CLINICAL STUDY WITH HUNOVA

Orthopedics – Ankle fracture

Rehabilitative treatment of fracture-dislocation of the ankle with hunova: a case study.

V. Da Pieve (MD), E. Tanco (PT), F. Rossi (PT)

Casa di cura privata Le Terrazze, Cunardo, Varese, Italy

We would like to share our experience applying hunova for the treatment of a fracture-dislocation of the ankle. Hunova is an engaging device for the patient, which allows to perform rehabilitation with personalized exercises able to improve ankle range of motion and muscle strength guaranteeing the possibility of quantifying the results achieved. The improvements we observed encouraged us to share this experience to support other clinicians. Therefore, we would like to provide an overview about the treatment protocol and the results we achieved in this case study report.

Introduction

Ankle fracture is a commonly used as a term to describe the fracture of the distal tibia or fibula. It is one of the most common lower limb injuries and the incidence has been increasing in the latest years. Depending on the severity, ankle fracture is treated with or without surgery, followed by a period of immobilization. Immobilization may result in decreased articular range of motion, muscular weakness and decreased muscle strength. In addition, ankle fracture can be accompanied by other injuries, which may further impair recovery. These injuries include damage to the cartilage and ligaments, the existence of free bodies within the intra-articular space or dislocation of the distal tibio-fibular joint. Consequently, people with an ankle fracture often experience pain, stiffness, weakness and limitations in activities such as stair climbing and walking causing reduced participation in work and recreation. For all these reasons, physical therapy becomes a very crucial activity for this kind of trauma. hunova is an innovative robotic device effective for the rehabilitation post ankle injury. It is composed of two sensorized platforms that allow to perform exercises both in sitting and upright position, providing the patient with continuous sensorial feedback. In addition, the device can be set in the ankle configuration binding the foot to the platform with a sandal and blocking the knee with a support to avoid lateral compensation. In this report we present a case study in which we share how we have achieved clinical improvements on ankle range of motion and muscular strength in isometric and isokinetic conditions after several treatment sessions on hunova in a case of severe fracture-dislocation of the ankle joint treated with surgery.

Medical History

We describe the case of a 48-year-old female patient (Body Mass Index: 29.38) admitted to our rehabilitation facility 1 month after surgery. The patient presented a severe dislocation of the left ankle joint associated with a fibula fracture. Her surgery consisted of a reduction and synthesis with plate and screws of the peroneal malleolus plus other 2 screws in secondary locations. The patient underwent 2 physical therapy cycles following surgery due to the fibula fracture. At the end of the first rehabilitation cycle the patient was evaluated with hunova (T0). After the assessment the second therapy cycle started on hunova.

Initial evaluation

At recruitment the report of the physiatrist was: Range of motion limited to the intermediate degrees (in dorsal and plantar flexion), residual pain to the pressure of the

insertion of the muscle short peroneus (V metatarsal bone) and along its course, pain to pressure of the proximal insertional surface and along the course of the tibialis anterior muscle.
Evaluations were performed at recruitment (T0), at the end of the treatment (T1) after a 2-month interval and at a 6 month follow up (T2). The assessment consisted of robotic evaluations on hunova always performed bilaterally in order to perform comparisons. The robotic evaluation included the following 2 categories of tests:
To evaluate ankle performance in terms of range of motion and force:

- *Ankle range of motion*: The subject is seated and must move the ankle (bounded to the platform) as far as they can in the indicated directions (right – left for frontal plane and forwards – backwards for sagittal plane). The test determines the maximum range of motion in all the movement directions.
- *Isometric test:* this test quantifies the force expressed [torque - Nm] in isometric conditions by the subject. The test consists of 3 contractions (in plantar or dorsiflexion) lasting 5 seconds at maximal strength and 5 seconds of rest. This test was performed at T0 and T1 with both ankles in 2 conditions: thrust in plantar flexion with the foot positioned 10° in dorsiflexion and the contrary i.e. pushing in dorsiflexion with the platform tilted 10° in plantar flexion. The parameters measured are maximum torque in Newton meters and the mean maximum torque.
- *Isokinetic test:* this test quantifies the force expressed [torque - Nm] in isokinetic conditions. The test consists of a series of 5 contractions in flexion-extension with 3 increasing speed levels (60°/sec, 90°/sec and 150°/ sec) or three decreasing resistance levels of the base.

