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ORIGINAL STUDIES

Complex rehabilitation in patients with knee arthroplasty

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Abstract

Background. Osteoarthritis (OA) - a progressive and incurable joint disease – is the most prevalent form of arthritis and is a leading cause of disability, a problem that becomes more pronounced with age. Like in the entire medical world, in Romania, knee arthroplasty is the most commonly performed joint replacement procedure for advanced stages of knee osteoarthritis (KOA).

Aims. In the present study, we aim to highlight the role of a supervised and complete rehabilitation program (inpatient and home-based) in the recovery of the clinical and functional status of advanced stage KOA patients who underwent elective TKA. Probably, the judiciously chosen parameters of physical exercise will permit to perform the kinetic program in healthcare, regardless of location, for this type of patients.

Methods. The study was a randomized controlled trial including two groups of patients (SG-study group and CG-control group), homogeneous in terms of biographical, clinical and functional features. All patients were completely assessed - clinically, by imaging and functionally.

Results. Clinical and functional parameters had a significantly modification (knee ROM, total WOMAC scale, stiffness and functional WOMAC subscales) in patients who underwent the complex rehabilitation program.

Conclusions. A combination of exercise, physical rehabilitation measures and properly selected pharmacological treatment will greatly help the management of these patients. The significant improvement in perception of balance confidence is welcome in controlling movement and gait in KOA patients with a well-fixed and well-aligned TKA.

Key words: knee arthroplasty, kinetic training, rehabilitation program

Introduction

Osteoarthritis (OA) - a progressive and incurable joint disease – is the most prevalent form of arthritis and is a leading cause of disability, a problem that becomes more pronounced with age (Kiliç et al., 2017). OA is found in almost 70% of the population aged over 60 years and the global prevalence is approximately 4%. Worldwide, there is a higher prevalence of OA among elderly women (Van Manen et al., 2012).

The primarily affected joints in OA are the knee and the hip. The progression of the disease is influential on quality of life. This includes functional and social activities, body image, and emotional well-being (Kongtharvonskul et al., 2015).

Knee osteoarthritis (KOA) is the most common and complex multifactorial joint disease, defined through three pathogenic aspects: local inflammation, articular cartilage loss and subchondral bone remodeling, with proliferative changes in the surrounding bones (Henricsdotter et al., 2016). KOA causes considerable pain and disability and imposes a major economic burden not only on those affected, but also on the whole society. For this reason, conservative treatments - weight reduction, medical treatment, rehabilitation programs (physiotherapy measures, regular exercises, occupational therapy, and orthotics) and lifestyle modifications (patient self-management education, mind/body interventions) - are often recommended for patients with mild to moderate KOA to reduce pain and improve function (Cudejko et al., 2018). The same goals of end-stage KOA

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treatment (relieving pain and improving knee functions) are obtained through conventional surgery - total knee arthroplasty (TKA), widely used around the world (Kim et al., 2011). Like in the entire medical world (Howells et al., 2016), in Romania, knee arthroplasty is the most commonly performed joint replacement procedure for advanced stages of KOA. Total knee arthroplasty (TKA) is indicated for patients with severe KOA, characterized by: continued, severe and refractory knee pain often at night, decreased mobility and affected activities of daily living, and imaging evidence of degenerative knee disease, when conservative options have been exhausted (Kim et al., 2011). So, in patients with severe KOA, TKA is aimed at restoring normal joint motion and mechanical features (alignment, restoring a normal Q angle, preserving the joint line), reducing pain, preventing further degenerative disease, returning the patient to full daily function, to work and recreational activities (Van Manen et al., 2012).

Although total knee arthroplasty is the proper surgical intervention for KOA (Iolascon et al., 2020), it is not always without complications (Healy et al., 2013; Bozic et al., 2014). Almost 20% of TKA patients experience unpleasant pain, caused by a wide variety of factors, and functional limitations (Beswick et al., 2012). Despite the positive consequences of TKA (self-reported functional ability and pain reduction), it does not eliminate all impairments (ascending / descending a flight of stairs, strength and mobility deficits) when compared to age-matched individuals without knee pathology, with a socioeconomic impact (Losina et al., 2012; Ravi et al., 2012).

The integrated use of multimodal analgesic drugs and rehabilitation, specially adapted physical activity represents the cornerstone of postoperative pain control and self-reported function improvement in patients with KOA (Jones et al., 2015). Taking into consideration that functioning is the third health indicator, complementary to morbidity and mortality (Stucki et al., 2019), a rehabilitation program is essential for the health strategy that aims to optimize the function of persons experiencing or likely to experience a limitation in functioning (***, 2018), as patients with TKA. Fifteen years ago, one of the primary conclusions from the consensus conference of the National Institute of Health surrounding TKA was that "the use of rehabilitation services was one of the most understudied aspects of the perioperative management of patients following total knee replacement" and "there is no evidence supporting the generalized use of any specific preoperative or postoperative rehabilitation interventions." (***, 2004).

