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Guest Editorial

The Enmeshed Neuropathy-Morton's Neuroma

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Received: December 24, 2019; **Published:** January 27, 2020

Preface

Morton's neuroma is contemplated as a compressive neuropathy of the common plantar interdigital nerve as it traverses within the forefoot. Compressive manifestations, repetitive and minimal trauma along with perpetual irritation of the plantar interdigital nerve and plantar aspect of transverse inter-metatarsal ligament is implicated in the pathogenesis. Morton's neuroma as a nerve entrapment neuropathy can engender clinical symptoms contingent to the impinged common plantar digital nerve particularly burning, tingling and numbness.

Disease characteristics

Morton's neuroma is a degenerative rather than a neoplastic condition which bears the additional nomenclature of Morton's metatarsalgia, interdigital neuritis, Morton's entrapment, interdigital neuralgia interdigital neuroma, interdigital nerve compression syndrome or inter-metatarsal neuroma. Morton's neuroma is frequently situated betwixt second and third metatarsals [1,2].

Morton's neuroma is commonly elucidated in adult, middle aged female subjects. A condition with a female preponderance, female to male ratio is 4 to 15 :1. However, precise incidence of the condition is obscure. Bilateral feet are infrequently implicated, however, a singular foot can generally delineate two neuromas [1,2].

Disease pathogenesis

Morton's neuroma is exemplified on account of compression of interdigital nerve as it abuts the distal end of transverse metatarsal ligament as engendered with dorsiflexion of toes. Morton's neuroma can be initiated by adopting a narrow toe-box or high heeled footwear with subsequent hyperextension or deviation of toes, inflamed inter-metatarsal bursa, inspissation of transverse metatarsal ligament, trauma to the forefoot, disorders of metatarsophalangeal joints, benign tumours such as lipoma appearing within designated web space and pursuing high impact sport activities such as football or basketball.

Morton's neuroma is frequently enunciated within the slender third inter-metatarsal space. The common interdigital nerve traversing third inter-metatarsal space incorporates branches of medial and lateral plantar nerves, thus the reinforced nerve is susceptible to compression and trauma [3,4].

Neural trauma can arise from impact with a sharp object, crushing force, inspissation of transverse metatarsal ligament, bursal expansion within the inter-metatarsal space or repetitive soft tissue trauma due to activities such as running and the aforesaid factors can engender Morton's neuroma.

Nerve compression and repetitive neural trauma can generate vascular alterations, appearance of endo-neural oedema and bursal enhancement with consequent peri-neural fibrosis.

Morton's neuroma can occur secondary to mechanical stress upon the nerves with fibroblastic proliferation within and circumscribing the implicated nerve. The third inter-metatarsal space is frequently incriminated (68%) followed by the second metatarsal space (32%). Morton's neuroma is exceptional within the first and fourth inter-metatarsal space [3,4].

Cogent anatomical factors defining the distribution of Morton's neuroma are due to wide third metatarsal space configures the confluence of medial and lateral plantar nerves. Also, intense shearing forces are encountered within the third inter-metatarsal space on account of enhanced mobility of the fourth metatarsal bone, in contrast to the third metatarsal bone. The second and third inter-metatarsal space is delineated as a narrow zone within the foot. Multiple neuromas are generated within a singular foot in an estimated one third to two third (28% to 65%) instances [2,4].

Clinical elucidation

Frequent clinical symptoms are appearance of pain in the distribution of plantar nerve and amidst heads of metatarsal bones. The pain is aggravated with walking and adopting tight, high heeled shoes and can be relieved by resting the foot or by discarding the shoes. Pain is of specific category and is described as burning or stabbing and is associated with tingling and electrical sensations.

