CLINICAL STUDY WITH HUNOVA

Orthopedics - Knee Prosthesis

hunova as a tool in rehabilitation following robotic knee arthroplasty

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We would like to share our clinical experience using the robotic device hunova as an assessment and training tool in rehabilitation after knee arthroplasty performed with an innovative robotic approach. The improvements we observed over treatment progression encouraged us to share this experience to support clinicians who are dealing with post knee arthroplasty rehabilitation like us. In response to the experimental therapy program, balance, reactivity and postural transitions improved in a significant way. Therefore, we would like to present in this case report how we have introduced the robotic device hunova in the rehabilitative pathway and share our assessment and training protocol that we are continuously using every day in clinical practice.

Introduction

Our clinic embraces knee arthroplasty robotic technique, which consists of using a robotic system to support the surgeon's choices during the application of the implant and elaborate the correct surgical instructions useful for positioning the prosthesis in the right place and balancing it perfectly. As a result, patients who undergo robotic knee arthroplasty surgery have much faster recovery times than those operated with conventional techniques. After the surgery, another robotic device supports physiotherapists who take care of the rehabilitation process: hunova allows to evaluate and practice postural control, stability and functional movements using different exercises both in standing and seated positions.

This case study aims to share a preliminary experience on the use of hunova for assessment and training after knee arthroplasty. Our aim was to investigate the best way to introduce the robotic device hunova in the post-surgery rehabilitation program. At first, we compared traditional therapy to the one adding hunova to assure the clinical outcome. Afterwards we explored differences between a non-robotic conventional protocol and an experimental rehabilitation protocol including hunova as a robotic training and assessment device. The purpose of this activity was to examine the effect of a robotic rehabilitation program among patients after knee arthroplasty surgery.

Materials and methods

Patients

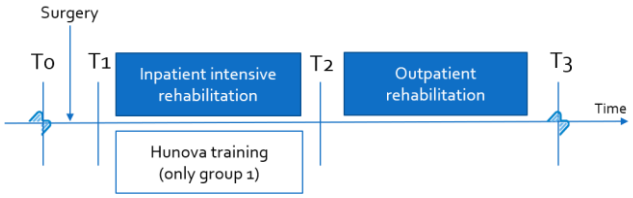
We observed 12 subjects who underwent a robotic knee replacement surgery and rehabilitation process at "Clinica San Francesco" have been involved in this preliminary study. This group of patients followed an experimental rehabilitation protocol including robotic training and assessment sessions. In addition, we considered a control group of 12 subjects aged matched with the previous ones who underwent traditional training, but robotic assessment. The 2 groups were homogeneous in gender, age, BMI, affected side and days of stay in clinic (Table 1). Clinical scales values at baseline are similar, too.

	Experimental Group (n:12)	Control Group (n:12)
Gender (F/M)	3/9	5/7
Age (years M ± SE)	62 ± 2	66 ±2.6
BMI (M ± SE)	28 ± 0.9	26 ± 1.6
Affected side (R/L)	7/5	7/5
Stay in clinic (days; M ± SE)	13.5 ± 0.3	13.2 ± 0.6
Clinical Scales		
BI at T0 (M ± SE)	69.1 ± 3.3	77.1 ± 5.1
KRS at T0 (M ± SE)	47.6 ± 2.4	46.1 ± 1.8
NPRS at T0 (M ± SE)	4.0 ± 0.4	3.7 ± 0.5

Table 1: Subjects characterization. F/M: Female/Male; BMI: Body Mass Index; R/L: Right/Left; BI: Barthel Index; KRS: Knee Rating Scale; NPRS: Numeric Pain Rating Scale; M±SE: Mean ± Standard Error.

Protocol

Figure 1 represents the rehabilitation protocol developed for patients who address to our clinic to have partial or total knee replacement surgery and start the rehabilitative process. It consists of a pre-intervention assessment session (T0 – clinical and robotic evaluation), a post-intervention intensive inpatient rehabilitation program (about 15 days, from T1 to T2), a pre-discharge clinical evaluation (T2) and a robotic assessment at follow up 3 months after surgery (T3). As far as this case study, only subjects belonging to the experimental group trained with hunova during the time frame T1- T2 along with traditional rehabilitation. In the same period, the control group followed conventional rehabilitation practice.



