Methodical-Practical Approaches in Functional Re-education after Distal Lower Leg Fractures

Paul LUCACI[a], Raluca-Mihaela ONOSE[a], Marius NECULĂEȘ[a*]

[a]*Alexandru Ioan Cuza" University of Iasi, Faculty of Physical Education and Sport, 3 Toma Cozma Str., 700554, Iasi, Romania*

Abstract

Distal lower leg fractures represent a pathology with numerous biomechanical and functional implications with impact on socio-professional life. This type of fractures can generate neurological sequelae through secondary lesions on the peripheral nervous system, such as injuries to the external popliteal sciatic nerve or peroneal nerve.

In our case study, we analyzed the functional recovery process of a sportsman who suffered a fibular and a tibial pillar fracture of the right lower limb.

Complex functional evaluations such as: pain, ankle joint mobility, muscle strength and gait were performed.

Paraclinical investigations were also carried out, such as radiography and computed tomography with 3D reconstruction, as well as functional explorations regarding the integrity and trophicity of the peripheral nervous system of the affected lower limb.

The physiotherapy program consisted in the re-education of functional deficits by using specific techniques and methods, neuroproprioceptive facilitation techniques, as well as manual therapy techniques.

The obtained results emphasize the positive evolution of the values of the functional tests carried out in the case study, as a result of the rehabilitation techniques which we performed.

The study's conclusions highlight the effectiveness of physiotherapeutic programs and manual techniques in the recovery of deficits after a distal lower leg fractures.

Keywords*: bone injuries, tibial pillar, recovery, motor deficit.*

[*] All authors contributed equally. Corresponding author: Marius Neculăeș. Tel.: +40 744 637342.
E-mail address: neculaes_marius@yahoo.com

1. Introduction

Fractures of the distal third of the calf have an increased incidence of 184 cases per 100,000 people per year (Neumann et al., 2016).

The tibia and fibula are the component bony elements of the calf and are responsible for supporting body weight and inserting specific muscles. Among the long bones of the skeleton, the tibia is the most frequently fractured, among its symptoms are strong and immediate pain, the appearance of edema and deformity, functional impotence (Goost et al., 2014; Tengberg et al., 2018).

The mechanism of production of these fractures can be direct trauma with high impact force or indirect trauma through the combination of rotation and compression force. This indirect mechanism can also be found in sports games when the foot is fixed on the ground and the rotational movement occurs in the overlying segments (Feria-Arias et al., 2018).

Orthopedic and surgical management is a challenge for the specialist team, influencing the process of functional re-education, which can be more difficult due to the fact that the distal blood supply is lower. At the same time, the soft tissues in the distal third are vulnerable due to the lack of musculature and the bone healing capacity is lower.

Fractures of the distal third of the calf can be treated with cast immobilization or bleeding reduction and fixation with osteosynthesis materials. If the orthopedic treatment will be conservative, the patient will not be allowed to load the affected lower limb until the fracture heals. This will lead to the hypotonia of the muscles of the affected limb and the installation of joint stiffness, which will negatively influence walking.

Muscle weakness is amplified by immobilization and the lack of loading of the affected limb, studies highlighting the fact that in the case of operated fractures, functional results are faster (Brown et al., 2001).

Depending on the severity and location of the calf fractures, the therapeutic protocol is decided, but the most appropriate treatment modality is surgical intervention with osteosynthesis with plates and screws or centromedullary rods for fracture reduction (Redfern et al., 2004).

Distal calf trauma is known to impact ankle functionality and patients' quality of life (Aydogan et al., 2020; Duckworth et al., 2016; Kent et al., 2020).

Calf fractures have multiple causes from simple falls to road accidents (Toth et al., 2017 and depending on their severity, rehabilitation results can sometimes be delayed.

For an effective management of the post-immobilization fracture, effective communication between the attending physician and the physiotherapist is necessary, in order to establish the phasing of resuming the loading of the affected limb and to determine if orthoses or other elements that can influence the rehabilitation process are necessary. The most important thing is that in the first phase both passive and active joint mobility is assessed and re-educated, then muscle strength and joint stability (Lin et al., 2012).

Functional assessment of the patient after calf fractures is very important and aims to establish the potential for recovery by testing joint mobility, muscle elasticity, muscle strength and endurance of the entire lower limb, balance, proprioception and gait.

After resuming walking without aids, exercises can be added to re-educate balance and joint stability, through dynamic activities that require neuromuscular control. Various unstable surfaces such as balance boards can be used in this sense.

