

THE IMPORTANCE OF REBALANCING FOOT BIOMECHANICS BY COMPUTERIZED PODOSCOPIC ASSESSMENT - STUDY IN CHARCOT MARIE TOOTH SYNDROMS

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Rezumat

Boala Charcot-Marie-Tooth (CMT) este una dintre neuropatiile motorii și senzoriale ereditare, un grup de variate tulburări moștenite ale sistemului nervos periferic, caracterizate prin pierderea progresivă a țesutului muscular și a senzației tactile în diferite părți ale corpului. În prezent incurabilă, această afecțiune este cea mai frecventă tulburare neurologică moștenită și afectează aproximativ una din 2.500 de persoane. Un diagnostic CMT implică evaluarea clinică a funcției musculare și atrofiei, testarea răspunsurilor senzoriale, electromiografie și studii de conducere nervoasă.

Adesea, cel mai important obiectiv pentru pacienții cu CMT este menținerea mișcării, a forței musculare și a flexibilității. Prin urmare, se recomandă o abordare de echipă interprofesională cu terapie ocupațională, kinetoterapie, ortezare, podiatru și chirurg ortoped.

Terapia fizică ar trebui să implice proiectarea unui program de exerciții care să se potrivească punctelor forte și flexibilității personale, dar și o evaluare podoscopică de calitate. Din cauza lipsei unei funcții senzoriale bune la nivelul picioarelor, pacienții cu CMT au nevoie de asistența kinetoterapeutului pentru a-și stabiliza picioarele sau a corecta problemele progresive prin reechilibrarea biomecanicii piciorului. Procedura presupune o evaluare computerizată și realizarea amprente plantei în spumă.

Ortezele plantare ajută la controlul căderii piciorului și instabilității gleznei și îmbunătățește senzația de echilibru. Încălțăminte adecvată este, de asemenea, foarte importantă în cazul persoanelor cu CMT, dar adesea acestea întâmpină dificultăți în a găsi pantofi potriviți din cauza picioarelor arcuite și a degetelor în formă de ciocan. Pacientul va folosi acești susținători plantari introduși în pantofii potriviți pentru creșterea suprafeței plantare de sprijin, reducerea varusului, încetinirea tendinței de retragere a aponevrozei plantei.

Cuvinte cheie: Charcot-Marie-Tooth, kinetoterapeut, evaluare computerizată, amprenta plantelor, reechilibrare.



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Abstract

Charcot-Marie-Tooth disease (CMT) is one of the hereditary motor and sensory neuropathies, a group of varied inherited disorders of the peripheral nervous system characterized by progressive loss of muscle tissue and touch sensation across various parts of the body. Currently incurable, this disease is the most commonly inherited neurological disorder, and affects about one in 2,500 people. A CMT diagnosis involves clinical evaluation of muscle function and atrophy, testing of sensory responses, and electromyography and nerve conduction studies.

Often, the most important goal for patients with CMT is to maintain movement, muscle strength, and flexibility. Therefore, an interprofessional team approach with occupational therapy, physical therapy, orthotics, podiatrist, and orthopedic surgeon is recommended.

Physical therapy should be involved in designing an exercise program that fits a person's personal strengths and flexibility, but also in a good evaluation podoscopic assessment. Due to the lack of good sensory reception in the feet, CMT patients need to see a physical therapist in order to stabilize their feet or correct progressive problems by rebalancing the biomechanics of the foot. The procedure involves a computerized assessment, the realization of the plant footprint in the foam and the creation of plantatory therapeutics on the mold.

These plantar orthoses help control foot drop and ankle instability and often provide a better sense of balance for patient. Appropriate footwear is also very important for CMT case, but often with difficulty finding well-fitting shoes because of their high arched feet and hammer toes. The patient will use these plantatory proponents in the right shoes in order to: increase of planting support surface, reduction of varus, slowing down the retraction tendency of plant aponeurosis

Keywords: *Charcot-Marie-Tooth, physical therapist, computerized assessment, plant footprint, rebalancing.*

Introduction

Charcot-Marie-Tooth disease (CMT), named after the three doctors who first identified it, is one of the most common inherited nerve disorders. CMT affects an estimated 1 in 2,500 people in the United States and 2.6 million people worldwide, although experts believe the number could be much higher. When the parts of the nerves - the axons and the myelin - become damaged, messages that run along the nerves move more slowly or have a weak signal. Over time, this causes muscles in the feet, legs, and hands to lose strength. Often, the muscle loss happens unevenly, which causes deformity as muscles waste away (atrophy) at different rates⁽¹⁾.

