Literature Review

Literature review of biomechanics of the ankle/ foot complex: changes in functional activities postoperatively for ankle fractures

Abstract

The ankle plays an important role in daily life under the functional point of view. It is essential to perform basic movements such as walking, running, etc. The ankle joint complex is a part of the body most frequently injured of the musculoskeletal system. Orthopedic fractures in this joint may be classified as low trauma and high energy, the latter trauma, usually found in traffic accidents and falls from great heights are the most disabling. In the general context often this type of fracture compromises neighboring joints due to misalignment of the loading axis of the involved segment, emerging pain and progressive functional disability.

In this context, this study aimed to review the literature of studies that were willing to analyze the biomechanical causes of the functional outcome of fractures of the complex orthopedic foot/ankle trauma generated by high and low energy. For this, a search was made in electronic databases indexing scientific articles, using the keyword search previously created. For better understanding we divided the literature review on topics: classification of ankle fractures, surgical treatment, no surgical indications and contraindications in cases of surgery, types of surgery with open reduction and internal fixation (ORIF), external and hybrid; wounds and complications consequences: amputation, obesity, arthritis and osteoarthritis, early motion, range of motion, gait pathology. From this review study, it is necessary that other publications in the field of physical therapy related biomechanical results of ankle fractures are carried out, since most studies were found in articles reporting on the medical surgeries.

Keywords: ankle fracture, tibial pilon fracture, open fracture reduction, surgical treatment

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Dr Viviane Ribeiro de Ávila
Universidade de Trás-os-Montes e Alto Douro (UTAD), Brazil

Correspondence: Dr Viviane Ribeiro de Ávila, Universidade de Trás-os-Montes e Alto Douro (UTAD), Rua Herculano Pena, 105, apto 301, Centro, Diamantina, MG, Brazil, CEP: 39.100-000, Email vivianeribeiroavil@hotmail.com

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Introduction

The ankle is one of the most important joints of the lower limb, playing an important role in daily life from a functional point of view. It is indispensable for locomotion, maintaining the bipedal position and realization basic movements such as: walking, running, etc.[1]

The bones that form the structure of the ankle are: talus and diaphysis of the tibia and fibula. There are numerous joints in the ankle/foot complex, however, only three play an important role in the execution of most of the movements performed by the ankle, namely: talocrural, subtalar and tibiofibular.[2,3] It is a strong joint, reinforced by various anatomical elements, which passively or actively has the ability to restrict talar mobility beyond physiological limits, which is why it is practically immune to degenerative changes and highly susceptible to traumatic events.[4] The talus, also known as the astrologer in anatomy, is a bone located in the lower extremities of the feet that articulates with the bones of the leg (tibia and fibula), forming the ankle. Talus injuries are rare and can compromise ankle and foot movements and result in severe disability.[5]

The fibula, formerly called the peroneus, is located laterally on the face of the tibia, thus constituting the lateral face of the leg. It articulates to the tibia at its ends, this type of joint has micro movements and is called syndesmosis, which are: proximal tibiofibular joint and distal tibiofibular joint. The only movement that takes place in these joints is a movement of separation and elevation.[6] The tibia is the long bone most frequently affected by fractures.[7,8] Distal tibial fracture, also known as "tibial pilon" fracture, was so named by Destot in 1911, comparing the relationship between the distal end of the tibia with the talus, located in the ankle joint.[9,10] It is an infrequent fracture representing more or less 1% of lower extremity fractures and 5 to 10% of tibial fractures.[10,11] This fracture is among the most serious injuries involving the ankle joint and remains the most challenging fracture to treat and, according to the AO Group classification, is generally classified as type C.[12]

The ankle joint complex is one of the most frequently injured body parts of the musculoskeletal system.[13] Orthopedic fractures in this joint can be classified as low- and high-energy trauma. In low-energy traumas, rotational and shear forces predominate, for example, rotational trauma in a skater, but it is a less traumatic type and has a better prognosis.[14] However, high-energy traumas, which in addition to car accidents also occur due to falls from great heights and sports injuries, are highly disabling traumas, temporarily or permanently, generating disabilities, sequelae and decreased functional capacity in victims of this type of trauma.[15,16] High-energy fractures are often open and involve more gravity compromising tissues, leading to the highest rate of complications.[17]

