An Immediate Effect of High-Power Laser Treatment versus Exercise Treatment in Patients with Anterior Cruciate Ligament Reconstruction Surgery

Lapassakan Pitiruangsit, PT, MSc[1], Winyoo Tongtippayanate, MD[2], Songthai Moonwong, MD[2], Pakpoom Philuek, MSc[3], Kittisak Sawanyawisuth, MD, PhD[4], Austtasit Chainarong, PhD[5]

[1] Department of Physical Therapy, Buriram Hospital, Buriram, Thailand; [2] Department of Orthopedic Surgery, Buriram Hospital, Buriram, Thailand; [3] Department of Sport and Exercise Science, Faculty of Science and Technology, Nakhon Ratchasima Rajabhat University, Nakhon Ratchasima, Thailand; [4] Department of Medicine, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand; [5] Faculty of Sport Science, Burapha University, Chonburi, Thailand

Abstract

Objective: To evaluate the immediate effect of high-power laser treatment in patients with anterior cruciate ligament (ACL) reconstruction surgery.

Materials and Methods: This was an intervention study comparing an exercise program and high-power laser treatment. The inclusion criteria were adult patients aged 18 years or older who received ACL reconstruction surgery, had an indication for physical therapy, and agreed to participate in the study. Eligible patients were randomly assigned into two groups. Each treatment was performed for nine minutes. The outcomes of this study comprised pain intensity score, range of motion measurements, and manual muscle strength. These outcomes were evaluated at baseline and after the intervention. Differences in outcomes from baseline were also calculated.

Results: There were 56 eligible patients. Of those, 30 patients (53.57%) received high-power laser treatment. Regarding the outcomes, there was one significant outcome between the two groups: difference in pain during knee flexion from baseline. The laser treatment group had a significantly higher difference of pain from baseline compared with the exercise group (–1.50 vs. –0.76, $p<0.001$). There was no significant difference between groups in terms of pain intensity score, range of motion measurements, and manual muscle strength.

Conclusion: High-power laser treatment may lower pain intensity while in the knee flexion position immediately after ACL reconstruction surgery.

Keywords: Pain intensity score; Pain; Range of motion; Muscle strength; Exercise; Physical therapy; Laser; High-power laser therapy; ACL reconstruction

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The anterior cruciate ligament (ACL) extends from the posteromedial aspect of the lateral femoral condyle to the anterior intercondylar area of the tibial plateau and is one of the two cruciate ligaments that stabilize the knee[1]. The incidence of ACL injury was 28.57 cases per 100,000 person-years in the United States, resulting in more than 400,000 ACL reconstruction surgeries per year[2]. The most common cause of ACL injury is sports, particularly in football. A previous study found that football and lacrosse had the highest rate of ACL injury among 15 sports in the National Collegiate Athletic Association Injury Surveillance System[3]. The average annual rate of ACL injury in football and lacrosse was 0.17 and 0.23 per 1,000 athlete-exposure in men and women, respectively. The main treatment of ACL injury is ACL reconstruction[4,5].

Rehabilitation care after postoperative ACL reconstruction is also crucial, including exercise and laser treatment[6-8]. A clinical practice guideline recommends several exercises for postoperative ACL reconstruction, including isotonic exercise, isokinetic exercise, or motor control exercises[6]. Previous studies found that high-power laser therapy may be

Correspondence to:

Chainarong A.
Faculty of Sport Science, Burapha University, Chonburi 20130, Thailand.
Phone: +66-38-102060
Email: austtasit@go.buu.ac.th
ORCID: 0000-0003-3856-6854

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What is already known about this topic?

There is limited evidence of high-power laser treatment in patients with anterior cruciate ligament reconstruction surgery.

What does this study add?

High-power laser treatment may lower pain intensity in the knee flexion position immediately in patients with anterior cruciate ligament reconstruction surgery.

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effective in pain reduction as a treatment in patients with myofascial pain in the upper trapezius muscle and hamstring tendinopathy[9,10]. The high-power laser treatment had significantly lower pain scale (2.23 vs. 4.78, p<0.001) and neck disability index (6.15 vs. 15.50, p<0.001) than the physiotherapy treatment[9]. However, there is limited evidence of high-power laser treatment in patients with ACL reconstruction surgery. This study aimed to evaluate the immediate effect of high-power laser treatment in this setting.

Materials and Methods

This was an open-labelled, intervention study comparing an exercise program and high-power laser treatment. The study site was the Physical Therapy Unit, Physical and Rehabilitation Department, Buriram Hospital, Buriram, Thailand; a tertiary care hospital in the lower northeast of Thailand. The inclusion criteria were adult patients aged 18 years or older who received ACL reconstruction surgery, had an indication for physical therapy, and agreed to participate in the study. Those who were pregnant, unable to complete the protocol, or had any contraindications for high-power laser treatment, including active cancer, active hemorrhage, venous thrombosis, arterial occlusion, or photosensitivity to laser, were excluded. The study period was between January 2024 and June 2024.

