

Benefits of a postoperative rehabilitation program on strength recovery after total knee arthroplasty

Beneficiile unui program de reabilitare postoperatorie asupra recuperării forței musculare după artroplastia totală de genunchi

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Abstract

Background. Total knee arthroplasty is the gold standard treatment for patients with advanced knee osteoarthritis. However, a significant muscle weakness, particularly in the quadriceps, is noted early after surgery, reflected in functional deficits and quality of life alteration. Physical therapy is necessary to address these problems, nevertheless rehabilitation service utilization has been one of the least studied aspects of medical care after total knee arthroplasty.

Aims. To comparatively evaluate the evolution of isokinetic strength parameters in patients that were and in those that were not included in the rehabilitation program after total knee arthroplasty.

Methods. 50 patients undergoing total knee arthroplasty for advanced osteoarthritis were distributed in 2 groups. 33 patients that accepted to take part into a standardized postoperative rehabilitation program were included into the rehabilitation group. The non-rehabilitation group consisted of 17 patients that refused any postoperative rehabilitation program. Isokinetic evaluation of knee extensor and flexor muscles was performed preoperatively and 6 months postoperatively by a Gymnax Iso 2 Dynamometer at angular velocities of 90°/s and 180°/s.

Results. Strength improvement from preoperatively to 6 months postoperatively was observed in all patients and for both extensors and flexors, but it was statistically significant only in rehabilitation group, for extensors, at 180°/s. At 6 months postoperatively, extensor strength was significantly higher in the rehabilitation group, for both testing velocities.

Conclusions. Six months after surgery, quadriceps strength was higher in patients included in the postoperative rehabilitation program, justifying strengthening exercise prescription. Further research is required for optimizing actual strengthening protocols.

Key words: arthroplasty, knee, strength, isokinetic, osteoarthritis.

Rezumat

Premize. Artroplastia totală de genunchi reprezintă standardul de aur în tratamentul pacienților cu gonartroză avansată. Un deficit muscular important se constată însă în perioada postoperatorie imediată, implicând alterarea funcțională și a calității vieții. Kinetoterapia este necesară în soluționarea acestor probleme, totuși reabilitarea acestor pacienți a fost foarte puțin studiată.

Obiective. Prezentul studiu și-a propus evaluarea izocinetică comparativă a musculaturii coapsei la pacienții care au efectuat și la cei care nu au efectuat un program de recuperare după artroplastia totală de genunchi.

Metode. 50 de pacienți propuși pentru artroplastie totală de genunchi au fost distribuiți în 2 loturi. În Lotul cu Recuperare au fost incluși 33 de pacienți, care au acceptat să participe la un program standardizat de recuperare postoperatorie. Lotul Non-Recuperare a constat din 17 pacienți, care au refuzat recuperarea postoperatorie. Evaluarea izocinetică pe extensorii și flexorii genunchiului a fost efectuată preoperator și la 6 luni postoperator, pe un dinamometru Gymnax Iso 2, la vitezele unghiulare de 90°/s și 180°/s.

Rezultate. La toți pacienții s-a constatat ameliorarea forței extensorilor și flexorilor genunchiului la 6 luni după intervenție față de valorile preoperatorii, dar aceasta a fost semnificativă statistic doar la pacienții cu recuperare, pentru extensori, la 180°/s. La 6 luni postoperator forța extensorilor a fost semnificativ mai mare la pacienții cu recuperare, pentru ambele viteze.

Concluzii. La 6 luni postoperator forța cvadricepsului a fost mai bună la pacienții incluși în programul de recuperare postoperatorie, justificând prescrierea exercițiilor de tonizare. Sunt necesare studii ulterioare pentru optimizarea protocoalelor actuale de tonizare musculară.

Cuvinte cheie: artroplastie, genunchi, forță musculară, izocinetic, gonartroză.