By now, medical studies have well demonstrated the following aspects:

- outcomes after TKA may be related to the type and intensity of postoperative rehabilitation that patients receive;

- optimal pain management generates a better and earlier functional rehabilitation after TKA and prevents chronic pain (Vergne-Salle, 2016);

- improvements in pain and functional performance are achieved with assistance from rehabilitation programs (Bade et al., 2010);

- traditional rehabilitation programs typically focus on improving knee strength (quadriceps muscle strength) and optimal range of movement, and improving gait and stair climbing (Westby & Backman, 2010).

The recovery of knee function in TKA patients following a traditional rehabilitation program is not complete, compared to healthy age-matched persons (Schache et al., 2016). The persistence of functional limitations and residual pain proves that an optimal rehabilitation program is required, with a consensus regarding the different stages – early postoperative, inpatient and outpatient, home-training (Glassou et al., 2014; El Bitar et al., 2015). Furthermore, prior to surgery, patients with end-stage KOA presented lower limb muscle dysfunction (Hinman et al., 2010). The inpatient rehabilitation program is focused on early and safe kinetic exercises (El Bitar et al., 2015) to improve knee range of motion and knee muscle strengthening (Artz et al., 2015).

Objectives

The aim of our randomized control study is to compare the outcomes of a complete rehabilitation program with those of traditional rehabilitation programs in elderly patients with unilateral TKA for KOA. Before complete rehabilitation management of all studied TKA patients, we made a comprehensive assessment to establish appropriate goals and rehabilitation measures, in accordance with the current European League Against Rheumatism (EULAR) guidelines (Fernandes et al., 2013; Iolascon et al., 2020).

Hypothesis

In the present study, we aimed to highlight the role of a supervised and complete rehabilitation program (inpatient and home-based) in the recovery of the clinical and functional status of advanced stage KOA patients who underwent elective TKA. Probably, the judiciously chosen parameters of physical exercise will permit to perform the kinetic program in healthcare, regardless of location, for this type of patients.

Material and methods

We mention that we obtained the approval of the Ethics Committee of the University of Medicine and Pharmacy of Craiova No 61/22.03.2019 and a signed informed consent from all the subjects participating in our study. Our research was performed on 38 patients, all previously diagnosed with end-stage KOA.

Research protocol

Period and place of the research

We conducted our study during the period April 2019 - February 2020 in the Rehabilitation Department of the "Filantropia" Hospital Craiova.

Subjects and groups

The study was a randomized controlled trial including two groups of patients (study group – SG and control group – CG), homogeneous in terms of biographical and rheumatic disease features, each consisting of 19 patients (Table I).

Table I
The demographic data of the patients.

Group		Age (years)	Age / place		Female age	Male age
			Urban	Rural		
SG Study group 19 patients	Average	65.05	65.36	64.63	64.00	69.00
	St.dev.	6.20	5.95	6.91	5.93	6.32
	Minimum	56	58	56	56	61
	Median	64	64	62	62	70
	Maximum	70	76	75	76	75
CG Control group 19 patients	Average	66.42	66.27	66.63	65.93	68.25
	St.dev.	5.08	3.93	6.65	5.44	3.30
	Minimum	56	60	56	56	65
	Median	68	67	70	68	68
	Maximum	72	72	72	72	72

The inclusion criteria taken into account when designing the groups were:

- patients older than 50 years of age, diagnosed with severe primitive knee osteoarthritis according to the American College of Rheumatology, with primary unilateral TKA typically in the previous 10 days;
- absence of other joint replacement;
- patients with stable cardiovascular and respiratory function, with normal blood pressure and without unstable medical conditions;
- compliance with physical exercise during the healthcare program.

Our study design was a single-blinded randomized controlled trial (Fig. 1).