The treatment of ankle fractures can be closed, when there is no deviation and they can be managed non-surgically, in which splints or traction are used, or open, where the majority of deviated bimalleolar fractures must be approached surgically, with the placement of plates , pins and screws. For there to be an indication for surgical treatment, the fracture must be exposed, with joint displacement or with deviation greater than 2.5 mm and the decision on the moment and surgical tactic depends on numerous factors, such as the conditions of the local soft tissues, the technical resources and technological resources of the medical team and the complete understanding of the existing injuries.[18,19]

In the general context, this type of fracture often compromises neighboring joints, due to poor alignment of the load axes of the segment involved, resulting in pain and progressive functional disability. To avoid sequelae, anatomical reduction and stable fixation of the joint surface are recommended, as well as early movement to prevent the formation of adhesions and capsuloligamentous retractions.[1] In addition, the best functional results can be achieved in patients with high cooperation, seen more frequently in autonomous, sporty and socially integrated individuals.[20] In this context, the present study aimed to carry out a literature review of the studies that were willing to analyze the causes of the functional biomechanical result of orthopedic fractures of the ankle/foot complex generated by high and low energy trauma. For this, a search was carried out in the electronic databases that index scientific articles, using the previously elaborated search keyword.

Material and methods

Literature search

To carry out this study, from August to December 2022, a search for scientific articles was selected in the following databases LILACS – BIREME (database of Latin American and Caribbean literature in Health Science), MEDLINE – Medical Index (Medical Literature Analysis and Retrieval System Online), SciELO (Scientific Eletronic Library Online) e PubMed (maintained by the National Library of Medicine). The articles were consulted with the following search descriptors (keywords and/or delimiters), written in Portuguese and English, used in various combinations: ankle, talus, fibula, tibia, tibial pilon, tibial plateau, fibula and tibia diaphysis, fibula and tibia distal (fracture, injury, anatomy, biomechanic, surgical, gait, functional results, outcomes, etc).

The time factor covered the period between 1969 and 2022, considering the following criteria for selection: articles that specifically dealt with orthopedic ankle fractures related to functional biomechanical results (gait analysis, lateral pressure of the forefoot, decrease in range of motion in dorsiflexion and plantar flexion), according to the results of the readings previously carried out, we realized the need to read the surgical articles, revealing the types of surgeries most used in these cases and the possible excellent, good, regular and worse results that directly influenced the functional biomechanical results found in the researched studies. For a better understanding, we divided the literature review into topics: classification of ankle fractures; surgical and non-surgical treatment, indications and contraindications in cases of surgery; types of surgery with open reduction and internal fixation (ORIF), external and hybrid; wound complications and their consequences: amputation, obesity, arthritis and arthrosis; early movement: range of motion, pathological gait.

Literature revision

Classification of ankle fractures

Ankle fractures at the level of the fibular malleolus are classified according to Weber and Danis: Type A: infra-syndesmal fracture located below the fibular syndesmosis. Type B: trans-syndesmal fracture located at the level of the fibular syndesmosis. Type C: supra-syndemal fracture located above the fibular syndesmosis.[21] Ankle fractures at the level of the tibial pilon can be classified in several ways, but the most widely used is the AO-ASIF (Association for the Study of Internal Fixation) classification, according to Ruedi-Allgower: Type A: fracture of the distal metaphysis of the tibia, not misaligned, with a fracture line reaching the articular surface. Type B: moderate comminution and moderate joint incongruity. Type C: great comminution and great articular incongruity.[20,22]

In addition, it is necessary to consider whether the fracture is open or closed and to assess soft tissue involvement. Therefore, immediate surgical treatment is required before six hours after the trauma, if the soft tissues are not in good condition, it is necessary to wait a period of at least six days to perform the surgery.[20,23] Currently, the tendency is to achieve open reduction and application of stable internal fixation with plate and screws, reconstructing the articular surface of the tibia and applying support bone graft in the tibial metaphysis.[24,25]

Surgical, non-surgical treatment, indications and contraindications in cases of surgery