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Introduction

End-stage knee osteoarthritis is a significant health problem all over the world, resulting in pain and limited participation in many activities of daily living and functional activities (Pozzi et al., 2013). Total knee arthroplasty (TKA) is the gold standard treatment for these patients and the annual worldwide incidence of this intervention has continuously increased over the past decade (Kurtz et al., 2007). In 2010-2011 more than 762,000 TKA were performed in Canada and the U.S.A. (Westby et al., 2014). It is expected that the demand for primary TKA in U.S.A. might approach 1.5 million procedures in 2020, because of the aging of population, with the subsequent increase of the number of revision procedures (Kurtz et al., 2007). Even more, the demand for these procedures in patients younger than 65 years is projected to exceed 50% of all TKA by 2016 (Kurtz et al., 2009). TKA has been shown to be a cost-effective treatment for the refractory pain and activity limitations of advanced osteoarthritis (Ethgen et al., 2004; Losina et al., 2009). Evaluating the effectiveness of TKA surgery is mainly based on patient-centered outcome measures, such as pain and physical function (Jones et al., 2007), depending not only on surgery-related factors (technique, the surgeon's experience and skill), but also on the physical rehabilitation process.

Physical therapy is necessary because of the significant weakness noted in the musculature after TKA, particularly in the quadriceps. Quadriceps strength has been shown to decrease by 62% after surgery, compared to preoperative values (Mizner et al., 2005a). In another study, quadriceps strength in the operated limb was reduced by 40% one month after TKA, compared to the non-operated limb (Mizner et al., 2005b). The difference between limbs regarding quadriceps strength decreased within 1 to 3 years of TKA, but this was the result of not only increased strength in the operated limb, but also of a progressive decline of strength in the non-operated limb (Zeni et al., 2010; Yoshida et al., 2012).

Even if these problems are well known, rehabilitation focused on specific deficits has not been systematically studied, neither is it routinely prescribed. Moreover, the conclusion of the consensus conference of the National Health Institute of U.S.A. in 2003 was that the use of rehabilitation services was one of the least studied aspects of medical care after total knee arthroplasty and that there was no proof sustaining the generalized use of some specific type of preoperative or postoperative rehabilitation intervention (***, 2003). Subsequent studies led to contradictory results, some of them showing the benefits of an intensive rehabilitation program, focused on the deficits found (Bade et al., 2011; Petterson et al., 2009), others being unable to evidence such advantages (Minns Lowe et al., 2007).

In this context, we tried to prove the benefits of the rehabilitation program that we applied to our patients after total knee replacement, based on specific muscle strengthening and functional improvement.

Hypothesis

The purpose of the study was to comparatively evaluate

the evolution of isokinetic strength parameters in patients that were and were not included in a rehabilitation program after total knee arthroplasty. We assumed that participation in the rehabilitation program would generate a better recovery of muscle strength after TKA.

Materials and methods

Research protocol

We mention that the research protocol was in conformity with the Helsinki Declaration, the Amsterdam Protocol and Directive 86/609/EEC, and the approval of the Ethics Committee of the University of Medicine and Pharmacy Cluj-Napoca regarding research on human subjects was obtained. The research procedures were explained to all the study participants and an informed consent was also obtained from all patients prior to the study.

The research was structured as a prospective cohort study.

a) Period and place of the research.

The study was conducted between June 2011 and June 2012 in the Rehabilitation Hospital Cluj-Napoca.

b) Subjects and groups.

The study included 50 patients undergoing total knee arthroplasty for knee osteoarthritis. Patients were recruited from the 3 orthopedic departments of Cluj-Napoca. The inclusion criteria were: end-stage knee osteoarthritis (according to ACR criteria), with TKA indication; age between 50 and 85 years. The exclusion criteria were: uncontrolled hypertension or diabetes, BMI greater than 35kg/m², significant neurological impairments, significant contralateral knee osteoarthritis (Kellgren-Lawrence stage 3 or 4), or other unstable lower extremity orthopedic conditions.

The patients were distributed into 2 groups.