To estimate the functional consequences of the ankle injury on balancing:

- *Balance test on static base* (Eyes Open - Eyes Closed): the subject must maintain their balance on a static surface in standing position. Evaluators include the area and the range of oscillation, the length of the trajectory of sway. In addition, trunk compensations are evaluated.
- *Reactive balance*: The test quantifies the patient's ability to quickly recover their correct posture after an unexpected external perturbation using sequences of impulses in the various directions (left, right, forwards) that arouse automatic postural responses.
- *Limits of stability*: The subject is standing and must move the load as a pendulum as far as they can in the indicated directions (right, left and forwards). The test calculates the range of movement of the load in the different directions.

Treatment intervention

Personalized hunova training sessions with variation of difficulty depending on the patient's performance were prescribed together with conventional physical therapy.
Each training session on hunova lasted 30 minutes, twice a week for 1 month. Sessions included exercises in bipodalic, monopodalic and ankle configurations with focus on:

- Bipodalic and monopodalic balance
- Lower limb general strengthening
- Ankle range of motion
- Ankle control of dynamics
- Ankle muscle strengthening

The treatment goal was to improve functional capability in all the categories listed above.

Results

At T1 the robotic evaluation *Balance test on static base* performed in standing position reports a reduction of postural sway. The sway area in the first evaluation has a value of 2.08 cm² with eyes open and 5.28 cm² with eyes closed. In the second evaluation the value decreases to 0.92 cm² with open eyes and 1.16 cm² with eyes closed resulting in normal values. The sway pathlength has this behavior, too. As far as the trunk oscillations, higher values than the normality in the first evaluation were measured (table 1). This was probably due to trunk involvement in the adjustment of balance control. It was significantly reduced in the second evaluation, which can be interpreted with a greater ability to activate distal (ankle) strategies in balance alignment.

Parameter name	T0	T1	Improvement %
Trunk sway range AP - EO [deg]	4.17*	1.82	56%
Trunk sway range AP - EC [deg]	4.27*	4.05*	5%
Trunk sway range ML- EO [deg]	3.84*	1.36	65%
Trunk sway range ML- EC [deg]	2.73*	1.19	56%

Table 1: Balance test on static base. Trunk parameters. Each parameter was calculated at T0, T1 and the percentage of improvement. Asterisks (*) mean that the value is not normal. Abbreviations: EC Eyes closed; EO Eyes open; AP Antero-posterior; ML medio-lateral.

In *reactive balance* test outcomes, the patient has reaction times above the normality only for anterior and right imbalances in the first evaluation at T0. These values reduce in the second evaluation close to the limits of normality (from 1.66 seconds to 0.78 seconds for the anterior perturbation and from 1.7 to 0.8 for the right side one). The fact that at T0 the response to the perturbation on the right side was very slow is explainable because this perturbation needs a response form the contralateral side i.e. the affected ankle side.
The value of the stability area of the *limits of stability* test at T0 is slightly reduced compared to the normality range (84.88 cm^2) due to a slighter limit in the forward direction. After the treatment, the stability area value enters in the normal range (93.60 cm^2).
Specific ankle evaluations were repeated 3 times: at T0, T1, T2. Table 2 presents the *ankle range of motion* values measured at T0, T1 and T2 both for the right and left ankle. Supination values are normal bilaterally, but all the other directions are limited for the left ankle at T0. After the left ankle treatment, there were significant improvements in pronation ROM (+14%) and in plantar flexion (+80%) at T1. At follow up data (T2) improves even more. In the *isometric test* (plantar flexion thrust) the torque exercised by the left ankle (maintenance of the contraction) appears (a, b) increased at T1 respectively by 31% for maximum torque and 33% for mean torque, showing an improvement in recruitment capacity.

Ankle ROM	R	L	R	L	R	L	R	L
	Supination		Pronation		Dorsi flexion		Planar flexion	
T0	18.2	18.5	17.9	15.7	25.7	17.2	23.9	15.1
T1	18.2	18.1	18.1	18.0	22.2	16.2	23.7	*27.3*
T2	18.2	18.1	18.1	17.6	25.5	21.4	25.8	20.8
Normal	18°		18°		25°		30°	

Table 2: Ankle Range of motion [deg] values measured at T0, T1 and T2. Abbreviations: R=Right, L=Left. Normal values are reported in the last row.

Also, recruitment time appears reduced compared to the first evaluation of 69% as well as a reduction in the variability of the torque with an increase of 28% from the first to the second evaluation (secondary parameters, not show in table 3). As far as pushing in dorsiflexion, the torque exercised by the left joint appears (a, b) increased by 12% and 8% respectively (T1), showing an improvement in the recruitment capacity. The recruitment time appears reduced compared to the first evaluation of 55% as well as a reduction in the variability of the torque. In general, an improvement in the functional capacity of the left tibiotarsal joint is observed from the first to the second evaluation. Bilateral symmetry at T1 (Symmetry R/L, table 3) has improved too: from an average of +30% towards the right to an average of +9% (where 0% is perfect symmetry). At follow up (T2) the mean torque value is even higher.