A typical interpretation is a sensation of walking on stone or marble. Numbness betwixt toes can emerge in less than half (< 50%) of the instances. Extensive walking or stress can cause the pain to extend upon extremities or foot along with the accompaniment of muscle cramps. Employing ultrasound or magnetic resonance imaging for diagnosing a Morton's neuroma demonstrates a discernible prevalence of clinical symptoms in approximately one thirds to half (33% to 54%) of the instances [5,6]. Forefoot pain on account of Morton's neuroma can be elicited by applying pressure upon the inter-metatarsal space. The "thumb- index finger squeeze test" is a sensitive screening test for clinical detection of Morton's neuroma which depicts an accuracy of 96%. The inter-metatarsal space is squeezed amidst tip of the index finger (dorsal region) and thumb (plantar region) and the confirmation is obtained by reproduction of clinical symptoms.

"Mulder's click" is generated with a firm medial to lateral compression of heads of metatarsal bones with a singular hand clasping the forefoot. A palpable or an audible click can be detected, particularly within the enlarged neurons. The manoeuver appears to be accurate in around three-fifths (62%) of instances of Morton's neuroma [4,5].

Histological elucidation

On gross examination, a prominent fusiform distension ensues adjacent to the bifurcation of plantar interdigital nerve accompanied by swelling of adjacent teno-synovial soft tissues. Microscopic examination demonstrates a thickened and thrombotic end-arterial tissue originating from digital arteries besides the appearance of endo-neural and peri-neural fibrosis. Proliferation of Schwann cells and fibroblasts are enunciated associated with degeneration of myelinated nerve fibres. Expansive, concentric perineural fibrosis ensues [4,6].

Differential diagnosis

Morton's neuroma necessitates a segregation from conditions such as metatarsal stress fracture, hammer toe, rheumatoid arthritis, osteoarthritis, ganglion cyst or malignant soft tissue or neural tumours [2,3].

Investigative assay

Diagnosis of Morton' neuroma is contingent to pertinent history and clinical examination. Digital palpation within the specific inter-metatarsal space can reproduce cogent clinical symptoms.

"Mulder's click" elucidates a pertinent crunching or clicking sound, a sign which can be elicited by constricting the forefoot in medio-lateral direction with simultaneous palpation of the implicated inter-metatarsal space. Plain radiographs with contingent, weight bearing joints can be obtained to discern the presence of bone nodules, bone or joint deformities, subluxation, dislocation, radio-opaque foreign bodies and the presence of arthritis [6,7].

Lateral clutching of the forefoot extrudes the contents of inter-metatarsal space towards plantar aspect with a consequently superior delineation of Morton's neuroma. The particular foot displacement can coincide with a palpable and/or audible click, a sign which is termed as a sonographic "Mulder's sign".

Escaped contents within the inter-metatarsal space can be contributed by Morton's neuroma and/or inter-metatarsal bursa. Mulder's click usually appears with Morton's neuroma, as the inter-metatarsal bursa is pliable, in contrast to the neuroma [6,7].

As Morton's neuroma and inter-metatarsal bursa coexist, associated manoeuvers can assist the distinction of dual entities. Inter-metatarsal space undergoes a dorsal compression with fingers while the ultrasound probe scans plantar aspect of inter-metatarsal space along the long axis. Morton's neuroma delineates a fusiform, elongated outline and can be displaced although it is not as compressible as the inter-metatarsal bursa. The bursa is usually located alongside dorsal aspect of inter-metatarsal nerve, demonstrates a spherical or elliptical outline and is generally markedly compressible in contrast to the neural tissue.

Ultrasound or magnetic resonance imaging can be employed for efficacious diagnosis, confirmation of Morton's neuroma and for excluding associated factors of pain in the forefoot particularly arthritis of the metatarsophalangeal arthritis and inter-metatarsal bursitis.

Morton's neuroma can delineate complexities such as chronic pain or complications due to therapeutic surgery or associated with corticosteroid injections. Morton's neuroma as a condition is devoid of specific diagnostic tests. Several clinical tests can procure false positive outcomes, particularly with diverse disease processes implicating the foot [2,3].

Ultrasound is contemplated as an accurate procedure for discerning Morton's neuroma. Normal plantar digital nerve commonly delineates a dimension of around 1 millimetre adjacent to head of the inter-metatarsal bones which can be appropriately identified on advanced resolution ultra-sonography and magnetic resonance imaging.