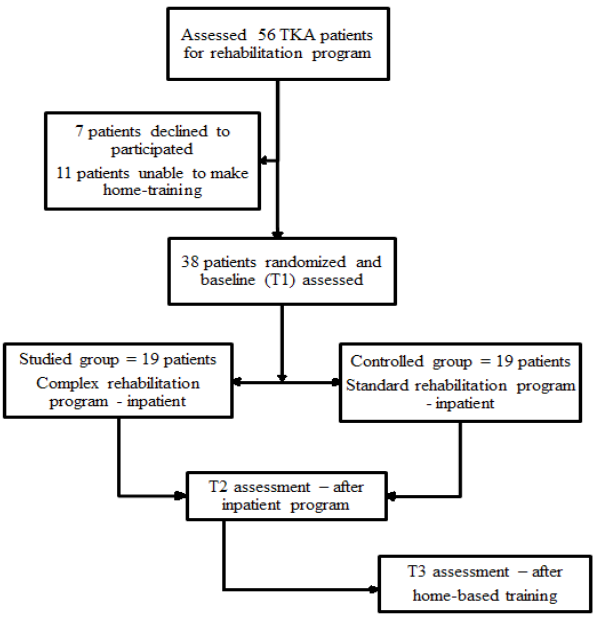

Fig. 1 – Diagram of our study.

We performed the patient randomization via the computer-generated list. Only the physical therapist knew the real allocation of each patient. The other members of the rehabilitation team and the patients had no information about the randomization. We respected the Recommendation for Interventional Trials (SPIRIT) guidelines (Chan et al., 2013).

Tests applied

We completed an initial clinical, laboratory (laboratory screening, imaging examination - radiography) and functional assessment. All tests applied are mentioned below.

The *clinical assessment* included:

- general physical examination (system examination including sensory evaluation);
- musculoskeletal examination – somatoscopic exam, systematic palpation of all areas of the knee, assessment of the range of motion (we used a goniometer), tenderness and stability and manual muscle testing of the lower limb muscles;
- exam in loaded bipodal, unipodal and sitting position;
- examination of balance and gait.

During the examination, we conducted *standard laboratory tests* and *radiological examination* of both knees (Fig. 2a - anteroposterior incidence and Fig. 2b - lateral incidence).

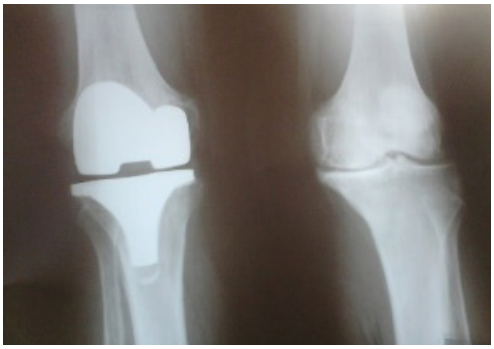

Fig. 2a – Anteroposterior incidence.

Fig 2b – Lateral incidence.

a) For *functional assessment,* we used:

- the VAS - Visual Analogue Scale (from 0 to 10, 0 = absence of pain and 10 = maximum pain score, other values between 0 and 10 are directly proportional to the intensity of pain, depending on the individual pain threshold);
- the WOMAC scale to assess the impact of knee disorder in performing activities of daily living (0-96, where 0 is maximum functional status and 96 is minimum, with maximum disruption of daily activities); we took into consideration two subscales of WOMAC questionnaire – WOMAC stiffness (0-8, where 0 is no stiffness and 8 is maximum stiffness), and WOMAC function (0-68, where 0 is no difficulty in function and 68 is the highest difficulty).

Outcomes for knee flexion, VAS, WOMAC scores were measured at admission to inpatient rehabilitation (T1), 3 weeks (T2), and 3 months (T3) after the commencement of

rehabilitation. These time points were chosen to adequately measure the rate of improvement in all outcome measures.

The rehabilitation program was performed in two phases:

- the inpatient period; when patients had the ability to perform some kinetic tasks (mentioned in Table II), we considered them to be able to be discharged from hospital;
- a home-based program with bi-monthly supervision (Table III).

b) The healthcare objectives were adapted for all patients and rehabilitation phases:

- pain status control;
- controlling the inflammatory process;
- restoring the mobility and stability of the knee;
- correcting the abnormal walking scheme, with recovery of normal walking;
- regaining motor control, optimal lower limb function.

c) The rehabilitation program was complex, based on non-surgical measures in both groups of patients, and included:

- pharmacological measures - analgesics, anti-inflammatory drugs,
- non-pharmacological measures - educational, dietary, and hygienic, posture, physical (cryotherapy, magneto-therapy, neuromuscular electric stimulation - NMES for the quadriceps), massage and kinetic measures.