Isometric test	*-10° (plantar flexion)*		*+10° (dorsi flexion)*	
	a	**b**	**a**	**b**
T0				
L	58.4	55.0	50.3	*47.0*
R	79.5	70.0	64.6	*60.4*
Symmetry R/L	+36%	+27%	+28%	*+28.5%*
T1				
L	76.7	73.3	56.4	*51.0*
R	81.2	79.0	61.0	*59.6*
Symmetry R/L	+5.8%	+7.7%	+8.1%	*+16.8%*
T2				
L	94.7	85	59.6	56.3
R	101.4	98.3	58.9	56
Symmetry R/L	+7%	+15.6%	-1%	-0.5%
Improvement % Left Ankle T0-T1	+31%	+33%	+12%	+8%
Improvement % Left Ankle T0-T2	+62%	+54%	+18%	+19%

Table 3: Isometric test values (T0 – T1 – T2). Abbreviations: a: maximum torque exerted during a contraction [Nm]; b: Mean maximum torque between contractions [Nm]. R=Right, L=Left.

Compared to T0 there is a global improvement in the efficiency of the left ankle in terms of recruitment and maintenance of the force in *isokinetic* conditions. The percentage values referred to the ankle joint recruitment speed and maintenance of the strength relating to the right and left ankle in the second evaluation tend to improve overall with respect to the first evaluation (38%, 49%, 100% for the different speed test, respectively), although a residual difference between left and right persists: bilateral symmetry is now considered normal (<20%) (Table 4). In figure 1, the torque raw data is plotted for the 60°/sec isokinetic test performed at T0 and T1 with the left ankle. Significant differences from T0 to T1 can be seen in the variability of the signal between the 5 movements and in the maximum peak value reached (21 Nm vs 35 Nm).

Conclusions

Following the rehabilitative treatment, the patient has an important improvement in the left ankle joint range of motion and muscular strength.

Isokinetic test	150°/s	90°/s	60°/s
T0			
L	18.5	18.8	16.5
R	36.6	36.1	42.4
Symmetry R/L	+97%	+92%	+156%
T1			
L	25.5	28.1	33.7
R	30.4	33.2	39.2
Symmetry R/L	+19.2%	+18%	+18.7%
T2			
L	34.7	33.8	29.8
R	42.7	40.5	40.7
Symmetry R/L	+23%	+19.8%	+36.5%
Improvement % Left Ankle T0-T1	+38%	+49%	+100%
Improvement % Left Ankle T0-T2	+87%	+86%	+80%

Table 4: Isokinetic test at different angular speed values measured at T0, T1 and T2 for both ankles. Values refer to the mean torque [Nm]. Abbreviations: R=right, L=Left.

Bilateral symmetry considering all the parameters from both the joints returns into the normality range. From this experience it emerges that hunova contributed to this achievement demonstrating that it is a powerful tool for rehabilitation after ankle traumas. hunova is an engaging device for the patient and integrates traditional treatment with personalized exercises able to stimulate ankle motion and dynamic control. Outcomes obtained show the effectiveness of robotic therapy in combination with conventional therapy, with an individualized and interdisciplinary approach. The subject has benefited in a very positive way from the treatment with hunova, in terms of improved functionality, independence and social integration. We believe that it is important to share our experience and support other clinicians which work with the same patient group.

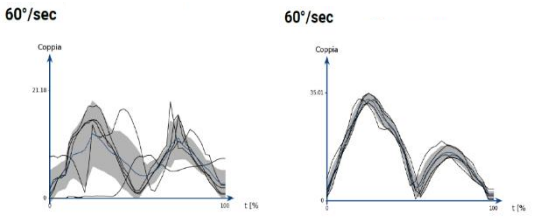

Figure 1: Isokinetic test performed at 60°/sec at T0 and T1 with the left ankle. The raw data plotted in the graphs is the torque value in the 5 repetitions: flexion-extension. The grey area shows the variability (standard deviation) of the repetitions.

About us

Our highly specialized rehabilitation clinic is in Cunardo, near Varese, Italy, and welcomes patients who need to carry out intensive multidisciplinary rehabilitation. It can be accessed in agreement with the NHS or privately, subject to an assessment of appropriateness by referring physicians. It is a modern structure equipped with state-of-the-art robotic equipment and can count on a network of collaboration with different territorial health entities.

info@clinicaleterrazze.com