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RESEARCH ARTICLE

Comparative Study on the Effectiveness of Early or Delayed Weight-Bearing After Anterior Cruciate Ligament Reconstruction

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Objectives. The aim of this study is to evaluate the efficacy of immediate weight-bearing versus two weeks delayed weight-bearing following anterior cruciate reconstruction. **Methods**. We conducted a prospective observational study on the efficiency of immediate or delayed weight-bearing following anterior cruciate reconstruction. 30 patients undergoing anterior cruciate ligament reconstruction were included in the study. The patients in the first group were allowed the maximum endurance level of weight-bearing on the operated leg from the first postoperative day, resuming normal walking as soon as possible. Patients in group II were barely allowed the loading of the affected limb after 2 weeks postoperatively. Patient assessment was performed preoperatively, immediately after the procedure and postoperatively at 6 weeks, 3 and 6 months. **Results**. The average pre- and postoperative values of the arthometric assessment show a statistically significant improvement of joint stability in both groups of patients. There were no significant differences in the development of joint mobility averages between the two groups. Following the evolution of functional test average values, there is a gradual function improvement in both groups of patients. The assessment results at 6 weeks and three months postoperatively shows that patients in the first group are significantly better in comparison with the results of patients in group II. The final evaluation showed no significant differences between the two groups of patients. **Conclusions**. The final assessment revealed no statistically significant difference in reported or objectively measured function. We believe that the weight-bearing exercises and the non–weight-bearing exercises are equally effective and safe in the post-ligamentoplasty recovery.

Keywords: ligamentoplasty, rehabilitation, weight-bearing

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Introduction

The anterior cruciate ligament reconstruction is a common procedure which allows patients to return to their daily and sports activities in the shortest time. After surgical reconstruction, a rigorous rehabilitation is necessary for a successful outcome. The main objectives of the post ligament reconstruction are reducing the pain and inflammation, completely recovering the articular amplitude, regaining muscle strength and, finally, recovering the pre-injury functional level [1].

It is known that during the first phase of postoperative rehabilitation, the reconstructed ligament should be loaded cautiously to protect the healing tissue. For a proper exercise selection, the orthopedic physician needs to be aware of how performing weight-bearing and non–weight-bearing exercises may affect the reconstructed ligament. Minimizing tensile loading of the graft is important, especially during the first several postoperative weeks.

Many studies have shown that anterior cruciate ligament loading is generally greater with non-weight-bearing exercises compared to weight-bearing exercise; for both types of exercises, the ligament is loaded to a greater extent: between 10° and 50° (generally between 10˚ and 30˚) compared to 50° and 100° of knee flexion [2-4]. The biggest challenge in exercise selection, after anterior cruciate ligament reconstruction, is the limited knowledge of the optimal timing for adjusting the weights and beginning the closed kinetic chain exercises, and the choice of exercises and their intensity, in order to avoid the unnecessary overloading and damaging of the neoligament.

The aim of this study is to evaluate the efficacy of immediate weight-bearing versus two weeks delayed weight-bearing following anterior cruciate reconstruction.

Material and methods

Our study was approved by the Research and Ethic Board of Târgu Mureș County Hospital (Registration number 3425/11.03.2015)

Between the 3rd of May and 20th of December 2015, the Orthopedics Clinic of the Târgu Mureș County Hospital conducted a prospective observational study on the efficiency of immediate or delayed weight-bearing following anterior cruciate reconstruction. 30 patients undergoing anterior cruciate ligament reconstruction – with autografts taken from the semitendinosus and gracilis muscles tendons – were included in the study. The performed surgeries strictly followed the protocol of the Orthopedics Clinic of Târgu Mureș County Hospital.

Inclusion criteria of patients:

- anterior cruciate ligament reconstruction with a hamstring graft, fixed with XO-Button;
- a difference smaller than 1 cm between the circumference of the thighs;
- time laps smaller than three months between the injury and the surgery;

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- age over 18 and under 35 years;
- signed agreement of the patient.