T_0	Pre surgery -> 1st day of hospitalization
T_1	Post-surgery -> 2nd day of hospitalization
T_2	Discharge ->15th day of hospitalization
T_3	Follow up 3 months post-surgery

Figure 1: Rehabilitation protocol

Clinical evaluation

Clinical evaluation was performed at admission (T_0) and at the end of the intensive rehabilitation period (T_2). All 24 subjects were assessed with the same clinical scales:

- Barthel Index (BI)
- Knee Rating Scale (KRS)
- Numeric Pain Rating Scale (NPRS)

Robotic evaluation

Robotic evaluation was performed before the surgery (T_0) and at follow up (T_3). The test performed were:

- *Balance test on static base* (Eyes Open - Eyes Closed): the subject must stand in bipodalic stance on the static platform and balance for 30 seconds. After a short pause, the evaluation is repeated with closed eyes. This test quantifies the subject's oscillations during the bipodalic stance with open (OE) or closed (CE) eyes (sway amount);

- *5 times sit to stand*: The purpose of this test is to evaluate the time needed by the subject to reach the standing position from the sitting one for a set number of times (5). It measures the duration of the task that is an indirect evaluation of the functional lower extremity strength;

- *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.

Robotic treatment intervention

The training protocol consists of 3 phases with increasing weight-bearing on the prosthetic limb (50% - 60% - 70% respectively) and with criteria of transition from one phase to another concerning range of motion and muscular strength (MRC scale). Each training session was performed with different difficulty depending on the patient's performance. hunova training sessions were focused on: weight-bearing sensibilization, proprioception and control, balance, lower limb strengthening, core stability and postural passages. The treatment goal was to improve functional capability in all the categories listed above.

Results

The robotic treatment

Each of the 12 subjects performed 8 personalized hunova training sessions. Physiotherapist found hunova easy to use, quick and helpful in daily practice. The device allows a standard and rapid customization of the therapy which can be patient-independent thanks to the real-time feedback.

Clinical results: the effect of surgery and intensive rehabilitation

BI, KRS and NPRS data was collected at T0 (pre-surgery) and T2 (last hospitalization day). As expected, in this interval of time all subjects from both groups improved compared to the pre-operative values of all the scales (Table 2). This result highlights the effectiveness of the surgery and the following rehabilitation treatment.

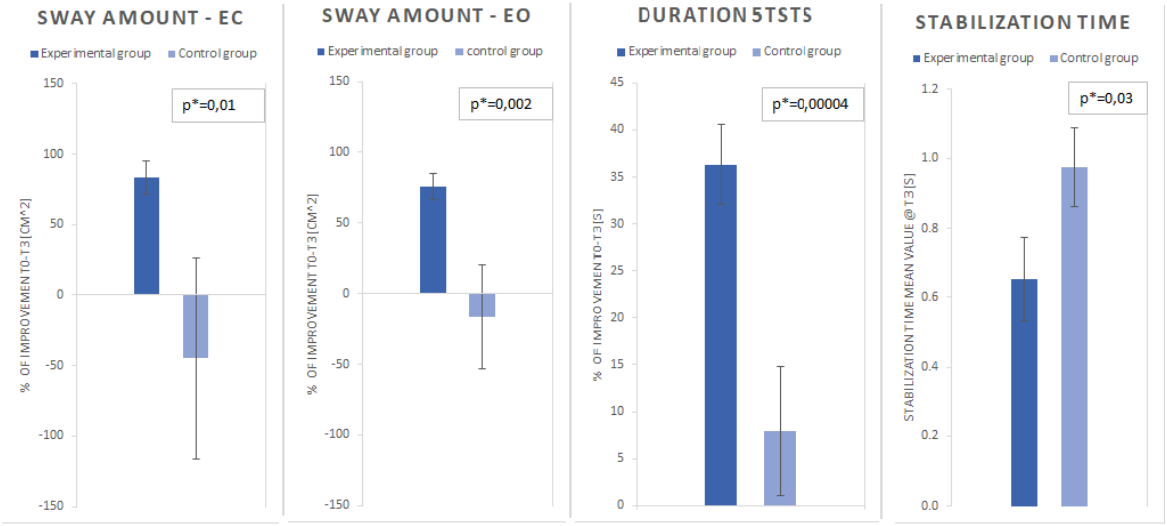


Figure 2. Balance test on static base results in the sway area parameter i.e. the amount of sway (a: Eyes Closed – EC; b: Eyes Open - EO). Percentage variation between T_0 and T_3 was calculated in order to visualize improvements from baseline. c: Five time sit to stand results in the total duration parameter. Percentage variation between T0 and T3 was calculated. d: Reactive balance test. Stabilization time at T_3 results after a perturbation in the opposite direction of the surgical side.