All patients of SG (study group) performed a complete rehabilitation program in contrast to the CG; more exactly, the standard rehabilitation program for CG was improved with some exercises (neuromuscular proprioception techniques - Kabat, Frenkel; closed-kinetic chain strengthening, such as ¼ squats, ¼ front lunges; complex gait training) to decrease muscle guarding, increase balance and return to functional daily activities. Each exercise session was supervised and performed twice daily, 5 days/week, 3 weeks. The a.m. kinetic program (5 minutes warm-up, 20 minutes ROM and progressive resistive exercises, 5 minutes cool-down) was preceded by neuromuscular electric stimulation - NMES for the quadriceps and a p.m. kinetic program (5 minutes warm-up, exercises for return to functional activities, 5 minutes cool-down), followed by 20 minutes of magnetotherapy.

Statistical processing

Statistical analysis was performed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA), along with the XLSTAT add-on for MS Excel (Addinsoft SARL, Paris, France) and IBM SPSS Statistics 20.0 (IBM Corporation, Armonk, NY, USA) for processing the data. To describe the numerical data used in the present study, we used the following statistical indicators: arithmetic mean and standard deviation, and spread indicators - minimum, maximum, median, quartiles (percentiles). None of the recorded data sets had a Gaussian distribution, therefore we had to use non-parametric tests. We used the Mann-Whitney test to compare the variables between the two groups, at all moments, and Friedman's test for paired data, in order to compare the results for each variable among the three evaluation moments, for each group.

Table II

Kinetic program for the inpatient rehabilitation program.

Components of the kinetic program applied for patients with knee arthroplasty between T1 and T2 evaluation period (SG = study group, CG = control group)

Objective		**Rehabilitation components / Intermediate Exercise Program**
Diminish pain and inflammation	SG, CG	1. Pain modulation modalities – cryotherapy, medication 2. Cyriax massage
Increase knee range of motion	SG, CG	1. Heel slides in supine or sitting position to increase knee flexion 2. Lower extremity range of motion (ROM) → active assisted active (AA/AROM) exercises (supine and seated positions) 3. Patellar and tibiofemoral joint mobilizations 4. Stationary bike without resistance to increase flexion ROM
Increased dynamic joint Stability Muscle strength 3/5-4/5 Full weight bearing per implant status	SG, CG	1. Progressive passive / then active stretches to hamstrings, gastrocnemius, soleus, quadriceps within a pain-free range 2. Active straight-leg raises in flexion, abduction, adduction, extension 3. Gravity-assisted knee extension in supine (placing a towel roll under the ankle and leaving the knee unsupported) and in sitting position 4. Continue isometric quadriceps, hamstring, gluteal isometric exercises, then concentric and eccentric quadriceps exercises. 5. NMES for the quadriceps if poor quad contraction is present. 6. Pain-free progressive resisted exercises using ankle weights
	SG	1. Neuromuscular proprioception techniques (Kabat, Frenkel) to decrease muscle guarding, and increase balance 2. Agonist contraction to decrease muscle guarding, particularly in the quadriceps, and increase knee flexion. 3. Closed-kinetic chain strengthening, such as ¼ squats, ¼ front lunges
Maximize patients' mobility and functional independence Return to functional activities	SG, CG	1. Ambulation with use of an assistive device 2. Ascend and descend stairs, with assistive device. Gait training on stairs to engage the knee through 0 -110° of motion, optimal ROM to ambulate on stairs without compensations. Focus on eccentric quad control and stabilization in the stance phase. 3. Training the transfers and sitting and standing balance 4. Protected, progressive aerobic exercise, such as cycling without resistance, walking !!! Assistive devices are discontinued when the patient demonstrates adequate lower extremity strength and balance during functional activities
	SG	1. Complex gait training - weight shifting, tandem walking, lateral stepping over / around objects, obstacle courses, front and lateral step-ups, closed-kinetic chain activities

Table III
Home-based kinetic program.

Objective Example exercises		Home-based kinetic program – between T2 and T3 (SG = study group, CG = control group)	
		Exercise parameters	
Flexibility (ROM)	SG, CG	Active movement of lower limbs Stretching of calf muscles, hamstrings and quadriceps	Daily, 5 sets for each of the lower limb joints, from distal to proximal Daily, 5 sets of 6 seconds for each of the muscle groups
Muscle strength	SG, CG	Isometric contraction of vastus medialis oblique into the quadriceps and gluteus maximus muscles	Daily, 3 sets, 5 repetitions/set, 6 seconds for isometric contraction, 1 minute rest between contractions
		Isotonic contraction of leg flexor and leg extensor, quadriceps muscle, calf muscles	Daily, in antigravity position for each muscle, 2 sets, 10 repetitions/ set, 2 minutes rest between sets. Intensity equal to maximal voluntary contraction
Endurance	SG, CG	Cycling, walking, housework	Daily, 30 – 40 minutes. Intensity equal to submaximal voluntary contraction
ADL (functional activities)	SG, CG	Sitting to standing in chair, bed, other places Stair climbing Getting in and out of car	Daily
Control of movement and gait	SG	Frenkel exercises for the lower limbs Front and back cross-over stepping Tandem walking Eyes closed walking (supervised!)	3 per week

Table IV
Values for parameters in all patients.