The first group (rehabilitation group - RG) consisted of 33 patients (24 women and 9 men), with a mean age of 67.4±7.3 years, who accepted to be included after TKA in a standardized 2-week rehabilitation program, performed at the Rehabilitation Hospital Cluj-Napoca. Its objectives were pain control, increase of the knee range of motion, strengthening of quadriceps, hamstrings, hip abductors, hip extensors and ankle plantar flexors, gait correction.

The second group (non-rehabilitation group - NRG) consisted of 17 patients (12 women and 5 men), with a mean age of 66.4±9.9 years, who did not agree to participate in any postoperative rehabilitation program.

c) Tests applied

The patients were assessed at 2 moments: preoperatively, and at 6 months postoperatively. Strength testing of knee extensor and flexor muscles was performed isokinetically, using a Gimmex Iso 2 dynamometer. The evaluation protocol included a session of warm-up and familiarization, consisting of a set of 10 submaximal repetitions of knee flexion and extension at a velocity of 240°/sec. After a rest period of 2 minutes, muscle performance was assessed by a set of 10 repetitions at a velocity of 180°/sec, followed by 5 repetitions at 90°/sec. A rest interval of 2 minutes between the sets reduced the effects of fatigue. For both extensor and flexor muscles, the dynamometer automatically recorded the following parameters: peak torque, angle at peak torque, maximal power, total work, flexor/extensor

ratio (for peak torque). Of these, statistical analysis was based on peak torque (PT).

d) Statistical processing.

Quantitative variables were expressed as mean ± standard deviation (SD). Once the normal distribution of data was confirmed by the Kolmogorov-Smirnov test, statistical analysis of differences between the two groups was carried out using Student t test for independent samples (variance was previously tested). Sex and side distribution between the groups was tested using a Pearson chi-squared statistic. The statistical significance threshold was at $p \leq 0.05$. The software used was Microsoft Excel 8.0 for Windows and MedCalc 12 (trial version).

Results

There were no differences in age, gender or body mass index (BMI) between the two groups of patients included in the research. The distribution of arthroplasty between the two sides was balanced in both groups (Table I).

Table I Patient demographic characteristics

Variable	RG (mean±SD)	NRG (mean±SD)	Statistical significance (p)
Age (years)	67.4±7.3	66.4±9.9	0.9106
BMI (kg/m ²)	31.8±4.9	33.3±6.1	0.7265
Gender (male/female)	9/24	5/12	0.8627
Affected side (left/right)	17/16	10/7	0.8480

When extensor strength was compared isokinetically, there was no significant difference between the groups at the baseline (preoperatively). Nevertheless, 6 months after TKA, patients who participated in the rehabilitation program had a significant advantage over those who refused participation (Table II). This advantage was obvious for both testing velocities (180°/sec and 90°/sec).

Table II Extensor strength before and 6 months after TKA, in the 2 groups

Parameter (Nm)	Assessment point	RG (mean±SD)	NRG (mean±SD)	Statistical significance (p)
PT E 180 %s	Preoperatively	38.4±9.9	39.1±8.7	0.1338
	At 6 months	54.8±6.2	43.6±7.3	0.0379
	p	0.0423	0.1012	
PT E 90 %s	Preoperatively	50.5±11.5	51.1±9.6	0.0973
	At 6 months	59.6±10.7	53.2±5.3	0.0447
	p	0.6282	0.0847	

A comparison of the preoperative and 6 month postoperative values of extensor isokinetic strength shows that even if patients without rehabilitation had a slight strength improvement, this was not significant for either of the 2 testing velocities (Fig. 1, Table II).

On the other hand, for patients included in the rehabilitation program, strength improvement from preoperatively to 6 months postoperatively was more consistent, but unfortunately, it reached statistical significance only when isokinetic testing was performed at a higher velocity (180°/sec), and not at a lower one (90°/sec) (Fig. 1, Table II).