Diagnostic sensitivity of ultrasound and magnetic resonance imaging appears to be similar and is cogitated at 90% and 93% respectively.

Ultra-sonographic delineation of Morton's neuroma describes a well demarcated round to ovoid mass within short axis and as an elongated, fusiform nodule within the long axis. The neuroma appears as hypoechoic nodule and is commonly situated betwixt heads of metatarsal bones or elucidated along plantar aspect of specific inter-metatarsal space.

Ultrasound can detect associated originators of pain within the forefoot such as joint disorders as cogitated with osteoarthritis, synovitis, soft tissue anomalies as in bursitis or inflammatory alterations, bone lesions as delineated with stress fracture, bony erosions or bone cyst.

Soft tissue aggregates appear diverse from Morton's neuroma and can be differentiated as impacted with solid or cystic contents and the accompaniment of neo-vascular articulations [3,4].

An inter-metatarsal nodule exceeding 20 millimetres is unlikely to be a Morton's neuroma. Instances of ambiguous diagnosis, inadequately discerned with imaging studies, can be further evaluated with tissue specimens obtained under ultrasound guidance.

Magnetic resonance imaging (MRI) can be employed to delineate Morton's neuroma where it is exemplified as a distinct, ovoid or dumbbell shaped mass in the inter-metatarsal space. Morton's neuroma depicts an intermediate to mild signal intensity on diffusion weighted imaging (T1W1 and T2W1). On the contrary, soft tissue of bursa appears hypo-intense or iso-intense on T1W1 and hyper-intense on T2W1. Thus, distinction betwixt bursa and neural tissue can be appropriately obtained [2,4].

Morton's neuroma exhibits a minimal to absent enhancement following intravenous administration of gadolinium contrast medium. The enhancement is usually on account of bursal soft tissue circumscribing the neuroma. With appropriate clinical elucidation, employment of gadolinium contrast medium is not a necessity for diagnosing Morton's neuroma.

Magnetic resonance imaging can be utilized to enunciate alternative modalities of pain in the forefoot such as bone anomalies as described with oedema, fracture, erosion or cyst and soft tissue aberrations as exhibited with bursitis, synovitis, muscular oedema, atrophy and rents in the plantar plate [2,4].

Therapeutic options

Treatment of Morton's neuroma is commenced with conservative methodologies such as modifying the footwear or incorporation of insoles, techniques which are beneficial in an estimated half (48%) of the instances. Anti-inflammatory drugs can be administered. Percutaneous therapy can be adopted in instances which are not benefitted with aforementioned measures. Surgical intervention is employed where conservative therapy is ineffectual.

Wide toed, low heeled, soft soled or firm soled shoes can be efficacious in alleviating pressure upon the nerve.

Soft buttress to the metatarsals can disperse the space and pressure amidst heads of metatarsal bones. Accompanying synovitis, joint instability or toe deformities can be managed with the employment of a Budin splint or adoption of a canopy toe strapping can decimate secondary neuralgia [7,8].

Administration of anti-inflammatory agents, tricyclic antidepressants as in amitriptyline or anti-seizure agents such as gabapentin can reduce severe neural manifestations. Blind or ultrasound guided injections of corticosteroids are beneficial for brief periods. Atrophy of subcutaneous and plantar adipose tissue, cutaneous discoloration and disruption of joint capsule adjacent to site of injection with subsequent induction of toe deformity can ensue. Additionally, radiofrequency ablation, cryotherapy or injectable alcohol within the nerve are a conservative and minimally invasive techniques of treating Morton's neuroma.

Lidocaine can be injected within the incriminated inter-metatarsal space. Percutaneous treatment of Morton's neuroma comprises of injectable local anaesthetics in combination with or absence of concomitant corticosteroids. Alcohol can also be therapeutically utilized.