Group		Study	Control	Study	Control	Study	Control
		T1		T 2		T3	
VAS	Average	7.21	7.63	4.89	5.05	3.16	3.26
	St.dev.	1.44	0.90	1.33	0.97	1.30	1.10
	C.V. (%)	19.93%	11.73%	27.15%	19.20%	41.24%	33.64%
	p value	p M-W = 0.358		p M-W = 0.797		p M-W = 0.940	
	Female	7.33±1.54	7.87±0.83	4.93±1.44	5.2±1.01	3.20±1.42	3.53±1.06
	Male	6.75±0.96	6.75±0.5	4.5±0.96	4.75±0.58	2.25±0.52	3±0.5
	Urban	7.45 ± 1.21	7.73 ± 1.10	5.18 ± 1.33	5.27 ± 1.10	7.45 ± 1.21	3.36 ± 1.29
	Rural	6.88 ± 1.73	7.5 ± 0.53	4.50 ± 1.31	4.75 ± 0.71	2.88 ±1.36	3.13 ± 0.83
ROM	Average	48.68	39.74	73.95	65.79	95.26	84.21
	St.dev.	6.20	6.34	7.18	7.86	9.20	5.07
	C.V. (%)	12.74%	15.96%	9.71%	11.95%	9.66%	6.02%
	p value	p M-W = 0.000		p M-W = 0.005		p M-W = 0.000	
	Female	50.00±6.27	48.00±6.26	74.00±7.84	66.33±7.5	96.00±10.04	85.00±4.63
	Male	43.75±2.5	38.75±7.5	73.75±4.79	63.75±7.5	92.5±5.0	81.25±6.29
	Urban	49.09 ±7.01	43.59 ±6.64	75.0 ± 8.37	65.91 ± 8.01	98.18 ± 9.52	84.55 ± 4.72
	Rural	48.13 ±5.30	43.53 ±6,23	74.5 ± 5,35	65.63 ± 8.21	91.25 ± 6.94	83.75 ± 5.87
t WOMAC	Average	56.26	60.26	43.84	49.11	34.84	41.37
	St.dev.	8.20	7.99	7.69	5.87	7.35	5.87
	C.V. (%)	14.58%	13.25%	17.54%	11.95%	21.10%	14.19%
	p value	p M-W = 0.087		p M-W = 0.039		p M-W = 0.003	
	Female	56.07±9.24	59.4±8.71	43.8±8.57	49.13±5.89	34.8±7.29	42.33±6.13
	Male	57.0±2.61	63.5±3.32	44.0±7.12	49.0±6.68	35.0±8.72	37.75±3.3
	Urban	55.64 ±10.69	58.45 ±7.31	42.73 ± 8.49	47.00 ±5.53	35.45 ± 8.47	39.82 ±6.15
	Rural	57.13 ± 2.9	62.75 ±8.68	45.38±6.67	52.00 ±4.84	34.00 ± 5.93	43.5 ± 5.07
s WOMAC	Average	5.16	5.00	3.21	3.79	1.79	3.00
	St.dev.	0.90	0.75	0.79	0.71	0.71	0.58
	C.V. (%)	17.42%	14.91%	24.52%	18.82%	39.86%	19.25%
	p value	p M-W = 0.436		p M-W = 0.017		p M-W = 0.000	
	Female	5.07±0.9	4.93±0.8	3.13±0.83	3.8±0.77	1.87±0.74	3.0±0.65
	Male	5.5±0.58	5.25±0.5	3.5±0.58	3.75±0.5	1.5±0.58	3±0.02
	Urban	4.73 ±0.9	4.82 ±0.75	3.18 ± 0.98	3.64 ±0.81	1.82 ±0.2	3.0 ±0.45
	Rural	5.75 ± 0.46	5.52 ±0.21	3.25±0.46	4.00 ±0.53	1.75 ± 0.71	3.0 ± 0.75
f WOMAC	Average	42.53	44.26	26.74	33.53	18.68	26.26
	St.dev.	6.96	6.85	6.40	5.99	5.68	6.30
	C.V. (%)	16.35%	15.49%	23.94%	17.88%	30.38%	23.98%
	p value	p M-W = 0.372		p M-W = 0.001		p M-W = 0.000	
	Female	43.07±7.73	43.0±6.78	27.47±6.96	32.27±5.73	19.33±6.08	26.57±6.81
	Male	40.5±2.08	49.0±5.42	24.0±2.71	38.25±4.99	16.25±3.3	27.0±4.55
	Urban	41.64±8.04	43.63±6.33	26.45±6.95	33.0±5.73	18.91±6.28	24.82±5.91
	Rural	43.75±5.39	45.5±7.78	27.13±6.01	34.25±6.67	18.38±5.13	28.25±6.65