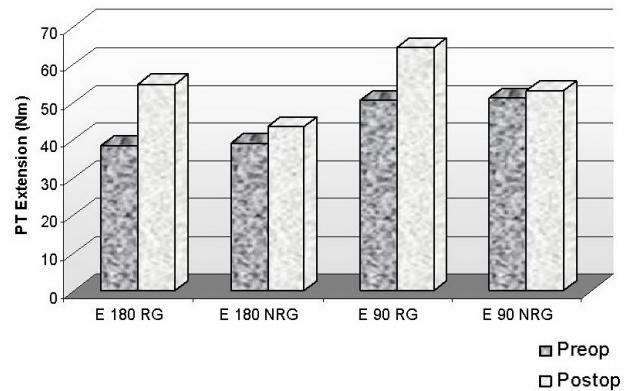


Fig. 1 – Comparative evolution of extensor strength after TKA in patients with and without rehabilitation

Table III Flexor strength before and 6 months after TKA, in the 2 groups

Parameter (Nm)	Assessment point	RG (mean±SD)	NRG (mean±SD)	Statistical significance (p)
PT F 180 %s	Preop	18.5±5.1	18.9±6.2	0.1538
	At 6 months	23.0±3.7	19.8±4.5	0.0883
	p	0.4895	0.5374	
PT F 90 %s	Preop	21.3±8.4	20.4±10.9	0.7219
	At 6 months	23.6±6.1	21.5±5.3	0.6048
	p	0.4365	0.2725	

Regarding flexor strength, it may be observed that a certain improvement from preoperatively to 6 months postoperatively was present in all the situations, with a slight advantage for the rehabilitation group (Fig. 2, Table III), but statistical significance was not reached in any case ($p > 0.05$).

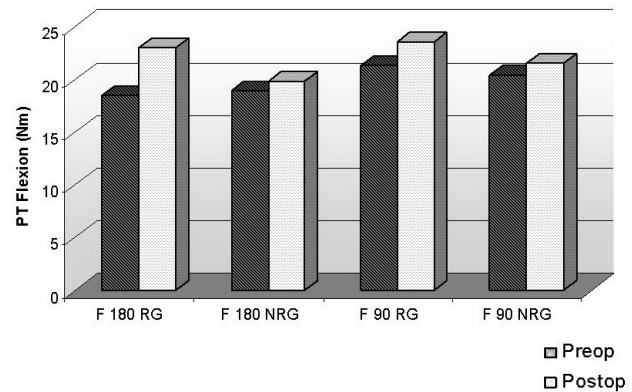


Fig. 2 – Comparative evolution of flexor strength after TKA in patients with and without rehabilitation

Even if the 6 month postoperative strength values were obviously higher in the rehabilitation group than in the group without rehabilitation, there was no statistical significance at either of the isokinetic testing velocities (Fig. 2, Table III).

Isokinetic strength values recorded at the angular velocity of 90°/sec were always higher than those recorded at 180°/sec (Figs. 1 and 2). Muscle strength was always higher in extensors than in flexors.

Discussions

In the present study, the evolution of muscle strength in patients that were included into a rehabilitation program after total knee arthroplasty was compared to that of patients who had no rehabilitation after the same intervention. An improvement of isokinetic strength from preoperatively to 6 month postoperatively was observed in all patients, with or without postoperative rehabilitation, for both extensor and flexor groups. Nevertheless, this improvement was statistically significant only in the rehabilitation group, for extensors, when isokinetic testing was performed at a higher velocity (180°/s).

Six months after arthroplasty, the strength of extensor muscles was significantly higher in patients included in the rehabilitation program compared to those with no rehabilitation after surgery, for both testing velocities. At the same evaluation, when flexor strength was analyzed, even if a slight advantage of the rehabilitation group was noted, this was not statistically significant for either of the two testing velocities.