Regardless of the classification system chosen, the objective of treating these fractures is to obtain an anatomical and congruent articular surface.[12] All joint fragments are aligned one after the other using the talus as a mold to restore anatomical congruence.[20] Integrity between the tibia and fibula in the ankle region is essential for the proper functioning of this joint; however, isolated injury to the distal tibiofibular syndesmosis does not necessarily produce ankle instability, the association with medial injury (rupture of the deltoid ligament or fracture of the medial malleolus) generates frank instability of this joint.[26]

Classically, non-displaced fractures can be treated non-surgically, however, most displaced bimalleolar fractures must be treated surgically.[26] Immediate surgical treatment is determined by the conditions of the soft tissues, which should allow 2 to 3 hours of surgery, only simple fractures without soft tissue involvement can be operated on in the first 6 to 8 hours.[20] When there are risks that prevent surgery during this period, only debridement of the wound should be performed with some type of preliminary external fixation and wait between 6 and 10 days until the disappearance of symptoms such as swelling, blisters, precarious state of the wound and others perform the definitive surgery.[11]

Paccola et al.[27] analyzed nine cases of tibial pilon fracture, with a mean follow-up of 55.11 months (minimum of nine and maximum of 102). According to the classification by Ruedi & Allgower, two were type I, six type II and one type III. Of these, six were treated surgically and three conservatively. The results show a close relationship with the quality of reduction and were comparable to other series reported in the literature. Tibial pilon fractures with significant deviation (types II and III) should be surgically treated with anatomical reduction, stable fixation and early physiotherapy.

The fibula is usually fractured in high-energy ankle injuries,[28], when this happens it is important that the fibula is fixed first to avoid poor reduction in tibial varus,[12] in this case, the ideal surgical technique for stabilizing the distal tibiofibular syndesmosis has a direct influence in the quantity and diameter of the screws used and in their position. However, biomechanically, two screws present greater resistance than one screw, and it is often necessary to remove the screws for a better functional result.[26]

Due to soft tissue limitation and the subcutaneous location of the fibula and tibia in the ankle, wound collapse often leads to exposure and infection of the bone and underlying equipment, contributing to dehiscence.[29] This complication can be saved with a muscle graft, the most used muscle for this procedure is the latissimus dorsi, followed by the rectus abdominis and gracilis.[30] Indications for surgery are based on radiographic results (anteroposterior and profile, but in more complex fractures also is also indicated the shroud), conventional two-plane and three-dimensional CT scans (when there is suspicion of malleolar fractures with traces extending to the articular surface of the distal tibia/pilon) and magnetic resonance imaging (diagnosis of stress fractures and osteochondral, tendon or ligament injuries), in addition to this, it is important to know the condition of the soft tissues, the general condition of the patient, the technical and technological resources of the medical team and the complete understanding of existing injuries by an experienced surgeon.[20,26]

The reasons why surgery may be contraindicated are: patients with severe polytrauma and cranioencephalic trauma, with impaired general status; peripheral vascular disease and/or infections, cases of diabetic neuropathy, advanced age, poor condition of the soft tissues, presence of swelling and blisters, psychiatric disorders, cases with multiple comminution of the fracture with very small bone fragments, therefore predicting unfeasible reconstruction.[31]

Types of surgery with internal fixator (ORIF), external and hybrid

The types of fixators used in ankle surgeries are internal (ORIF), external and hybrid. In most displaced joint fractures, reconstruction of the distal end of the tibia is best achieved by ORIF, exceptions include severely crushed fractures.[20] If the soft tissues allow it, ORIF should be performed within 6 hours after the trauma. This method significantly reduces soft tissue complications, with functional results equivalent to those of hybrid fixation.[11] In another older study Ruedi & Allgower[32] reported 74% excellent and good results in patients followed for an average of 9 years after treatment with modern internal fixation techniques for that time. Unfortunately, leading surgeons continued to publish poor results and high complication rates after internal fixation.[33,34]

Hybrid fixation is a method that often starts with the reconstruction of the fibula, if the conditions of the soft part allow it, it proceeds to the reconstruction of the tibia, with due filling of the metaphyseal spaces with spongy bone graft. After that, the external fixator is applied, which is installed from the calcaneus to the tibial metaphysis.[11] Theoretically, the benefit of the hybrid external fixator is that it allows movement of the ankle joint, without thinking about movement of the metaphysis on the fractured side.[17.] In addition to its functional results being equivalent to those derived from ORIF and traditional external fixation, good results were also found with the Ilizarov-type circular external fixator method combined with minimally invasive surgery.[11]