Eligible patients were randomly assigned into two groups by a simple random sampling method: exercise program or high-power laser treatment. The exercise program was performed according to the previously published article and comprised three exercise postures: patellar mobilization, heel slides with assist, and double-leg mini squats[11]. Each posture was performed three times in one minute with a total time of 9 minutes. The Class IV Therapeutic Laser device with a wavelength of 980 nm for its thermal effect (Mphi5, ASA laser®, Arcugnano, Italy) was used for laser treatment. A fixed multidiode applicator was applied 10 cm above the patellar tendon of the affected side using 2 modes: pain mode and contusion mode (Figure 1). The pain mode was applied by continuous wave pumped with static mode, 100% intensity, and a dose of 964.80 Joules for 5 minutes, while the contusion mode was performed by continuous wave pumped with static mode, 100% intensity, and a dose of 771.84 Joules for 4 minutes. The total time for laser treatment was 9 minutes.

Baseline characteristics were evaluated prior to study intervention, including age, sex, education, marital status, health insurance, side of injury, conditions of injury: acute or chronic, and mechanisms of injury. The outcomes of this study comprised pain intensity score during knee flexion and extension, range of motion of the knee during flexion and extension, and muscle strength during knee flexion and extension. Pain intensity score was measured using a numeric rating scale ranging from 0 (no pain) to 10 (worst imaginable pain); range of motion measurements were reported in degrees; manual muscle strength was assessed using the Manual Muscle Test (MMT) scale, scored from 0 (no contraction) to 5 (full strength against maximum resistance). The range of motion was measured using a universal goniometer, with 0 degrees indicating a neutral position in knee extension[12]. These outcomes were evaluated at baseline and after the intervention. Differences of outcomes from baseline were also calculated.



Figure 1. High-power laser treatment in patients with anterior cruciate ligament reconstruction surgery.

Statistical Analyses

Baseline characteristics of each study group were calculated and reported as median (range) for numerical variables or number (percentage) for categorical variables. Differences in studied variables between the two study groups exercise program or high-power laser treatment were compared using an independent Student's t-test for numerical variables and

Fisher's exact test for categorical variables. Regarding the outcomes, the mean (standard deviation, SD) of each studied variable after the intervention and the difference from baseline were calculated by study group. A comparison of the study outcomes between both groups was performed using an independent Student's t-test. A significant level was declared if a p-value was less than 0.05. All statistical analyses were computed using Stata Statistical Software, version 18.5 (StataCorp LLC, College Station, TX, USA).

Ethical Approval

The study protocol was approved by the Ethics Committee for Human Research, Buriram Hospital, Buriram, Thailand (BR04-01/01.0).

Results

There were 56 patients with ACL reconstruction surgery who participated in the study. Of those, 30 patients (53.57%) received high-power laser treatment. Baseline characteristics of both groups were reported in Table 1. There was only one factor significantly different between the two groups: condition of patients. The exercise group enrolled 26 patients (100%) with acute ACL injury, while only 19 patients (67.86%) had acute ACL injury (p=0.002). The mean age of both groups was comparable (26.07 vs. 27.51 years, p=0.532). Most patients were male in both groups: 84.00% in the exercise group and 80.00% in the laser group (p=0.741). The most common cause of acute ACL injury was sport (52 patients; 92.86%).

Regarding the outcomes, there was one significant outcome between both groups: difference in pain during knee flexion from baseline (Table 2). The laser treatment group had a significantly higher difference in pain from baseline during knee flexion compared with the exercise group (–1.50 vs. –0.76, p<0.001). Even though there were significant differences in outcome variables between both groups at baseline and after the intervention, including range of motion during knee flexion and manual muscle strength during knee flexion, these variables had comparable differences from baseline between both groups. The laser group had significantly higher range of motion during knee flexion than the exercise group (127.33 vs. 109.61 degrees, p=0.011) as well as after the intervention (131.90 vs. 117.69 degrees, p=0.028). The difference from baseline of this variable between both groups was comparable (4.56 vs. 8.07, p=0.106).

Table 1. Baseline characteristics of patients with anterior cruciate ligament reconstruction surgery who received either an exercise program or high-power laser treatment

Factors	Exercise (n=26)	Laser (n=30)	p-value
Average of age (years); mean [SD]	26.07 [7.92]	27.51 [8.93]	0.532
Male sex; n (%)	21 (84.00)	24 (80.00)	0.741
Education; n (%)			0.832
Primary school	2 (7.69)	2 (6.67)	
Secondary school	8 (30.77)	10 (33.33)	
Diploma	9 (34.62)	7 (23.33)	
College	7 (26.92)	11 (36.67)	
Marital status: single; n (%)	11 (55.00)	15 (60.00)	0.770
Insurance; n (%)			0.206
Basic	10 (47.62)	17 (70.83)	
Social security	3 (14.29)	0 (0.00)	
Government	8 (38.09)	7 (29.17)	
Side; n (%)			0.276
Left	15 (57.69)	11 (39.29)	
Right	11 (42.31)	17 (60.71)	
Conditions; n (%)			0.002
Acute	26 (100)	19 (67.86)	
Chronic	0 (0.00)	9 (32.14)	
Mechanism of injury; n (%)			0.999
Sport	24 (96.00)	28 (93.33)	
Accident	1 (4.00)	2 (6.67)	

SD=standard deviation

Discussion

This study found that high-power laser treatment can significantly reduce pain intensity from baseline compared to the exercise treatment immediately in patients with ACL reconstruction surgery. As previously reported, high-power laser treatment is an effective modality in several tendinitis conditions, including Achilles tendon or whiplash[13-15]. This study added that the high-power laser treatment was also effective in patients with ACL reconstruction surgery postoperatively for 2 to 4 weeks in terms of pain reduction.