These findings are similar to those reported by Petterson, who compared the outcomes of patients that followed progressive strengthening protocols after TKA with those of control patients that received standard rehabilitation based on functional training (Petterson et al., 2009). It was highlighted that one year after TKA, subjects of the progressive strengthening group had significantly higher quadriceps strength and better performance-based test results (Timed Up and Go - TUG, Stair Climbing Test - SCT, Six Minute Walk - 6MW). Quadriceps strength predicted 28% of the variability in TUG, 26% of that in SCT and 37% of that in 6MW, indicating that quadriceps strength is the strongest predictor of functional performance following TKA. Therefore, recovery of quadriceps strength after TKA is imperative.

In another research (Moffet et al., 2004), an intensive functional rehabilitation protocol (including a warm-up, specific strengthening exercises, functional task-oriented exercises, endurance exercises and a cool-down period) was compared with a standard rehabilitation protocol after TKA. The intensive rehabilitation group had better outcomes for the 6MW test and for the Western Ontario McMaster Universities Arthritis Index (WOMAC) 4 months and 6 months after surgery, but these improvements were not maintained at the 12-month follow-up.

In a very recent study (Ardali, 2014), it was found that the use of a daily adjustable progressive resistance exercise protocol early after TKA was free of adverse events and improved quadriceps strength and functional performance.

In a systematic review on lower limb strength following TKA (Schache et al., 2014), it was shown that muscle weakness was particularly obvious for quadriceps and less obvious for hamstrings. There was a tendency towards hamstring weakness in these patients, but there were not enough studies and the existing ones were very heterogeneous, so conclusions based on strong evidence could not be drawn. Reduced hamstring strength along with reduced quadriceps strength may affect balance, as co-contraction of the two muscle groups is important for knee proprioception and stability. In the same review, location

of surgical incision and prosthesis design characteristics were mentioned as possibly affecting the strength recovery of lower limb muscles following total knee replacement.

So, in a prospective study performed on patients undergoing TKA by minimally invasive surgical techniques (Schroer et al., 2010), it was demonstrated that quadriceps strength returned to preoperative levels by 3 months postoperatively and was 17% stronger at 6 months and 30% stronger at 1 year than preoperative levels. The recovery of extensor and flexor strength was more rapid and more complete than that previously demonstrated after TKA with a medial parapatellar arthrotomy.

On the other hand, it was shown that knee flexion torque on the TKA side was positively associated with bone strength in the same leg and, therefore, successful rehabilitation might diminish bone loss in the operated leg (Rantalainen et al., 2012).

In another systematic review focused on physical exercise after TKA (Pozzi et al., 2013), the authors concluded that an optimal outpatient physical therapy protocol should include progressive strengthening and intensive functional exercises, that outpatient physical therapy performed in a clinic under the supervision of a trained physical therapist may provide the best long-term outcomes after surgery, and that telerehabilitation does not improve the range of motion, strength and functional impairments to the same extent as supervised physical therapy sessions that include progressive exercises.

An expert consensus on best practices for post-acute rehabilitation after total hip and knee arthroplasty was an important step toward reducing practice variations and improving the quality of rehabilitation services after these surgical interventions (Westby et al., 2014). It was stated that patients should be offered structured post-acute rehabilitation, provided by trained professionals.

Conclusions

1. Six months after TKA, quadriceps strength was higher in patients that were included in the postoperative rehabilitation program.
2. As quadriceps deficit has been proved to be important immediately after TKA and related to functional impairments, strengthening exercise protocols should be prescribed after this type of surgery.
3. Current strengthening protocols should be improved in order to more efficiently increase quadriceps strength, therefore further research is required to determine the optimal exercise prescription that can safely lead to better functional outcomes.

Conflicts of interest

There are no conflicts of interest.