The study by Milenkoviü et al.[35] aimed to estimate efficacy of distal tibial pilon fractures treatment using the external skeletal and minimal internal fixation method. This retrospective study involved 31 patients with tibial pilon fractures operated on using the method of external skeletal fixation with a minimal internal fixation. The percentage of union was 90.32%, nonunion 3.22% and malunion 6.45%. The ankle joint arthrosis as a late complication appeared in 4 (12.90%) patients. All arthroses appeared in patients who had type C fractures.They concluded that in fractures types B and C of the tibial pilon, dynamic external skeletal fixation allows early mobility in the ankle joint being a good method of treatment for all types of fractures.

Catagni and Carvalho Filho[22] in a study with the objective of presenting a method of external fixation with the Ilizarov device, with or without internal fixation, with minimal synthesis and minimal skin incision for the treatment of tibial pilon fractures. Found 100% of bone healing in the cases. Only two cases (6.6%) of unsatisfactory functional results (one of them with associated calcaneal fracture and not showing pain after subtalar arthrodesis) and 93% of functional results were good or excellent, convincing us that the method represents alternative safety for the treatment of tibial pilon fracture.

Taylor and Allum[36] concluded in their work that the external fixator is an excellent method to manage complex tibial fractures, but care must be taken and mobilize of the ankle joint later. In the past decade, the use of indirect reduction techniques that minimized banded tissue has helped to reduce the incidence of wound complications after internal fixation. In addition, the main pilon fractures are better treated with external fixation techniques, it was this type of use that reduced the rate of wound complications the most.[17]

Wound complications and their consequences

Amputation

In the past, many severe tibial fractures resulted in amputation below the knee. With the advancement of studies and surgical techniques, today we have a good chance of salvaging the fractured limb and, with this evolution, a reduction in hospital costs was also observed.[7,37.]

Thordarson[17] divided wound complications after fracture treatment into: intraoperative (joint penetration, poor reduction, inadequate fixation); perioperative (wound complications or dehiscence, superficial or deep infection) and postoperative (stiffness and arthrosis, malunion and nonunion, post-traumatic arthritis).

In the study by Wyrsch et al.,[34] osteosynthesis was compared with or without an internal fixation plate limited to internal fixation in the treatment of pilon fractures. Of 20 patients only 4 had complications, however 3 of these patients underwent amputation below the knee due to wound complications after ORIF. These authors concluded that the external fixator is a satisfactory method of treatment and is associated with fewer operative complications compared with the internal fixator. McFerran et al.[33] in a series of 52 pilon fractures, reported an average complication in 28 patients (54%) in an average of 3 weeks after surgery, 10 patients (40%) had to be reoperated: 6 bone graft for malunion, 1 osteotomy for malunion, 2 fixation revisions and 1 amputation below the knee.

Brauns and Lammens[38] reported a series of ten patients that were identified with sequels of an infected pilon tibial fracture. All were victims of high-energy accidents. The initial treatment for closed fractures (6/10) was ORIF. Open fractures (3/10) were initially treated by an external fixation, which in a second stage was converted to a plate osteosynthesis. Only one patient (1/10) had a conservative treatment with a leg cast because developed an ulcerative wound that surinfected. All fractures were classified as grade III according to Rüedi and Allgöwer classification. Nine out of ten patients were able to perform all activities of daily life. Eight of the ten patients preferred the use of orthopaedic shoes for walking long distances.

Sirkin et al.[39] reported in their article 34 closed and 22 open fractures using a fixation plate in the fibular fracture and placing a medial external fixator between the foot and the tibia in complex pilon fractures. Of the 34 closed fractures, there was 1 case of osteomyelitis that had to remove the equipment, and of the 22 cases of open fractures 2 developed wound infection, 1 had to do multiple debridements, and the others also had an ipsilateral open calcaneal fracture that required amputation below the knee.