Researchers recognize five main types of Charcot-Marie-Tooth disease and many subtypes. Research is still under way to define all of the different types fully. CMT type 1 is the most common form of the disease. Understanding what the disease is, what causes it, how doctors diagnose it, and the different treatment options available can help to manage the disease and lead an active and fulfilling life. Researchers know that faulty genes cause CMT disease. Although many of these genes have been identified, ongoing research continues to discover additional genes involved in CMT. The disease is usually passed on from parent to child, with a 50 percent chance of the child inheriting the condition. However, recent testing has found that some people have the faulty genes, but their parents do not⁽²⁾.

Key diagnosis factors:

- family history of neuropathy, pes cavus, or abnormal gait
- walking difficulties
- pes cavus
- steppage gait

- past surgery to feet and ankles
- balance difficulties in childhood
- ankle weakness
- sensory abnormalities in hands and feet.

Risk factors include family history of neuropathy, pes cavus (high foot arches with hammer toes), or abnormal gait.

Early symptoms of CMT:

- clumsiness
- slight difficulty in walking because of trouble picking up the feet
- weak leg muscles
- fatigue.

Common symptoms of CMT:

- foot deformity (very high arched foot/feet)
- difficulty lifting foot at the ankle (foot drop)
- curled toes (known as hammer toes)
- loss of lower leg muscle, which leads to skinny calves
- numbness or burning sensation in the feet or hands
- "slapping" when walking (feet hit the floor hard when walking)
- weakness of the hips, legs, or feet
- leg and hand cramps
- loss of balance, tripping, and falling
- difficulty grasping and holding objects and opening jars and bottles.

Later symptoms of CMT

- similar symptoms in the arms and hands
- curvature of the spine (scoliosis).

Very rare symptoms of CMT

- speech and swallowing difficulties
- breathing difficulties, especially when lying flat



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- hearing loss
- vocal cord paralysis.

General treatment of CMT

Although there is no cure for CMT, therapies can treat the symptoms. The development of a comprehensive treatment plan with a health care team can help people with CMT lead an active life. Treatment plans generally involve one or more of the following:

- physical and occupational therapy: therapists work to improve muscle strength and stamina and to help people complete tasks of daily living
- braces and other orthopedic devices: custom shoes or shoe inserts (foot orthoses) help to improve walking ability; leg braces prevent ankle sprains and improve walking ability
- surgery: for some people, surgery can help prevent or reverse foot and joint deformities
- pain management: pain-killing drugs may be prescribed for people who have severe pain⁽¹⁵⁾.

Complementary therapies

Some people with CMT disease has found that alternative therapies - such as acupuncture, biofeedback, capsaicin, alpha-lipoid acid, or meditation - can help relieve symptoms⁽³⁾.

The case study was conducted on a 39-year-

old patient, height 178 cm, weight 68 kg, foot size 42, diagnosed with Charcot Marie Tooth Syndrome, who presented himself to clinic on May 15, 2017 with the following symptoms: - imbalance in walking dynamics- retraction of the plantar aponeurosis- bilateral Varus foot-pain both in the legs and calves. The initial somatoscopic and somatometric evaluation of the patient, which was carried out with the Sensor Medica Baropodometric Platform - 620x440mm, with an acquisition frequency of 400Hz, which uses the sensors to perform static and dynamic baropodometric analysis (gait analysis). Free Step software has been associated with this platform. Thus, it was highlighted: - The pressure zones on the soles both when standing and walking- Positioning the center of gravity in the support polygon- Load distribution (left-right and front-back)- Gait analysis.



Figure 1. Initial evaluation

Material and working method

Measurement and evaluation methods were used in this approach with the help of the

Sensor Medica baropodometric platform - 620x440mm and with the help of a podograph (which is actually a box with a scratched membrane for imprinting the plantar impression). Then, with the help of the foam box, the molding was executed, and later in the manufacturing workshop, the individualized coupons. This is how they were interpreted: - Cough fingerprint - Static examination - Static balance test - Dynamic test. Cough impression with static examination, observing the projection of the center of gravity to the left - the patient standing with equal weight on both legs, looking forward, arms next to the body (which highlights the loading of the external edge bilaterally on the scale 1-1 with the overpressure area at the level of the head MT 5 bilaterally figure 2).

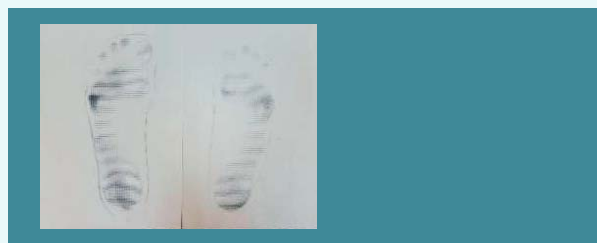


Figure 2. The fingerprint cough

Afterwards, the static examination was carried out (photo with static analysis) in which the patient stepped on the podobarometric platform barefoot with his feet slightly apart. This examination revealed an asymmetric distribution of body weight - 59% left leg and 41% right leg, as well as a rotation of the projections of the centers of gravity of the legs - for the left leg further forward, for the right leg further back (support polygon photo - Figure 3). Also, the support surfaces are different on the right leg, being smaller than the left leg, suggesting a greater retraction of the plantar aponeurosis at the level of the right leg⁽⁴⁾.