Exclusion criteria of patients:

- previous knee surgery;
- presence of associated intra-articular lesions such as meniscus injuries, chondral injuries which needed revascularization, damage to the capsuloligamentous apparatus;
- other orthopedic conditions of the leg or the presence of neurological disorders causing functional limitations;
- poor compliance to the recommended treatment plan;
- non-compliant patient.

Two groups were formed, each with 15 subjects/patients.

The patients in the first group were allowed the maximum endurance level weight-bearing on the operated leg from the first postoperative day, resuming normal walking as soon as possible. The recommended exercises in the first phase of recovery were carried out in open and closed kinetic chain.

The patients in group II were barely allowed the loading of the affected limb after 2 weeks postoperatively. The first phase of the recovery program was based on free and active exercises with progressive resistance made only in open kinetic chain. The time spent performing exercises was about 2 hours/day (4x30 min, with progressively increasing length and difficulty of the exercises).

For both groups, the rehabilitation program was initiated the first postoperative day. In the first phase of recovery combating pain and inflammation, protecting the repaired tissue, improving joint mobility, focusing on restoring full extension, preventing muscle atrophy and improving muscle tone and strength were the main objective.

In the second recuperative phase the main aim was the progressive increase of joint mobility by restoring the complete motion amplitude, resuming normal gait, improving the muscular strength and endurance, improving joint stability, the proprioception and motor control and progressively resuming daily activities. The ultimate objective of the complete recovery was restoring tone, muscle strength and endurance, fully restoring joint stability, proprioception and motor control rehabilitation and gradual resumption of sports activities (performed safely).

Patient assessment was performed preoperatively, immediately after the procedure and postoperatively at 6 weeks, 3 and 6 months. The ligamentous laxity was evaluated using a knee ligament arthrometer KT-1000. To assess the active range of joint mobility of the knee, the test was performed in the supine position. The mobility and joint stability were assessed using the „stair climbing" test. The „6 minutes walk" test was used to assess muscular endurance. With Tegner-Lysholm score, the difficulty of carrying out daily activities was measured and rated.

The statistical analysis was performed using the Graph Pad Software. The data were considered as nominal or quantitative variables. The nominal variables were characterized using frequencies. The quantitative variables were measured for distribution normality, using the Kolmogorov-Smirnov test, and were characterized by median and percentiles (25-75%) or, when appropriate, by mean and standard deviation (SD). A chi-square test was used in order to compare the frequencies of nominal variables. The quantitative variables were compared using the T test or the ANOVA test. We used the Bonferroni correction in order to account for multiple comparisons. The level of statistical significance was set at $p<0.05$.

Results

The distribution of age and gender of the two groups was balanced.

The general data of patients included in the study are shown in Table I.

The average pre- and postoperative values of the arthometric assessment show a statistically significant im

Table I. General data of the patients included in the study

	Group I	Group II
Average (years) age (min-max)	25.53 (18-34)	26.80 (18-35)
Gender (F/M)	9/6	8/7
Affected knee (right/left)	7/8	10/5