Percutaneous agents can be injected blindly or in accompaniment with ultra-sonographic guidance. Adopting local anaesthetics in combination with steroids can depict superior outcomes, in contrast to singular employment of local anaesthetic agent. A single blind or ultrasound guided injection is advantageous in around 45% instances whereas 75% to 80% subjects are benefited with multiple, blind injections [8,9].

Influence of dimension of Morton's neuroma on treatment response to injections is debatable. Neuromas beneath < 5 millimetre magnitude demonstrate superior results at 6 months of therapy rather than neuromas exceeding > 5 millimetres. However, therapeutic outcomes at 12months are identical, regardless of the magnitude of Morton's neuroma.

Corticosteroid therapy can engender complications in an estimated 1% to 5% instances comprising of atrophy of the subcutaneous or dermal tissue, hypopigmentation and necrosis of the adipose tissue. Particulate corticosteroids depict enhanced proportion of dermal and subcutaneous tissue atrophy.

Alternative drugs considered advantageous in treating Morton's neuroma are alcohol, botulinum toxin and hyaluronic acid. Injections of alcohol demonstrate a response rate of around 69% to 84% and complications in roughly 3% subjects. Plantar pain can ensue on account of inflammatory reaction evoked with perilesional leakage and dispersal of alcohol [8,9].

Application of botulinum toxin displays a benefit in roughly 70.6% implicated individuals and hyaluronic acid exhibits a benefit in approximately 84% subjects.

Percutaneous radiofrequency ablation is a procedure which appears successful in around 68% to 100% instances. Divergent outcomes are secondary to technical aspects such as variously enumerated of ablation cycles and diverse criterion of subject selection.

Complications to radiofrequency ablation are enunciated in around 5% instances with the emergence of haematoma, persisting pain, temporary nerve irritation, infection and numbness at the site of injection [7,9].

Surgical options can be employed to alleviate intractable clinical symptoms. Morton's neuroma can be exterminated with a dorsal or a plantar surgical approach. As surgical scar engendered by the plantar incision is painful, a dorsal surgical approach can be preferred. It is crucial to refrain from injuring the dorsal cutaneous nerve. Minimal quantities of plantar adipose tissue should be eliminated.

Plantar incision can be gainfully employed for managing reoccurrence of Morton's neuroma. Proportion of misinterpreted or residual Morton's neuroma declines with the adoption of plantar approach as incision of transverse metatarsal ligament may not be necessitated.

Also, segments of incriminated nerve are suitably visualized and can be resected proximally. Arterial and venous vasculature can be appropriately visualized. However, plantar scars are painful and plantar keratosis can ensue in approximately 5% instances. Surgical therapy is indicated in persons unresponsive to conservative or percutaneous therapies [3,5].

Surgical manoeuvers comprise of elimination of the lesion (neurectomy) or inter-metatarsal ligament resection (neurolysis). Neurectomy can be achieved through a dorsal or a plantar access. Surgical excision can benefit an estimated 50% to 88% individuals and demonstrates complications in around 25% subjects of neurectomy and roughly 7% in persons undergoing neurolysis. Surgical complications are constituted by post-operative infection, articulation of a haematoma, configuration of hammer-toe, hypertrophic scar or keloid, complex regional pain syndrome and persistent post-operative pain, numbness and stiffness of metatarsophalangeal joints.

Reoccurrence of painful neuromas following surgical eradication can ensue in approximately 4% instances. Repetitive surgical intervention is minimally efficacious in recurring Morton's neuromas. Conservative measures can be suitably employed prior to adopting additional surgical measures [4,5].

Minimally invasive techniques can be applied in order to decompress the nerve by endoscopically or percutaneously dividing the deep inter-metatarsal ligament. Neural decompression as cogitated with division of the deep transverse inter-metatarsal ligament with or without osteotomy of heads of metatarsal bones can be beneficial in around 94% and can be accompanied by complications in about 6% subjects [9].