Figure 3. Static examination

From the same position of the patient, a balance test was also performed in which the patient was asked to remain motionless for 30 seconds with both eyes closed and eyes open. After the test, it was found that the patient makes a little more effort to maintain his balance with his eyes closed than with his eyes open.



Figure 4. Center of gravity distribution with eyes open and closed

The last test was the dynamic one in which the gait analysis was carried out (left and right photo with fingerprints considered, average surface cm2, average maximum pressures).

The patient was asked to walk barefoot from one side of the room to the other, stepping normally with his feet on the baropodometric platform. Several steps were taken with each leg so that an average could be obtained. It was found that the contact surfaces of the legs during walking are different, the right leg having a significant roll on its external edge from the heel to the tip - suggesting a more pronounced varus (Figure 5).



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Figure 5. The average of the prints for the left foot and the right foot while walking

Considering the clinical examination, the cough impression and the podobarometric analysis, at the end the molding of the two legs was made in order to execute the plantar supports. The mold was made with the help of the foam box in which the patient stepped without any alignment corrections being made (figure 6, the impression in the foam). Later, plaster was poured into the foam mold. The resulting plaster positives were processed, after which the plantar supports were laminated and finished (see figure 7 plant supporters).



Figure 6. The impression in the foam in order to execute the plantar supports on the mold

As a working hypothesis, the methods used had the following aspects in mind:

- increasing the plantar support surface by making a plantar supporter on the mold
- reduction of varus
- slowing down the retraction tendency of the plantar aponeurosis
- pain relief
- biomechanical rebalancing of the entire axis of the body by ensuring an optimal support base⁽⁵⁾.

On the basis of all these evaluations, in our orthotics-prosthetics workshop, with the help of the equipment provided, the appropriate pads were made. The testing and delivery of the medical devices was carried out (Figure 6).



Figure 7. Plantar supports or individualized heel pads

During the whole period, a kinetic program was carried out in parallel under the guidance of physiotherapists, a program that includes both passive, active, passive-active and active techniques with resistance, free or with sticks, elastic buttocks or rolls, manual

therapy, and reflexology with antalgic and decontracting purposes.

Conclusions

The patient returned for re-evaluation in February 2018 and highlighted the following aspects:

- what you get after making and wearing the cleats is an improvement in the level of stability both statically and while walking
- the plantar support surface has increased, resulting in improved walking dynamics
- the varus was reduced
- the retraction tendency of the plantar aponeurosis has been stopped
- the pain has decreased
- biomechanically rebalanced the entire axis of the body by providing an optimal support base
- the patient is satisfied with the wearing of the insoles and the ease of transferring them into the worn shoes, as well as the quality of their sanitization after wearing⁽⁶⁾
- as a result of the interaction with the physiotherapy and orthotics services, the patient continues to follow an individualized program in this endeavor, being satisfied with the state of his health.
- Following the study of this case, we can draw the following particular conclusions:
 - ➔ the patient no longer complains of pain in the lower limbs
 - ➔ walking takes place with much more ease and balance, without tension on the joints of the knees, hips and spine
 - ➔ the functional independence of the

patient is increased both in normal walking and in practicing team games

- ➔ the kinetic and orthopedic program brought value both at the level of the condition, but especially on a general level⁽⁷⁾.

Most people with Charcot-Marie-Tooth (CMT) disease learn how to manage their symptoms and go on to live fulfilling lives. Generally, the progression of the disease is slow. In many cases, the symptoms are mild, and properly fitted orthotics can help with difficulty in walking⁽⁸⁾. In more severe cases, people with CMT must wear braces or use a wheelchair to get around. In rare cases where CMT causes difficulty with breathing, additional medical consultation is recommended to manage these symptoms⁽⁹⁾.

CMT1A is caused by a 1.4 Mb duplication of the *PMP22* gene (encoding peripheral myelin protein 22 kD) and is the most common hereditary neuropathy⁽⁸⁾.

CMT patients typically present clinically (despite their genetic heterogeneity) with an indolent, length-dependent, sensorimotor polyneuropathy. The slowly progressive nature of the condition (as opposed to an immune-mediated etiology) and noticeable length-dependent weakness/atrophy (rather than a predominantly stocking glove sensory loss with minimal to no weakness more typical of common metabolic-toxic neuropathies) are clinical clues to CMT in addition to uncovering any suggestive family history. The majority of patients also have pes cavus as a hallmark feature with smaller percentages having scoliosis, hip dysplasia, restless legs syndrome, tremor, or hearing loss^(9,10,11,12,13,14,15,16,17). We mention that all three authors quoted in equal parts to the construction of this case study.



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