To fully understand the effect of the intensive treatment, we examined how the total improvement is divided among the different items of KRS clinical scale at T_2. Interestingly the group who trained with hunova shows a better gait control at T_2.

	Experimental group (n:12)		Control group (n:12)	
	T_0	T_2	T_0	T_2
BI (M ± SE)	69.1 ± 3.3	96.7 ± 0.7	77.1 ± 5.1	93.4± 2.2
KRS (M ± SE)	47 ± 2.4	88 ± 1.1	46 ± 1.8	87 ± 1.7
NPRS (M ± SE)	4.0 ± 0.4	0.4 ± 0.1	3.7 ± 0.5	0.2 ± 0.1
KRS sub score GAIT (M ± SE)	4.7 ± 1.1	12 ± 0	3.3 ± 0.7	10 ± 0.5

Table 2: Clinical Scales Results for the two groups (Experimental and control) at the two moments (T0 and T2). BI: Barthel Index; KRS: Knee Rating Scale; NPRS: Numeric Pain Rating Scale; M±SE: Mean ± Standard Error.

Robotic Results: The long-term effect

The robotic evaluations executed before the surgery and at follow up, revealed that 3 months after the knee replacement the group who trained with hunova:

1. has a greater improvement in terms of postural stability (sway) in both eyes' conditions (Figure 2a-2b, Table 3);
2. takes less time to carry out the postural transition five times (Figure 2c, Table 3);
3. takes less time to stabilize following a perturbation in the opposite direction to the operated side with respect to the control group at T3 (Figure 2d).

	Experimental group (n:12)	Control group (n:12)
	Δ% T_0 - T_3	Δ% T_0 - T_3
Test 1: SWAY AMOUNT - EC (M ± SE)	83.2 ± 11.6	-44.8 ± 71.4
Test 1: SWAY AMOUNT- EO (M ± SE)	75.6 ± 9.4	-16.6 ± 36.6
Test 2: DURATION (M ± SE)	36.3 ± 4.3	36.3 ± 4.3

Table 3: Robotic evaluations results for both groups (experimental and control group). Test 1: Balance test on static base; Test 2: Five times sit to stand; EC: Eyes Closed; EO; Eyes Open; M±SE: Mean ± Standard Error.

Conclusions

Patients undergoing knee arthroplasty constitute a heterogenous population with variable recovery times and exercise tolerance between different subjects. For this kind of patients, personalized rehabilitation together with continuous monitoring and objectification of improvements are fundamental elements for the best postoperative outcome. hunova was essential in this process. In fact, the device allowed to perform robotic assessments and trainings in two different locations (outpatient and inpatient "Clinical San Francesco" rehabilitation centers, respectively) granting training sessions consistent with evaluations. Moreover, robotic parameters that feature training sessions were set based on the patient's ability: session overall difficulty depends on performance. hunova has proved to be an effective support for our rehabilitation process that begins with the preoperative assessment of the patient, a personalized post-surgery treatment and a new evaluation at three months after the prosthesis. The preliminary results presented in this case study show the validity of training with hunova in combination with conventional therapy in the intensive rehabilitation process after robotic knee arthroplasty.

The experimental group has benefited in a very positive way from the treatment using the robotic device, in terms of both balance and functional ability. The 12 subjects who performed training sessions on hunova during the intensive rehabilitation inpatient phase have better results in orthostatic stability, in postural passages such as sit to stand and in time response to disturbances with respect to the control group at follow up (T3) 3 months after surgery. Balance, stability and postural passages can influence the patient's surgical outcome. This resulted in improved functionality, independence and social integration of the patient after the knee replacement. Therefore, we believe that it is important to share this experience and support other clinicians who are dealing with the same rehabilitative challenge.

About us

The "Clinica San Francesco", thanks to the establishment of the CORE, the European Robotic Orthopedics Center, is a real point of reference in knee surgery. Robotic prosthetic surgery minimizes complications during implantation of the prosthesis and accelerates patient recovery times. Motor re-education begins the day after surgery for both the hip and the knee. The postoperative hospitalization is considerably reduced and allows, in the prosthetic knee assembly, discharge in a short time. The orthopedic surgery department has a physiotherapy and rehabilitation ward, available for both inpatients and outpatients. The physiatrists and physiotherapists of the San Francesco Clinic develop, in collaboration with the surgeons who performed the operations, personalized rehabilitation physiotherapy paths to better face the post-operative course.

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