Thordarson et al.[12] described that the osteomyelitis that develops in chronic tibial pilon fractures is a serious problem, in order to have a good result and save the extremities it is necessary to have a complete understanding of the wounds and the best method for their debridement, as well as, having a good team with an orthopedic surgeon, an infectious disease specialist and a plastic surgeon. In addition to these procedures Marsh et al.[40] and Canada[41] reported that many cases of early amputation were caused by uncontrollable factors associated with wound complications, such as patients with a history of diabetes, malnourished, smokers, poor circulation, poor immunity, inadequate use of of the tourniquet for an extended period beyond that recommended by the doctor and also by abandoning the return to check the state of the wounds (bubble formation), change the dressings, carry out the prevention of infection of the pins, if so, replace them to avoid infection (osteomyelitis).[17]

Thordarson[17] concluded in his review study on management strategies and prevention of complications after treatments of tibial pilon fractures, that soft tissue management is as important as bone reconstruction when dealing with complex fractures.

Obesity

Graves et al.,[42] in a study on the hypothesis that obesity would be a protective factor against the complications of wounds in pilon fractures, proposed two questions: 1) the dimension of the ankles of obese patients are wider than in thin patients; 2) increased tissue surrounding the ankle may decrease wound complications. Were compared 31 fractures (obese) with 83 fractures (thin), of these groups, 8 complications occurred in the wounds, 4 in the obese group (13%) and 4 in the thin group (5%). The following conclusions emerged from this study: Obese patients have a risk of wound complications after surgery almost 3 times greater than thin patients, the second hypothesis being negative and confirmed by this study and by the study of other authors on different types of orthopedic fractures on the ankle in obese patients.[14,43]

Strauss et al.[14] studied ankle fractures in obese patients from high- and low-energy impact wounds and concluded that the greater the impact, together with the aggravation of more bone fractures involved, the greater the destruction of the soft parts of the body, causing greater complications in the wounds, in addition he reported the fact that the nerve on the injured side was pressed by the patient's increased mass, the identification and dissection of this nerve may be more of a challenge in this patient population due to the subcutaneous fat layer.

Most reports in the literature that relate complications after comminuted fractures of the tibial pilon emphasize their relationship with high-energy trauma, as well as reporting that they are the most difficult to reduce anatomically and are associated with the worst results.[17] High-energy trauma is the most frequent cause of death in patients younger than 44 years, adults and young adults, that is, the economically active population.[15,44] In addition, Karunakar et al.[16] reported that the probability of morbidity in obese patients was 5 times higher when compared to lean patients, probably due to greater complications in the wounds after acetabular fracture fixation surgery.

Arthritis and arthrosis

As a result of this type of injury, arthrosis can appear progressively over the long term. To avoid arthrosis, bone grafting and medication are used.[31,23] Among the complications after treatment of diaphyseal fractures of the tibia, rotational deformity is not highly valued; however, it can present cosmetic problems and produce arthrosis or other functional complications.[7] Other late complications, such as stiffness and post-traumatic arthritis, correlate with the initial severity of the injury and the accuracy of the reduction. Less movement in the ankle can be minimized by performing exercises earlier to increase range of motion after stable fixation has been achieved.[17]

Murachovsky et al.[31] studied 41 patients with deviated calcaneal fractures. In 32 feet, 71.1% needed bone grafting. The satisfactory functional clinical result was found in 89% of the operated feet. In 42 feet (93.3%) the presence of arthrosis of the subtalar joint was observed. The main complaint in the group of patients with unsatisfactory functional results was pain that limited the performance of daily activities. The average time from trauma to return to work was 7.9 months. Six patients did not return to work and four had to change their original activity for a lighter one. According to Pollak et al.,[45] comminuted fractures of the tibial pilon were always considered to be of high severity due to their complexity, which could lead to major sequelae such as arthrosis, pain and limitation of movement. For this reason, several patients do not return to their activities as before the trauma.

Giordano et al.[18] described the treatment results of 15 patients with poorly healed tibial fractures. The main complaint was the existence of deformity of the lower limb, consequent to the vicious consolidation of the tibia due to failure of previous treatments. The results were 100% satisfactory in terms of bone consolidation and 93.3% of satisfactory functional results, however, a patient with a severe fracture of the tibial pilon, with great joint destruction, was the one who had an unsatisfactory functional result, as he had persistent pain in the ankle due to tibiotalar arthrosis after removal of the external fixator, which persisted until the moment with a follow-up of seven months, not ruling out the need to perform tibiotalar arthrodesis in the future. The authors concluded that individuals who present some acquired deformity of the lower limb suffer a significant reduction in their quality of life, however, they attest that the correction of the deformities, the possibility of sustaining body weight throughout the treatment and the eradication of the infection, when present, they bring substantial improvement in the quality of life of these patients.