Comparison between each recorded variable at each moment, for SG - Friedman's test $p < 0.0001$
Comparison between each recorded variable at each moment, for CG - Friedman's test $p < 0.0001$
C.V. (%) = coefficient of variation - the ratio of the standard deviation to the mean, expressed as percentage.
VAS = pain scale, ROM = range of motion for knee flexion, t WOMAC = total WOMAC scale score, s WOMAC = stiffness subscale score, f WOMAC = functional subscale score, p M-W = p Mann-Whitney

Results

The two groups (SG - study group and CG – control group) were compatible in terms of structure. Comparing the age distribution for the two patient groups, with the Mann-Whitney test, no statistically significant differences were obtained (pMW=0.438).

For all variables, a highly significant improvement over time was observed (Table IV).

Comparing, at each moment, for each recorded variable, the study ant the control group, we made the following observations:

- VAS: at all moments, there was no statistical difference between the two groups; the average VAS scale values for subscales of patients (female/male, urban/rural) had a synchronic evolution, decreasing after the rehabilitation program, without significant differences;

- ROM: at all moments, there was a significant difference between the two groups; only patients of SG obtained an optimal flexion in the operated knee, over 90^0 range of motion, regardless of age, gender or background (Fig. 3).

- scores for WOMAC scale (t WOMAC or tW), and two subscales for stiffness (sWOMAC or sW) and function (f WOMAC or fW): initially, there was no difference between the groups (p M-W = 0.087 – for tW, p M-W = 0.436 – for sW, p M-W = 0.372 – for fW); for the second evaluation, there was a significant difference between the two groups (p M-W = 0.039 – for tW, p M-W = 0.017 – for sW, p M-W = 0.001 – for fW); for the third evaluation, there were significant and highly significant differences between the two groups (p M-W = 0.003 – for tW, p M-W = 0.000 – for sW, p M-W = 0.000 – for fW) (Fig. 4).

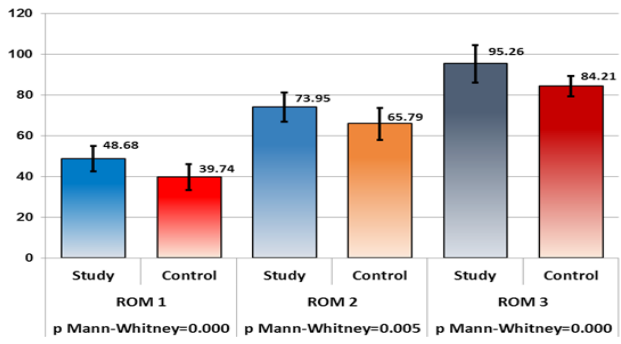

Fig. 3 – The mean values of ROM at all evaluation moments.

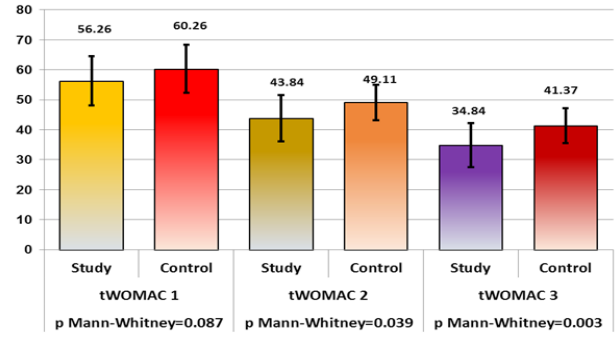

Fig. 4 – The mean values of total WOMAC scale score at all evaluation moments.

Discussions

Worldwide, a multidisciplinary approach to TKA patients is more and more implemented in clinical practice. Rehabilitation, including physiotherapy and exercise, is widely promoted after total knee replacement (Artz et al., 2015).

In our study, we proved the importance of a complete assessment and complex rehabilitation program (12 supervised and progressive exercises inpatient sessions, which started within the first postoperative month, and an 8 weeks home-based program) for quality of life in KOA patients. Published data for comprehensive evaluation and reassessment during regular follow-ups (Iolascon et al., 2020) argues the importance of functioning and correct patient management, in light of the interaction between patient's health capacity and environmental factors (Stucki & Bickenbach, 2017).

