiology, pathophysiology and treatment still are matter of controversy and there still is a lack of long-term follow-up data on surgical outcome. We reported the clinical outcomes for 81 patients who had undergone surgery on 98 feet. To our best knowledge, this investigation represents the longest reported follow-up of clinical outcome (15.3 years). In summary this investigation showed a high rate of pain relief in the long term after surgical excision for Morton's neuroma. At the time of follow-up 76.5 % of the patients reported good or excellent results. These data is comparable with results of similar investigations with shorter follow-up in the past.

Table 2 Effect of additional forefoot procedures on clinical result

Measure	Feet with additional surgical procedures	p value	Feet with neuroma excision alone
No. of feet	61		37
Neuroma score	61	p=0.347	61
AOFAS score	73	p=0.229	78

Table 3 Clinical outcome of neuroma excision in second, third and fourth webspace

Measure	Second webspace	p value	Third webspace	Fourth webspace
No. of feet	36		73	2
Neuroma score	58	p=0.200	62	50
AOFAS score	67	p=0.044	75	85

Table 4 Outcome of single vs. multiple neuroma excision on clinical result

Measure	Single neuroma	*p* value	Multiple neuromas
No. of feet	85		13
Neuroma score	63	$p=0.038$	53
AOFAS score	77	$p=0.001$	55

Coughlin et al. [10] reported in 85 % of patients excellent and good results after neuroma excision through a dorsal approach. They also reported that patients who had undergone excision of neuromas in adjacent interspaces or bilateral had a slightly lower level of satisfaction, but this difference was not significant. We observed similar findings with significantly worse outcome for patients with multiple neuromas. Furthermore the AOFAS score in our patients was significantly lower in cases of surgery for more than one neuroma. It remains unclear if the presentation of multiple neuromas itself is the reason for a lower level of satisfaction, if multiple neuromas correlate with other underlying forefoot pathologies, or if diagnosis of these multiple neuromas was correct at all. It has to be considered that Morton's neuroma is a clinical diagnosis and histological examination merely proves that a nerve has been resected [8], as histological results do not show correlation to clinical presentation of Morton's neuroma.

Coughlin et al. [10] also reported that a mild or moderate interspace tenderness after surgery is common on examination. We detected similar symptoms in about a quarter of our patients. According to our own findings, we agree with Coughlin et al. [10] that patients were not impaired in everyday life and it did not have influence on patient's satisfaction. Giannini et al. [9] reported excellent and good results in 78 % of their patients. The postoperative average score was 67 points in his own neuroma score, compared to 62 points in our own patients using Gianninis score. Womack et al. [15] reported excellent results in 51 % of their cases, but in contrast to our results they had 40 % poor results. They reported an average neuroma score of 53 points and a significantly poorer outcome for surgery in the second webspace. We only found a slightly lower score for surgery in the second webspace compared to neuromas in the third webspace, but this difference was significant only for AOFAS score. So according to our data, location of a single neuroma shows a prognostic tendency to poorer results with certain reservations, as the results are only significant in one scoring system. Womack et al. [15] furthermore reported that loss of sensation influenced their outcome to a higher rate of poor results. In our investigation, about 72 % had a reduction of sensibility. About 26 % of the patients had normal sensibility at the follow-up. Most of the symptom-free patients reported that they had sensory deficits following surgery, which recovered over time. Only one patient (1 %) complained about dysaesthesia on examination. The clinical outcome was not influenced by sensory deficits in our patients. Most of them reported that they did not have limitatons in daily life and that they had been informed about it in detail before surgery. This shows that detailed information before surgery is important for the patient's postoperative satisfaction.

Table 5 Effect of postoperative sensibility on clinical results

Measure	Normal sensibility	*p* value	Numbness	Dysaesthesia
No. of feet	26		71	1
Neuroma score	67	$p=0.646$	59	50

Certain reservations [29, 31] exist regarding transection of the deep intermetatarsal transverse ligament. In our data we found slightly better results for patients where the deep transverse ligament had been transected during neuroma excision. Patients with preserved transverse ligament were more prone to develop a painful amputation neuroma.

Pace et al. [32] reported 82 % excellent and good results with an average AOFAS score of 90 points. The lower score of 75 points in our patients can be interpreted as a higher incidence of concomitant forefoot pathologies and an older patient collective. This higher incidence of concomitant pathologies and the older age generally decreased the clinical result in terms of lower scoring results in all patients, but was not calculated as a risk factor for inferior results of neuroma excision. In our results, no significant difference was seen between groups with or without concomitant forefoot pathologies. These observations were made in a similar way by Nery et al. [13], who also were not able to find different results in patients with or without concomitant forefoot pathologies, following neuroma excision. Morton neuroma often occurs coincidentally with other forefoot pathologies and a detailed examination of the forefoot is mandatory to exclude other causes of pain, which is all more important, as other diagnostic methods failed to prove higher diagnostic value than clinical assessment.

Limitations of this investigation are possible recall bias due to its retrospective design and the lack of exact preoperative data in terms of comparable scores.

Conclusion

The present long-term follow-up study was focused on clinical results and patient satisfaction after excision of Morton's neuroma. We demonstrated that surgical excision resulted in a high rate of good and excellent results. The location of neuroma as prognostic factor for outcome cannot be judged definitely according to our data. The incidence of multiple neuromas is correlated with inferior outcome. Concomitant foot and ankle disorders are common. The loss of sensibility

is common and does not have an influence on the patient's satisfaction with surgery. The rate of complications or recurrent neuromas is very low.