The cure of arthrosis and arthritis, despite studies reporting good results with the application of bone graft, has been debated and may be related to several factors, symptomatic patients often require early arthrodesis of the ankle or even amputation.[17,20]

Early movement

Range of motion

Dorsiflexion is lost more than plantar flexion in tibial fractures treated with an external fixator.[36.] Taylor and Allum[36] analyzed 31 patients in his research, the average loss of ankle mobility was 20^0, with 8^0 for plantar flexion and 12^0 for dorsiflexion, this difference being highly significant (p>0.001, t test). For closed and open fractures, the loss was 6^0 and 22^0, respectively, this difference was also statistically significant (0.05>p>0.02, t test).

In a survey of pilon fractures of 20 patients treated with external fixation, ankle range of motion was classified as excellent in 6 patients (a minimum of 10 degrees of dorsiflexion and 30 degrees of plantar flexion); good in 9 patients (from 5 to 10 degrees of dorsiflexion and 25 degrees of plantar flexion); fair in 3 and worse in 2 patients.[46] Marsh et al.[47] reported that the mean range of motion in 49 patients after placement of an external fixator in distal tibial fractures was 8^0 dorsiflexion and 28^0 plantarflexion.

In a survey of 16 patients treated with limitation of an internal fixator and hybrid external fixator in fractures of the distal tibia, 50% had excellent and good results in range of motion and 50% had fair and worse results in range of motion.[48] Ruedi and Allgower,[49] in a study of intra-articular fractures of the lower limbs and tibia, reported that 40% of patients suffered loss of range of motion in the ankle joint, but they did not quantify this.

One study found that after traumatic ankle fractures, the impact of ankle sprain caused pain and limitation of movement in 25% of the patients surveyed, in addition to possibly have resulted in soft tissue injury.[50, 51] Six to 12 months after ankle sprain, signs of early arthritis were related to pain at the end of the range of motion.[52] After the result of the weight-bearing lunge test, the authors found that ankle dorsiflexion asymmetry greater than 2.5 cm between sides is indicative of risk of ankle sprains.[53] These functional alterations in the biomechanics of the ankle/foot complex can be evident on both sides, injured and uninjured, and impact body movement kinematics as well as static and dynamic balance in movements such as walking, stepping, running, jumping, cutting and kicking.[54–57]

Pathological gait

The functional damage imposed by the loss of joint mobility during gait due to bone fractures is more visible during the stance phase. Lack of mobility in the ankle occurs at around 15^0 of plantar flexion, because this is the natural resting posture of the joint, with a functional deficit of 25^0 in relation to normal mobility.[58] According to Thordarson et al.,[12] a significant postoperative stiffness may lead to gait abnormality, therefore, earlier range of motion work should be allowed to release the tissues and acquire adequate bone stability.

A study was carried out with the aim of investigating pressure and preferential gait speed after muscle grafting for tissue reconstruction in severe tibial fractures. Results indicated incomplete recovery of gait symmetry patterns. In particular, the duration of the stance phase was significantly shorter on the operated side, averaging 701 ms compared to 765 ms on the other side, considered normal ($p<0.001$). The point of peak pressure under the foot was different in the bilateral comparison, being regularly higher under the lateral region of the forefoot on the operated side. This can be explained by the attempt to reduce the load on the ankle joint during the stance phase of gait.[59,60] This loading lateralization (weight bearing) after surgical reconstruction of severe tibial fractures has also been previously studied.[61]

Also confirming this pressure lateralization during gait corroborated the study by Vasarhelyi et al.[6] who found other findings in addition to those mentioned above. His study aimed to measure gait pressure in individuals with fractures in the tibiofibular joint reaching the distal syndesmosis before and after removing the screws. Were taken 3 measurements, 1 and 6 weeks before screw removal and 4 months after screw removal.