Our patients had no standard regarding the severity of symptoms in the indication of TKA. The decision for TKA is based on individual response to non-surgical treatment and was not conditioned by any other individual factor - age and weight.

Before and after intervention, we carefully decided the medication prescribed for pain and inflammation, taking into consideration the compliance and adherence to drug treatments against the known adverse effects of each drug category (Stewart et al., 2018). All patients had painless status during and after the rehabilitation program. We did not mention any significant differences between the average VAS values in our patients. Pain perception improved in all our patients regardless of the applied rehabilitation measures. We respected the order in the program, to have the possibility of painless training. Magnetic therapy was indicated in order to reduce sympathetic tonus and control pain. Also, cryotherapy was optimally applied to control joint swelling and postsurgical joint inflammation. None of our patients had a severe degree of pain. This is a frequently described subjective parameter for absence of proximal tibial tenderness after knee replacement (Simpson et al., 2009; Beswick et al., 2012).

The rehabilitation program was established in accordance with other clinical trials and reviews in which there are mentions of recommendations and benefits of early supervised exercise therapy following TKA in the immediate postsurgical setting, with a heterogeneous group of exercises.

Our applied rehabilitation program included only two stages: an inpatient program and home-based training. We did not perform an outpatient program because, as mentioned in other trials, there was no difference in pain and functional outcomes between patients randomized to home-based and outpatient rehabilitation (Piqueras et al., 2013). Also, we considered the patient's financial possibilities to access the outpatient program for 2–3 weeks.

The components of the kinetic program performed in our patients were carefully chosen. We tried to apply an optimal inpatient physical therapy protocol. The difference between the kinetic programs in our patients is represented by neuromuscular proprioceptive exercises and complex

gait training (inpatient phase) and Frenkel exercises for lower limbs with gait coordination exercises (home-based phase). Other exercises – mobilization and strengthening exercises, complemented by functional exercises – were identical and all parameters (intensity, duration, frequency) were based on patient progress.

Criteria for progression, and evidence of progression and compliance among patients were very important, as mentioned in other controlled clinical trials (Meier et al., 2008).

We considered that permanent supervised rehabilitation therapy may be effective in limiting some of the impairments following TKA. Several studies without direct oversight produced poor results (Pozzi et al., 2013). Bade et al. mentioned in their studies that more intensive rehabilitation, using progressive resistance exercise and functional strengthening, may substantially improve patient function without compromising safety (Bade et al., 2017). This conclusion is sustained by our results.

In SG, all patients had superior outcomes in functional performance and gait status compared with CG. This aspect is demonstrated by the values of ROM, total WOMAC and WOMAC subscale scores. Probably, performing coordination and agility exercises after the standard kinetic program - isometrics and active range of motion exercise with progression to weight-bearing exercise and daily activities – was effective and safe for lower limb function.

For ROM flexion there was evidence of improved flexion in all patients, with these observations:

- SG females had a higher percent of improvement at both evaluation moments after the rehabilitation programs than CG females (48% at T2 and 29% at T3 – for SG, 35% at T2 and 28% at T3 for CG);
- SG males had a higher percent of improvement only at T2 (68% compared with 64% in CG males); in the final evaluation, the differences were approximately equal, 26% for SG and 27% for CG);
- SG urban patients had a higher percent of improvement at both evaluation moments after the rehabilitation programs than CG urban patients (53% at T2 and 30% at T3 – for SG, 51% at T2 and 28% at T3 for CG);
- rural patients had approximately equal values of flexion improvements (50% at T2 and 26% at T3 – for SG, 50% at T2 and 27% at T3 for CG);
- SG patients had a higher percent of improvement in the final evaluation (28%) than CG patients (27%).

Our results differ from those of other studies, where benefits for ROM flexion were seen, particularly, after 6 months (Artz et al., 2015).

We established in our study a WOMAC – stiffness subscale because this sign is associated with more severe dissatisfaction. Even if the joint is not painful, a stiff knee related to surgery is very difficult to manage daily and therefore likely to be associated with important lower limb dysfunction (Beswick et al., 2012).

At both evaluation moments, after beginning the rehabilitation program, all SG patients had improvements in the scores of total WOMAC scale and stiffness and functional WOMAC subscales, regardless of age, gender or the environment of origin.

The kinetic measures performed (progressive passive / then active stretching, neuromuscular proprioception techniques) allowed to control the postsurgical knee stiffness. Our results sustain this affirmation: the improvement in the stiffness WOMAC score was better for SG (38% and 65%) than CG (25% and 30%) at both evaluation moments (T2 and T3). Gait training and correct posture in bed and chair were possible for our patients after both knee joints had stiffnessless status.