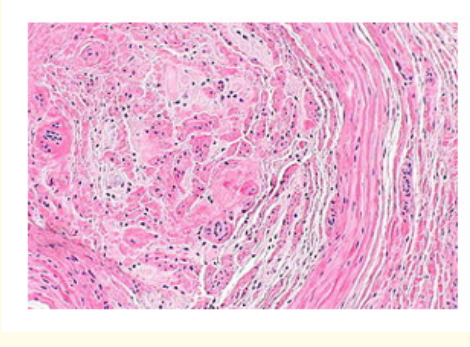

Figure 1: *Morton's neuroma with concentric perineurial fibrosis, proliferation of Schwann cells with end-arterial thrombosis [10].*

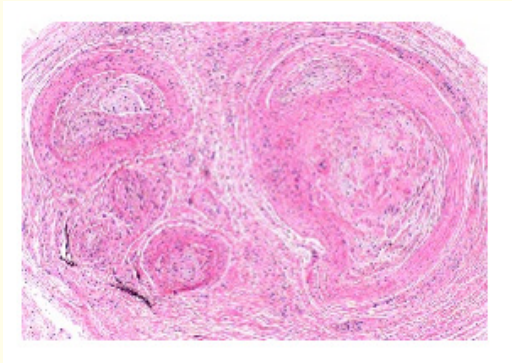

Figure 2: *Morton's neuroma with endovascular thrombosis and concentric fibrosis around the implicated nerve [11].*

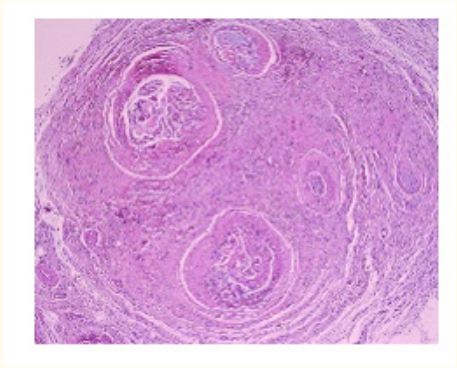

Figure 3: *Morton's neuroma with concentric fibrosis surrounding the nerve, luminal thrombosis and thickening of the nerve [12].*

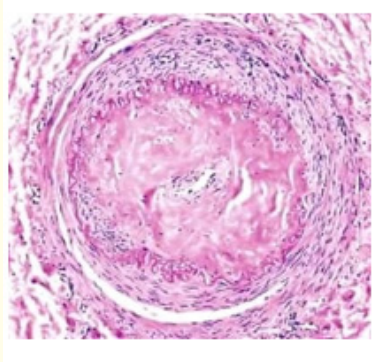

Figure 4: *Morton's neuroma with end-arterial thrombosis, thickened common plantar nerve and concentric fibrosis [13].*

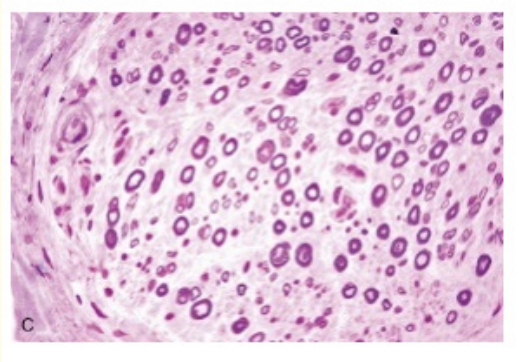

Figure 5: *Morton's neuroma with thrombotic end-arteritis and proliferation of Schwann cells [13].*

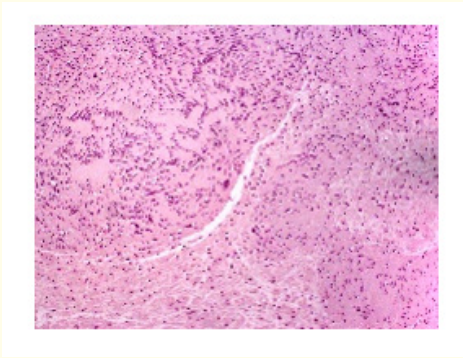

Figure 6: *Morton's neuroma with thrombosis of the inundated vasculature and perineurial fibrosis [14].*