The gait pattern after a fracture of the tibiofibular joint reaching the distal syndesmosis is characterized by an excess of weight in the rearfoot as well as a shift in weight from the metatarsal to the sides of the forefoot. However, this difference returned to normal after 4 months after surgery, when the screws were removed. The authors concluded that temporary blocking of the tibiofibular joint leads to an increase in load on the hindfoot as well as a transfer of weight from the midfoot to the lateral foot. Confirming these findings, the study by Giordano et al.[26] reported that often the resistance of the screws is the very cause of the deformities, which can lead to a tarsal impingement blocking normal movement between the fibula and the tibia. Furthermore, these findings support the assumption that the fibula is more loaded during gait after severe tibial fractures, compensating for a long healing period with external fixation.

Gait analysis showed significant deficits comparing the fractured side with the healthy side in terms of pressure. Patients with more success in surgery place more load on the lateral forefoot side of the injured leg. Similarly, less successful surgery results in reduced pressure under the metatarsal head. Load transfer to the lateral forefoot is a possible way to decrease the load on the knee joint and prevent degenerative changes in the knee cartilage. Although this study did not report the type of fracture or the clinical evolution, the results may illustrate the compensatory mechanism that was used to recover gait symmetry after alteration of the ankle due to trauma.[61]

Contreras et al.[15] aimed in this study to offer a clinical, radiographic and biomechanical gait evaluation of patients with intra-articular calcaneal fractures, submitted to open reduction and internal fixation, where 24 fractured feet were analyzed, because there were two bilateral intra-articular fractures of the calcaneus. The results were satisfactory, with an average score of 75.5 in the AOFAS (American Orthopaedic Foot & Ankle Society) criterion, this index demonstrates that there were good functional results, allowing the patient to resume his activities. The author concluded that it is not enough for the individual to walk again, but the pattern to be acquired is a relevant factor for quality of life.

Medeiros et al.[62] carried out a clinical and functional evaluation of intra-articular calcaneal fractures. Associated with these fractures were six fractures, one of which was a tibial pilon fracture. In this study, 73% of satisfactory results were found, physiotherapy was started two months after the event with progressive support and, at three months, full weight bearing and gait training. As for gait, 36 patients had no difficulty on different terrains, 59 had mild difficulty on uneven terrain, stairs, slopes and slopes and 12 maintained intense difficulty walking on irregular terrain. The authors concluded that residual edema and poor alignment can limit walking and wearing shoes.

In the study by Wang,[63] a three-dimensional gait analysis was performed in 18 patients with a multi-segmented foot model one year after ankle fractures that were surgically treated and was also used to quantify foot movements. The data were compared to the control gender, presenting the same characteristics, but healthy. The correlations of patients with ankle fractures showed less plantar flexion and less range of motion in the talocrural joint on the fractured side. It is believed to be a sign of residual joint stiffness after surgery and splinting. In addition, the forefoot segment had less movement in the sagittal and transverse planes in the transverse ranges of motion, less plantar flexion in the hallux segment, less dorsiflexion and less range of motion in the sagittal plane. The deviations found in the forefoot segment may have contributed to the compensation mechanisms of the injured ankle joint. The results of this study showed that gait analysis with a multi-segmented model of the foot offers a quantitative and objective way to perform dynamic assessment of postoperative ankle fractures, and makes it possible to better understand not only how the injured joint is affected, but also neighboring joints.

Conclusion

The studies reviewed in this literature review confirmed the importance of early movement of the ankle/foot joint to prevent stiffening and possible functional sequelae. With this procedure accompanied by a physiotherapist, it is possible to have a recovery of motor function and quality of life. The most common causes of these fractures were car accidents, falls from great heights, being run over and sports injuries. This data is important because the worst functional results of orthopedic ankle fractures were caused by high-energy trauma.

The results emphasized that despite long periods of adaptation after severe orthopedic ankle fractures, patients failed to fully return to the normal walking patterns they had prior to the injury. In the study by Mazur[64] these gait patterns were significantly improved when patients were wearing shoes with adequate heels or orthopedic insoles. He also concluded that it was reported by his patients that this disability did not make them less functional for tasks of daily living.

From this review study, it is necessary that other publications in the area of physiotherapy relating biomechanical results of ankle fractures be carried out, since most of the studies found were articles in the medical area reporting about the surgeries.

Acknowledgments

None.

Conflicts of interest

The authors declare no conflicts of interest.

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