Physical function was measured using WOMAC-function subscale and total WOMAC score. As shown in Table IV, there was a significant difference in mean values between SG and CG, in the T2 and T3 assessments. The improvement of these two scores was better for SG (38% and 65% for functional WOMAC, 22% and 38% for total WOMAC score) than CG (25% and 30% for functional WOMAC, 19% and 31% for total WOMAC score), at both T2 and T3. The particular structure of the kinetic program applied to our SG patients explains these results, different from other clinical trials (Madsen et al., 2013).

Also, we did not start the inpatient rehabilitation program early after knee replacement; the functional performance was not lost in the following three months after TKA.

We consider that a complex and supervised kinetic program has similar effects to the early initiation of progressive resistance exercises and functional strengthening in limiting the extent of this knee function loss (Jakobsen et al., 2014).

One of the most important targets of our rehabilitation program, similarly to other studies (Meier et al., 2008), was to regain the strength of muscles around the knee and of the entire lower limb. All patients had a large decrease in quadriceps strength immediately after TKA, due to rest and previous hypotrophy due to pain status. This loss of strength generates functional impairments (Thomas & Stevens-Lapsley, 2012), so the recovery of muscle parameters is essential. We used in our rehabilitation program progressive exercise protocols, based on isometric and isotonic contractions. To optimally regain the quadriceps strength, we indicated NMES, which was well tolerated.

The role of this physical measure is known (Pozzi et al., 2013), but the aim of our study was not to elucidate the contribution of NMES to complete rehabilitation of TKA patients.

The stable bipodal posture and safety during the gait are two important biomechanics aspects in patients with TKA. We consider that a kinetic program should contain some special exercises for balance and gait. Over the first two weeks after surgical replacement, Kabat technique and Frenkel exercises for the lower limbs permit to decrease muscle guarding and increase balance. So, the patient has full trust to perform exercises to maximize functional independence and return to daily activities. This recovery objective is debated in several recent systematic reviews (Henderson et al., 2018) whose authors have demonstrated benefits of postoperative rehabilitation programs after TKA, but have questioned the quality of evidence supporting these benefits (Warwick et al., 2019).

The major role and benefit of the rehabilitation program after total joint replacement was to regain function and quality of life for patients, while decreasing hospital

length of stay in the orthopedic clinic. Today the average of this indicator is 2 to 4 days (Keswani et al., 2016). So, all medical teams are focused on improving the surgical techniques, better pain management, faster mobilization, modifications of rehabilitation protocols, and pathway directed care (Argensen et al., 2016).

Educational training is as important as the kinetic program. Preoperative and postsurgical education measures familiarize patients with the correct mode of daily training, especially in the home-based phase of the rehabilitation program (Peer et al., 2017), so their knowledge expectations after knee replacement can be fulfilled (Soeters et al., 2018).

The single negative aspect is the lack of large randomized trials with adequate methodology on rehabilitation for TKA patients, with a paucity and heterogeneity of results (Argensen et al., 2016; Sattler et al., 2019). Most studies are performed on patients who followed a complete rehabilitation program – inpatient, outpatient and home-based training. During the hospital stay, the main rehabilitation objectives were pain control, optimal knee mobilization and achievement of functional status. Regaining gait and balance is continued during home-based training (Oatis et al., 2014).

The limitation of our study is the absence of rehabilitation (preoperative physiotherapy and exercise programs), which should improve patient disposition at the time of surgery and may prepare patients for a better recovery after surgery (Wang et al., 2016).

We could not establish what type of preoperative program our patients performed, so we did not take into consideration this outcome. Probably, the best results in our study were obtained by those patients who attended the kinetic and adapted physiotherapy program.

One important aspect, certainly established and respected in our study, is the early application of the rehabilitation program after joint replacement, despite a lack of evidence for the optimal type, duration or frequency of measures to provide the best clinical outcomes (Sattler et al., 2019).

Conclusions

1. A multimodal and multidisciplinary therapeutic approach represents the gold standard for regaining function and quality of life in TKA patients.

2. A combination of exercise, physical measures and properly selected pharmacological treatment will greatly help the management of these patients.

3. The significant improvement in perception of balance confidence improves movement control and gait in KOA patients with a well-fixed and well-aligned TKA.

4. The values obtained for knee flexion (ROM) and WOMAC were attributes of the control group, and to normative values, so we can conclude that our rehabilitation program had significant efficiency in restoring the functional ability for patients, regardless of age and gender.

Conflicts of interests

No conflicts of interests.

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