Table II. The average values of evaluations

	Group I (mean(SD))	Group II (mean(SD))	p##
Arthrometry (mm)	p# < 0.0001	p# < 0.0001	
Healthy knee	1.07 (0.961)	1.00 (0.756)	0.83
Preoperatively	3.40 (0.986)	3.67 (0.976)	0.46
Postop. 6 weeks	0.40 (0.507)	0.67 (0.724)	0.25
Postop. 3 months	0.20 (0.414)	0.33 (0.488)	0.42
Postop. 6 months	0.20 (0.414)	0.33 (0.488)	0.42
Goniometry (°)	p# - 0.63	p# - 0.59	
Healthy knee	124.00 (2.828)	123.00 (3.703)	0.41
Preoperatively	123.60 (3.066)	122.40 (3.961)	0.36
Postop. 6 weeks	122.33 (3.244)	121.00 (3.928)	0.31
Postop. 3 months	123.40 (3.269)	122.13 (3.335)	0.30
Postop. 6 months	123.73 (3.105)	122.87 (3.502)	0.48
Stair climbing test (sec)	p# < 0.0001	p# < 0.0001	
Preoperatively	13.460 (1.1331)	13.593 (1.1423)	0.75
Postop. 6 weeks	9.453 (1.7927)	10.787 (1.4451)	0.004
Postop. 3 months	7.60 (1.474)	9.68 (1.924)	0.0001
Postop. 6 months	6.607 (1.4949)	6.780 (1.6483)	0.41
6 minute walk test (m)	p# < 0.0001	p# < 0.0001	
Preoperatively	543.33 (53.123)	548.00 (50.530)	0.80
Postop. 6 weeks	475.27 (48.243)	515.20 (44.293)	0.02
Postop. 3 months	417.67 (49.617)	456.87 (31.688)	0.01
Postop. 6 months	387.67 (29.437)	400.33 (31.627)	0.26
Tegner-Lysholm score	p# < 0.0001	p# < 0.0001	
Preoperatively	61.27 (9.051)	59.60 (8.617)	0.61
Postop. 6 weeks	84.27 (6.808)	76.67 (9.225)	0.01
Postop. 3 months	95.33 (2.968)	92.40 (4.579)	0.04
Postop. 6 months	96.53 (2.696)	95.53 (2.900)	0.33

*The level of statistical significance was set at $p<0.05$.
p#- data obtained by vertical comparison
p##- data obtained by horizontal comparison