In order to reintegrate into the socio-professional activity, it is necessary for the patient to regain complete mobility of the affected joints, muscle strength, joint stability and the achievement of correct walking from a biomechanical point of view. For the reinsertion in the sports activities, the individual must be able to perform in addition, the correct running, the unilateral support, the jumps and be retrained to the effort in a correct and efficient way.

2. Material and method

The present research is based on the case study of a 26-year-old female performance athlete who sustained a fracture of the tibial pillar and right fibula in the distal third following an avalanche. Following the clinical consultation and paraclinical investigations (radiographs and computer tomograph with 3D reconstruction, fig 1), the orthopedic-surgical treatment consisted in the

bleeding reduction of the fracture with a plate locked in "L" and screws (fig 2). Postoperative radiological control revealed a good reduction of the fracture and a correct positioning of the osteosynthesis material.

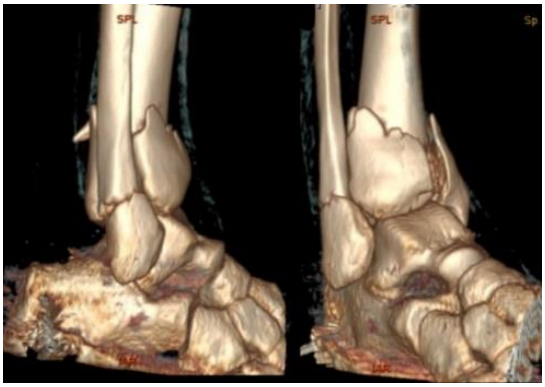


Figure 1. Preop 3D CT

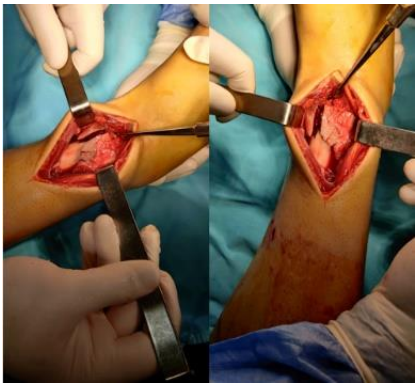


Figure 2. Intraoperative image

The functional evaluation was carried out 30 days postop and consisted in the first stage in the testing of joint mobility and muscle strength, along with the evaluation of pain, trophicity and sensitivity of the affected limb (Figure 3). Following this, important mobility deficits of the talo-crural joint, muscle hypotrophies at the level of the calf and thigh, the presence of algoneurodystrophic syndrome and motor deficit in the territory of the deep peroneal nerve were found. At 105 days postoperatively, gait parameters such as step cadence, step length and distance covered in the 5-minute interval could also be evaluated.

Figure 3. Postop appearance

The physiotherapy plan applied after the first 30 postop days consisted in performing passive mobilizations of the affected ankle with the association of passive stretching on the Achilles tendon in order to increase the range of motion and to relax the sural triceps muscles. Neuroproprioceptive facilitation techniques such as rhythmic initiation, slow inversion and hold-relax technique were also used to promote regaining joint mobility. Active exercises for the affected ankle as well as for the fingers and overlying joints were also performed at this stage. Proprioceptive stimulation exercises using balls and sensory activation objects were introduced to re-educate plantar sensitivity. To facilitate lymphatic drainage, manual pressure techniques were used to stimulate the resorption of the edema and de-tension the plantar aponeurosis.

At 2 months postop elements were added to the program from the previous stage to increase the difficulty of the exercises. Thus, low resistances were used and the number of repetitions was increased, adding other PNF techniques such as slow inversion with opposition and the relaxation-opposition technique, designed to overcome the limitations of joint mobility. Also at this stage, special emphasis was also placed on indirect loading exercises of the ankle joint to prepare for the resumption of walking. Increased attention was also paid to general toning exercises to maintain the athlete's overall tone.

In the 3rd stage, 90 days postop the boot-type orthosis was removed, and the difficulty of the exercises and the degree of loading of the affected lower limb increased, so that 105 days postop, according to the indications of the attending physician, after the control x-rays performed (Figure 4), independent walking resumed. At this stage, the focus was on exercises to re-educate walking and joint stability. From the category of FNP techniques, the active movement of relaxation-opposition and relaxation-contraction were added, to overcome outstanding mobility limitations. To increase joint stability and muscle strength, the rhythmic stabilization technique was used along with alternating isometrics.