References

1. Morton TG (1876) A peculiar and painful affection of the fourth metatarso-phalangeal articulation. Am J Med Sci 71:37–45
2. Civinini F (1835) Su d'un nervoso gangliare rigonfiamento alla pianta del piede. Lettera anatomica al Dr. Salomone Lampronti, Pistoia, Tip Bracali
3. Durlacher L (1845) Treatise on corns, bunions, the diseases of nails and the general management of the feet. Simpkin-Marshall, London
4. Bennet GL, Graham CE, Mauldin DM (1995) Morton's interdigital neuroma: a comprehensive treatment protocol. Foot Ankle Int 16:760–763
5. Graham CE, Graham DM (1984) Morton's neuroma: a microscopic evaluation. Foot Ankle Int 5:150–153
6. Lassmann G (1979) Morton's toe: clinical, light, and electron microscopic investigations in 133 cases. Clin Orthop Relat Res 142:73–84
7. Gauthier G (1979) Thomas Morton's diseases: a nerve entrapement syndrome. A new surgical technique. Clin Orthop Relat Res 142:90–92
8. Morscher E, Ulrich J, Dick W (2000) Morton's intermetatarsal neuroma: morphology and histological substrate. Foot Ankle Int 21:558–562
9. Giannini S, Bacchini P, Ceccarelli F, Vannini F (2004) Interdigital neuroma: clinical examination and histopathologic results in 63 cases treated with excision. Foot Ankle Int 25:79–84
10. Coughlin MJ, Pinsonneault T (2001) Operative treatment of interdigital neuroma. A long-term follow-up study. J Bone Joint Surg Am 83:1321–1328
11. Mann RA, Reynolds JC (1983) Interdigital neuroma. A critical clinical analysis. Foot Ankle Int 3:238–243
12. Wu KK (1996) Morton's interdigital neuroma: a clinical review of its etiology, treatment and results. Foot Ankle Surg 35:112–119
13. Nery C, Raduan F, Del Buono A, Asaumi ID, Maffulli N (2012) Plantar approach for excision of a Morton neuroma: a long term follow-up study. J Bone Joint Surg Am 94:654–658
14. Dereymaeker G, Schroven I, Steenwerckx A, Stuer P (1996) Results of excision of the interdigital nerve in the treatment of Morton's metatarsalgia. Acta Orthop Belg 62:22–25
15. Womack JW, Richardson DR, Murphy GA, Richardson EG, Ishikawa SN (2008) Long-term evaluation of interdigital Neuroma treated by surgical excision. Foot Ankle Int 29:574–577
16. Greenfield J, Rea J, Ilfeld FW (1984) Morton's interdigital neuroma: Indications for treatment by local injections versus surgery. Clin Orthop Relat Res 185:142–144
17. Coughlin MJ (2000) Common causes of pain in the forefoot in adults. J Bone Joint Surg Br 82:781–790
18. Mulder JD (1951) The causative mechanism in Morton's metatarsalgia. J Bone Joint Surg Br 33:94–95
19. Sharp RJ, Wade CM, Hennessy MS, Saxby TS (2003) The role of MRI and ultrasound imaging in Morton's neuroma and the effect of size of lesions on symptoms. J Bone Joint Surg Br 85:999–1005
20. Symeonidis PD, Iselin LD, Simmons N, Fowler S, Dracopoulos G, Stavrou P (2012) Prevalence of interdigital nerve enlargements in an asymptomatic population. Foot Ankle Int 33:543–547
21. Read JW, Noakes JB, Kerr D, Crichton KJ (1999) Morton's metatarsalgia: sonographic findings and correlated histopathology. Foot Ankle Int 20:153–161
22. Bencardio J, Rosenberg ZS, Beltran J, Liu X, Marty-Delfaut E (2000) Morton's neuroma: Is it always symptomatic? Am J Roentgenol 175:649–653
23. Rasmussen MR, Kitaoka HB, Patzer GL (1996) Nonoperative treatment of plantar interdigital neuroma with a single corticosteroid injection. Clin Orthop 326:188–193
24. Espinosa N, Seybold JD, Jankauskas L, Erschbamer M (2011) Alcohol sclerosing therapy is not an effective treatment for interdigital neuroma. Foot Ankle Int 32:576–580
25. Betts L (1940) Mortons metatarsalgia: neuritis of the fourth digital nerve. Med J Aust 1:514–515
26. McElvenny RT (1943) The etiology and surgical treatment of intractable pain about the fourth metatarsophalangeal joint (Morton's toe). J Bone Joint Surg Am 25:675–679
27. Thompson CE, Gibson JNA, Martin D (2004) Interventions for the treatment of Morton's neuroma. Cochrane Database Syst Rev (3):CD003118
28. McKeever DC (1940) Surgical approach for neuroma of plantar digital nerve (Morton's metatarsalgia). J Bone Joint Surg Am 34:490
29. Akermark C, Saartok T, Zuber Z (2008) A prospective 2-year follow-up study of plantar incisions in the treatment of primary intermetatarsal neuromas (Morton's neuroma). Foot Ankle Surg 14:67–73
30. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M (1994) Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 15:349–353
31. Bojsen-Moller F (1978) Anatomy of the forefoot, normal and pathologic. Clin Orthop 142:10–18
32. Pace A, Scammel B, Dhar S (2010) The outcome of Morton's neurectomy in the treatment of metatarsalgia. Int Orthop 34:511–515