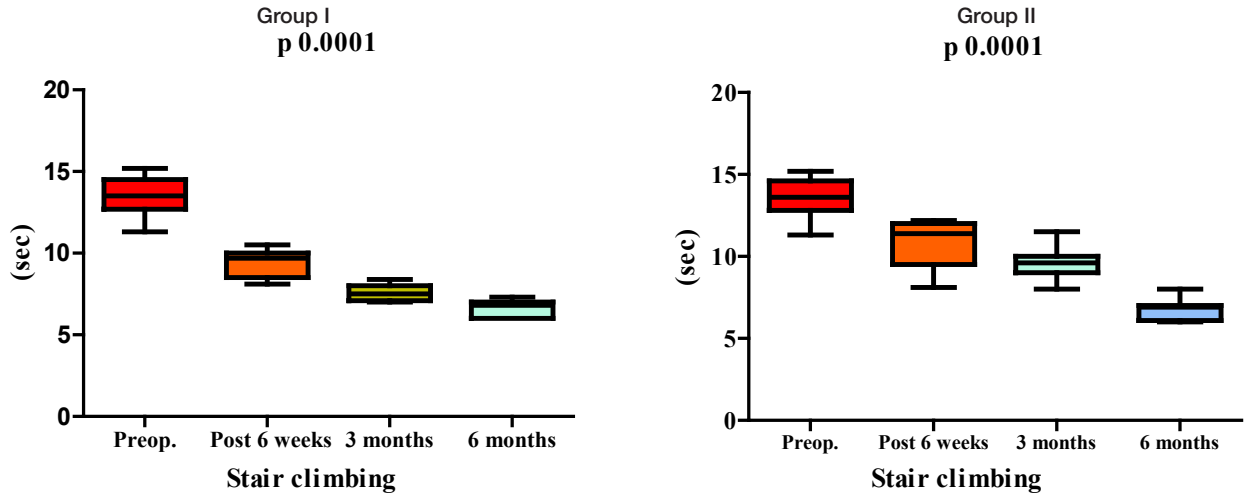

Fig. 1. The evolution of the average values of stair climbing test

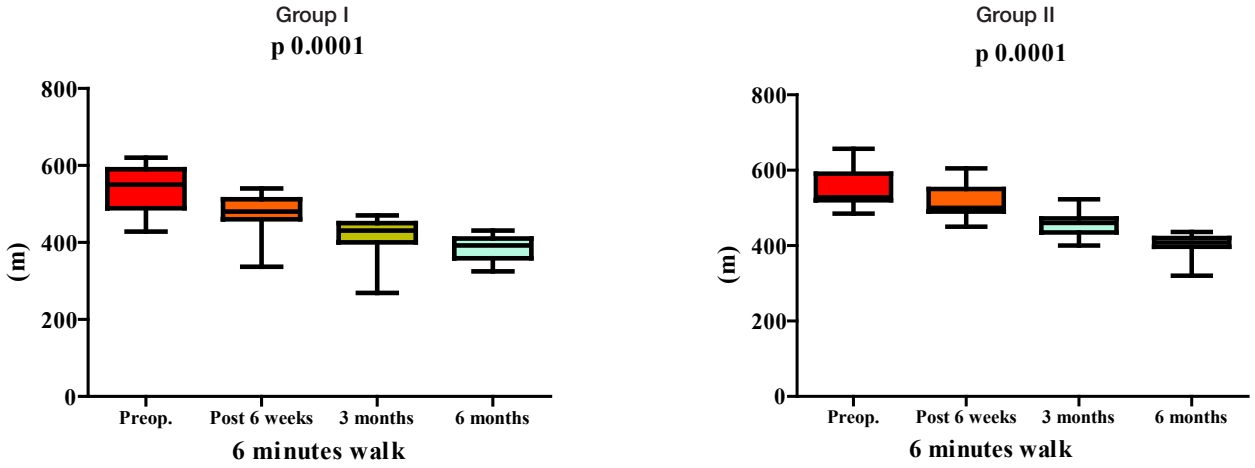

Fig. 2. The evolution of the average values of 6 minute walk test

provement of joint stability in both groups of patients ($p < 0.0001$). There were no significant differences between groups in different moments of pre- and postoperative evaluations.

After (statistically) processing the obtained data, there were no significant differences in the development of joint mobility averages between the two groups. The obtained average values are shown in Table II.

By comparing the average values of functional tests, the statistically significant differences between the two groups were observed only between the 6 weeks and 3 months postoperative assessment. The results of patients in the first group were significantly better.

At the final assessment, no statistically significant values were registered.

The evolution of the „stair climbing" test values is shown in Fig. 1. The evolution of the „6 minutes walk" test values is shown in Fig. 2.

The obtained average values are shown in Table II.

Following the evolution of functional test average values, there is a gradual improvement of function in both groups of patients.

The improving quality of life is significant in both groups of patients. The assessment results at 6 weeks and three months postoperatively of patients in the first group are significantly better in comparison with the results of patients in group 2. The final evaluation showed no significant differences between the two groups of patients.

The evolution of the average values is shown in Fig. 3.

Discussion

The appropriate rehabilitation process is the key to successful anterior cruciate ligament surgery. The aim of the rehabilitation is to decrease pain and inflammation, restore full range of motion and improve joint stability, features required to perform daily living and sports activities, and for regaining the previous quality of life. The anterior cruciate rehabilitation has undergone considerable changes in the last few decades; however, there is still no consensus on the post-surgery management in rehabilitation, especially regarding the resumption of full weight-bearing. In the early to mid-1990's it has been proposed that weight-bearing should be delayed to prevent ligamentous laxity and the graft should be protected by immobilization. Today, early weight-bearing is allowed, even recommended.

In the last few years, extensive research has been conducted, regarding the timing for full weight-bearing. In the present study, we formed two groups. The patients in