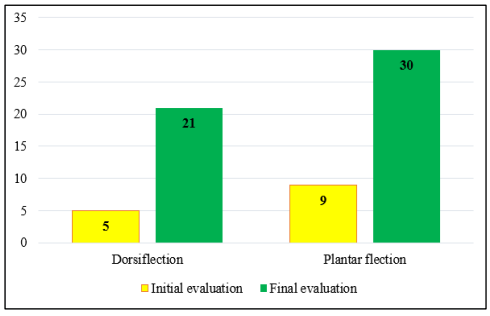
Figure 4. X-ray (105 days postop)

The re-education of walking parameters was achieved both with the help of the treadmill and through specific walking exercises and application routes, which aimed at the biomechanically correct realization of the phases of locomotion.

3. Results and discussions

In order to be able to highlight the progress achieved following the application of the functional re-education programs, we made the graphic interpretation of the values of the functional tests obtained at the initial assessment and at the final assessment.

Figures 1 and 2 show the evolution of joint mobility and muscle strength from the initial evaluation to the final evaluation.



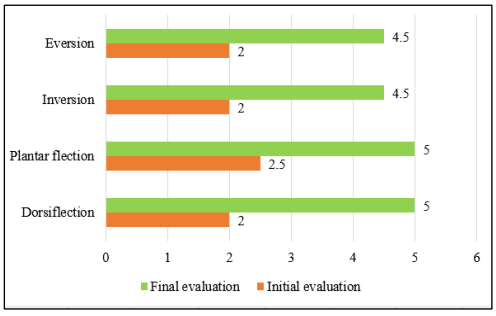
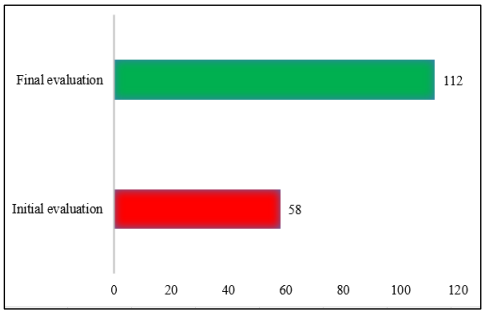


Figure 1. Right ankle joint mobility (degrees) **Figure 2.** Right ankle muscle testing

According to the figures above, joint mobility and muscle strength improved following the application of physical therapy programs and PNF techniques, which aimed to regain maximum ankle range of motion and also increase muscle strength to normal levels. An important role in re-educating the mobility of the right ankle joint was played by passive stretching, which, by stretching the Achilles tendon, favored the regaining of flexibility and muscle-tendinous elasticity. Specific ankle functional rehabilitation methods and techniques must be performed under the guidance of specialists, who will supervise the entire recovery process and monitor the patient's progress (Moseley et al., 2015).

Figures 3 and 4 highlight the evolution of step cadence (fig 3) and step length (fig 4) from the initial assessment to the final assessment.



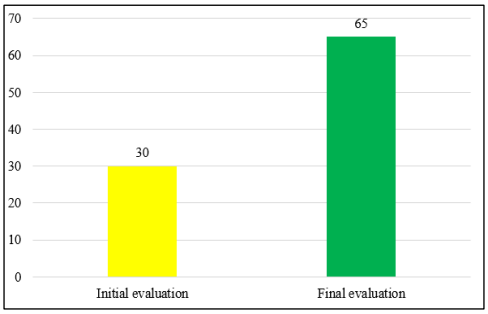


Figure 3. Cadence of steps (steps/minute)

Figure 4. Step length (cm)

Functional re-education programs after fractures of the distal third of the calf also have a positive effect on the correction of walking parameters. In the figures above, the favorable evolution of cadence and step length is highlighted, which was supported by the specific gait re-education exercises. A very important role for the fulfillment of this objective was the realization of the locomotion on the rolling carpet, where by setting the speed and inclination parameters, the correction of the cadence, the length of the step and the average loading time on each lower limb was achieved. Re-education of cadence and step length is important because it contributes to achieving efficient walking with an optimal movement speed, this latter parameter being significantly affected in the case of these fractures (Van Hoeve et al., 2019).

Figure number 5 highlights the evolution of the distance covered in the 5-minute interval, from the initial evaluation to the final evaluation.