Acknowledgement

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References

- Ardali G. A daily adjustable progressive resistance exercise protocol and functional training to increase quadriceps muscle strength and functional performance in an elderly homebound patient following a total knee arthroplasty. *Physiother Theory Pract* 2014 Jan 7 [Epub ahead of print].
- Bade MJ1, Stevens-Lapsley JE. Early high-intensity rehabilitation following total knee arthroplasty improves outcomes. *J Orthop Sports Phys Ther* 2011;41(12):932-941.
- Ethgen O, Bruyère O, Richy F, Dardennes C, Reginster JY. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. *J Bone Joint Surg Am* 2004;86-A(5):963-974.
- Jones CA, Beaupre LA, Johnston DW, Suarez-Almazor ME. Total joint arthroplasties: current concepts of patient outcomes after surgery. *Rheum Dis Clin North Am* 2007;33(1):71-86.
- Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am* 2007;89(4):780-785.
- Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030. *Clin Orthop Relat Res* 2009;467(10):2606-2612.
- Losina E, Walensky RP, Kessler CL, Emrani PS, Reichmann WM, Wright EA, Holt HL, Solomon DH, Yelin E, Paltiel AD, Katz JN. Cost-effectiveness of total knee arthroplasty in the United States: patient risk and hospital volume. *Arch Intern Med* 2009;169(12):1113-1121.
- Minns Lowe CJ, Barker KL, Dewey M, Sackley CM. Effectiveness of physiotherapy exercise after knee arthroplasty for osteoarthritis: systematic review and meta-analysis of randomised controlled trials. *BMJ* 2007;335(7624):812.
- Mizner RL, Petterson SC, Snyder-Mackler L. Quadriceps strength and the time course of functional recovery after total knee arthroplasty. *J Orthop Sports Phys Ther* 2005a;35(7):424-36.
- Mizner RL, Petterson SC, Stevens JE, Vandenborne K, Snyder-Mackler L. Early quadriceps strength loss after total knee arthroplasty. The contributions of muscle atrophy and failure of voluntary muscle activation. *J Bone Joint Surg Am* 2005b;87(5):1047-53.
- Moffet H, Collet JP, Shapiro SH, Paradis G, Marquis F, Roy L. Effectiveness of intensive rehabilitation on functional ability and quality of life after first total knee arthroplasty: A single-blind randomized controlled trial. *Arch Phys Med Rehabil* 2004;85(4):546-556.
- Petterson SC, Mizner RL, Stevens JE, Rasis L, Bodenstab A, Newcomb W, Snyder-Mackler L. Improved function from progressive strengthening interventions after total knee arthroplasty: a randomized clinical trial with an imbedded prospective cohort. *Arthritis Rheum* 2009;61(2):174-183.
- Pozzi F, Snyder-Mackler L, Zeni J. Physical exercise after knee arthroplasty: a systematic review of controlled trials. *Eur J Phys Rehabil Med* 2013;49(6):877-892.
- Rantalainen T, Valtonen A, Sipilä S, Pöyhönen T, Heinonen A. Maximal voluntary isokinetic knee flexion torque is associated with femoral shaft bone strength indices in knee replacement patients. *Knee* 2012;19(2):116-119.
- Schache MB, McClelland JA, Webster KE. Lower limb strength following total knee arthroplasty: a systematic review. *Knee* 2014;21(1):12-20.
- Schroer WC1, Diesfeld PJ, Reedy ME, LeMarr AR. Isokinetic strength testing of minimally invasive total knee arthroplasty recovery. *J Arthroplasty*. 2010;25(2):274-279.
- Westby MD, Brittain A, Backman CL. Expert consensus on best practices for post-acute rehabilitation after total hip and knee arthroplasty: a Canada and United States Delphi study. *Arthritis Care Res* 2014;66(3):411-423.
- Yoshida Y1, Zeni J, Snyder-Mackler L. Do patients achieve normal gait patterns 3 years after total knee arthroplasty? *J Orthop Sports Phys Ther* 2012;42(12):1039-49.
- Zeni JA Jr, Snyder-Mackler L. Early postoperative measures predict 1- and 2-year outcomes after unilateral total knee arthroplasty: importance of contralateral limb strength. *Phys Ther* 2010;90(1):43-54.
- ***. NIH Consensus Statement on total knee replacement. NIH Consens State Sci Statements 2003;20(1):1-34.