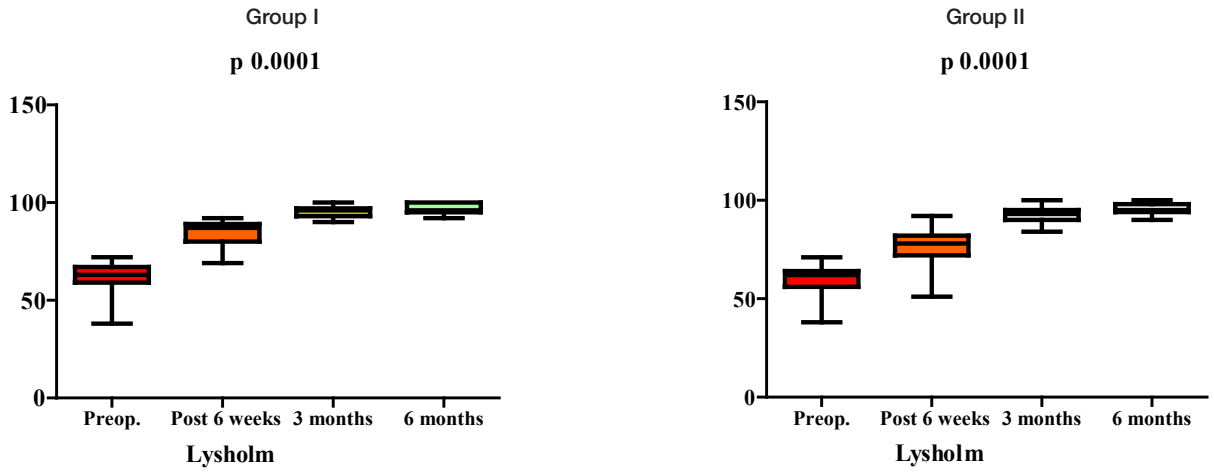

Fig. 3. The evolution of the average values of Tegner-Lysholm score

the first group underwent immediate weight-bearing (as tolerated), performing open and closed kinetic chain exercises. The patients in the second group were kept "on hold" – non-weight-bearing – for 2 weeks, performing exercises in open kinetic chain. The results of our study have shown that, at the final assessment, there were no statistically significant differences between the two groups of patients, with regards to range of motion, knee laxity and functionality. Significant differences were found at 6 weeks and 3 months evaluation regarding the knee functionality and self-reported quality of life assessment.

Regarding the ligamentous laxity, no statistically significant differences were found between the two study groups. Many authors have demonstrated that there is no knee laxity difference between early and delayed weight-bearing groups [5-7]. Heijne et al. [8] concluded that the start of open kinetic chain exercises leads to significantly increased anterior knee laxity. Yack et al. [9] reported that there was more laxity in the early weight bearing group. The literature provides no clear indications on the optimal timing to include weight-bearing exercises. Future research in this area is needed to determine which types of exercises are safer in anterior cruciate ligament rehabilitation. Until these questions are answered, we recommend activities that minimize graft strain.

Quadriceps and hamstring weakness occurs frequently after anterior cruciate ligament reconstruction. Quadriceps strength deficits in the injured limb range from 5% to 40%, hamstrings strength deficits have been reported to range from 9% to 27% [10,11]. The goals of muscular training are to prevent atrophy, improve strength, power, muscular balance between agonist-antagonist groups and endurance. It is important to keep balance between quadriceps and hamstring strength. The strength ratio of hamstrings to quadriceps should be between 60 and 80 percent [12]. Strength imbalance between hamstring and quadriceps may increase the risk of re-injury.

Many studies have demonstrated that closed kinetic chain exercises were more effective than open kinetic chain exercises in inhibiting muscle atrophy of the knee flexors and improving muscle strength [4,8,13]. Combined open and closed kinetic chain exercises enhance better quadriceps and hamstring torque without reducing knee joint stability [5].

Patient-reported knee function, quality of life, and activity level after anterior cruciate ligament reconstruction were higher in the closed kinetic group at 6 weeks and 3 months postoperative assessment. At the final assessment the scores were similar (no statistically significant differences).

Our results indicated that closed and open kinetic chain exercises seem to have similar outcomes on knee laxity and function and therefore could both be used during the rehabilitation of a patient after anterior cruciate ligament.

Conclusions

The results of this study revealed no significant difference between patients who used closed kinetic chain and open kinetic chain exercises with regards to knee laxity and range of motion. With regard to short and medium-term results, we concluded that a combination of weight-bearing and non-weight-bearing exercises for muscle strength and endurance was better than using closed kinetic exercises alone. The final assessment revealed no significant difference in patient reported or objectively measured function. We believe that the weight-bearing exercises and the non–weight-bearing exercises are equally effective and safe in the post-ligamentoplasty recovery.

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Conflict of interest

None to declare

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