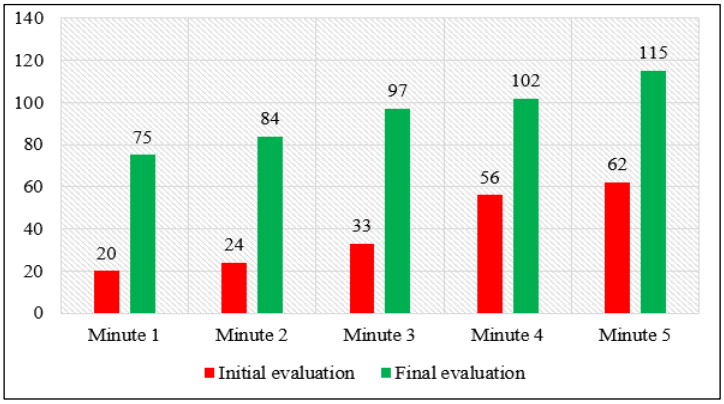


Figure 5. Distance covered in 5 minutes (meters)

The possibility of moving over long distances is conditioned by the integrity of the joint and muscle structures, which must ensure the correct execution of the movements and generate the necessary force for them. The applicative routes used to re-educate long-distance walking have significantly contributed to increasing this potential, a fact that is highlighted in figure number 5, where it can be seen that from a distance of 20 m covered in one minute at the initial assessment, the patient could walk a distance of 75 meters at the final assessment.

Through effective physical therapy management and consistent performance of functional re-education programs, patients can resume normal walking (Bopple et al., 2022).

4. Conclusions

The conclusions of the present research highlight the necessity and importance of physiotherapy programs applied early and customized to the patient's remaining functional for an efficient and correct recovery.

Along with active physical therapy, neuroproprioceptive facilitation techniques, passive mobilizations, tractions, passive stretching of the calf muscles and the Achilles tendon can contribute to the functional re-education of the lower limb and the resumption of daily activities.

Regaining joint mobility, muscle strength, stability, proprioception and re-education of walking parameters can influence the quality of life of patients with fractures of the distal third of the calf.

References

Aydogan E., Langer S., Josten C., Fakler J. K. M., & Henkelmann R. (2020). Outcomes of tissue reconstruction in distal lower leg fractures: a retrospective cohort study. *BMC Musculoskeletal Disorders*, 21(1).

Böpple J.C, Tanner M, Campos S, Fischer C, Müller S, Wolf S.I, Doll J (2022). Short-term results of gait analysis with the Heidelberg foot measurement method and functional outcome after operative treatment of ankle fractures, *J Foot Ankle Res*. 15(1):2.

Brown O, Dirschl D, Ombremskey W (2001). Incidence of Hardware-Related Pain and Its Effect on Functional Outcomes After Open Reduction and Internal Fixation of Ankle Fractures, *Journal of Orthopaedic Trauma,* 15(4):271-274.

Duckworth AD, Jefferies JG, Clement ND, White TO (2016). Type C tibial pilon fractures: short- and long-term outcome following operative intervention. *Bone Joint J*., 98-B:1106–11.

Feria-Arias E, Boukhemis K, Kreulen C, Giza E (2018). Foot and Ankle Injuries in Soccer. *Am J Orthop*, 47(10).

Goost H, Wimmer MD, Barg A, Kabir K, Valderrabano V, Burger C (2014). Fractures of the ankle joint: investigation and treatment options. *Dtsch Arztebl Int*. 111(21):377-88.

Kent S, Yeo G, Marsland D, Randell M, Forster B, Lutz M, Okano S. (2020). Delayed stabilisation of dynamically unstable syndesmotic injuries results in worse functional outcomes. *Knee Surg Sports Traumatol Arthrosc*, 28:3347–3353.

Lin CW, Donkers NA, Refshauge KM, Beckenkamp PR, Khera K, Moseley AM (2012). Rehabilitation for ankle fractures in adults, *Cochrane Database Syst Rev*. 11:CD005595.

Moseley A.M, Beckenkamp P.R, Haas M, Herbert R.D, Lin C.W (2015). Rehabilitation After Immobilization for Ankle Fracture: The EXACT Randomized Clinical Trial, *JAMA*, 314(13):1376-85.

Neumann M., Strohm P., Reising K., Zwingmann J., Hammer T., et al. (2016). Complications after surgical management of distal lower leg fractures, *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 24, 146.

Redfern DJ., Syed SU., Davies SJM (2004). Fractures of the distal tibia: minimally invasive plate osteosynthesis. *Injury*, 35:615–20.

Tengberg PT, Ban I (2018). Treatment of ankle fractures. *Ugeskr Laeger*, 180(41):V11170883.

Toth M. J., Yoon R. S., Liporace F. A., & Koval, K. J. (2017). What's new in ankle fractures. *Injury*, 48(10): 2035–2041.

Van Hoeve S., Houben M., Verbruggen J. P. A. M., Willems, P., Meijer K., & Poeze, M. (2019). Gait analysis related to functional outcome in patients operated for ankle fractures. *Journal of Orthopaedic Research, 37(7):1658-1666.*