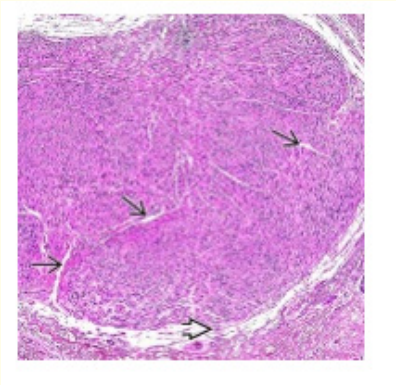

Figure 7: *Morton's neuroma with abundant, concentric fibrosis and propagation of Schwann cells [15].*

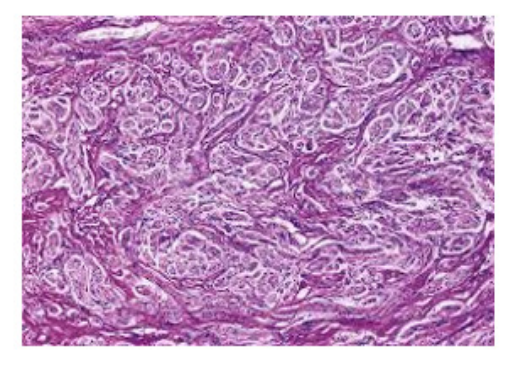

Figure 8: *Morton's neuroma with abundant, circumscribing fibrosis and Schwann cell proliferation [16].*

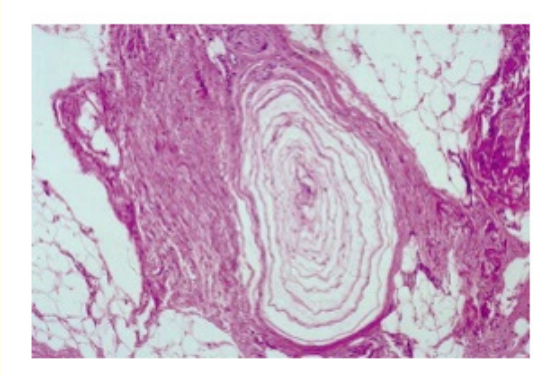

Figure 9: *Morton's neuroma with abundant, perineurial fibrosis and expansive Schwann cells [17].*

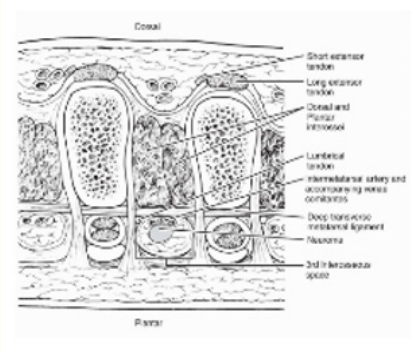

Figure 10: *Morton's neuroma with classic pathogenesis [18].*

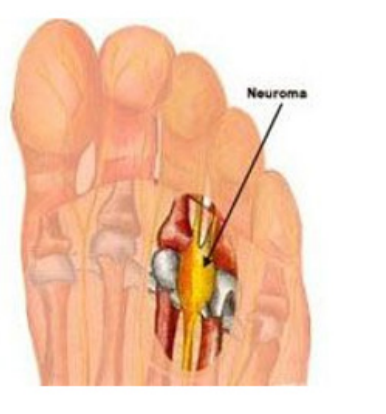

Figure 11: *Morton's neuroma with preferential location [19].*

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13. Image 4 and 5 Courtesy: Science direct.

14. Image 6 Courtesy: Wikipedia.

15. Image 7 Courtesy: Basic Medical Key.

16. Image 8 Courtesy: Foot and ankle clinics.

17. Image 9 Courtesy: Springer link.

18. Image 10 Courtesy: Musculoskeletal Key.

19. Image 11 Courtesy: Pinterest.

Volume 3 Issue 2 February 2020