The high-power laser treatment is considered a non-invasive and painless therapy. The mechanism of pain reduction from high-power laser treatment may be related to the photochemical and photothermic effects[15]. These effects are related to an increase in blood flow, vascular permeability, and cell metabolism, leading to repair of damaged ligament as well as removal of painful stimuli. A previous study found that the 3-W (360 J) laser treatment increased blood flow over time from 1 to 4 minutes from baseline at the forearm[16]. At 1 and 4 minutes after laser treatment, blood flow was 2.767 and 2.794 mL/minute per 100 mL tissue compared to 2.417 mL/minute per 100 mL tissue at baseline (p<0.01 and 0.032, respectively). These

Table 2. Outcomes of patients with anterior cruciate ligament reconstruction surgery who received either an exercise program or high-power laser treatment in two time periods: baseline and after the intervention

Factors	Mean (SD)		p-value
	Exercise (n=26)	Laser (n=30)	
Pain while knee flexion baseline	2.30 (1.34)	2.70 (1.44)	0.300
Pain while knee flexion after the intervention	1.53 (1.20)	1.20 (0.99)	0.255
Difference from baseline	−0.76 (0.51)	−1.50 (0.73)	<0.001
Pain while knee extension baseline	0.92 (0.79)	1.26 (1.22)	0.228
Pain while knee extension after the intervention	0.46 (0.50)	0.46 (0.73)	0.976
Difference from baseline	−0.46 (0.50)	−0.80 (0.80)	0.070
ROM while knee flexion at baseline	109.61 (24.36)	127.33 (25.99)	0.011
ROM during knee flexion after the intervention	117.69 (22.68)	131.90 (24.11)	0.028
Difference from baseline	8.07 (11.05)	4.56 (3.62)	0.106
ROM while knee extension baseline	20.00 (54.09)	8.10 (30.81)	0.308
ROM during knee extension after the intervention	19.92 (56.26)	6.83 (31.82)	0.281
Difference from baseline	−0.07 (3.36)	−1.26 (2.63)	0.144
MMT while knee flexion baseline	2.50 (0.70)	3.13 (0.81)	0.003
MMT while knee flexion after the intervention	3.03 (0.99)	3.56 (0.85)	0.037
Difference from baseline	0.53 (0.50)	0.43 (0.50)	0.441
MMT while knee extension baseline	3.69 (0.67)	3.56 (0.67)	0.492
MMT while knee extension after the intervention	4.19 (0.84)	4.06 (0.82)	0.578
Difference from baseline	0.50 (0.50)	0.50 (0.57)	0.999

SD=standard deviation

pain intensity score was measured using a numeric rating scale ranging from 0 (no pain) to 10 (worst imaginable pain); range of motion (ROM) measurements are reported in degrees; manual muscle strength was assessed using the manual muscle test (MMT) scale, scored from 0 (no contraction) to 5 (full strength against maximum resistance).

data supported the findings of this study that laser treatment was effective in pain reduction immediately after the 9-minute protocol of laser treatment. Note that the pain reduction was found only during knee flexion (Table 2). These findings may be explained by more severe pain during knee flexion than during knee extension in this study. The average pain intensity was almost 3 out of 10 at baseline in knee flexion, but it was only about 1 out of 10 in knee extension (Table 2).

There are some limitations in this study. First, the enrolled patients had a different proportion in terms of condition status (Table 1). The exercise group had 100% of patients with acute ACL injury, while only 67.86% of patients in the laser treatment group had acute ACL injury (p=0.002) despite the randomization of the study. The sample size in this study was a convenience sample. These differences may affect the outcome of the study. Range of motion and manual muscle strength during knee flexion were significantly different between both groups at baseline and post-intervention. The difference from baseline of these variables was comparable between both groups, though indicating a non-significant effect of the interventions between both groups. Second, the study protocol was performed in patients with ACL reconstruction surgery postoperatively for 2 to 4 weeks. Types of operation may vary among patients. Finally, the outcomes were evaluated immediately after the intervention. Long-term effects of laser treatment may be required.

Conclusion

High-power laser treatment may lower pain intensity in the knee flexion position immediately in patients with ACL reconstruction surgery.

Authors Contributions

LP and AC designed the study, collected data, interpreted data, and drafted the manuscript. WT, SM, PP, and KS collected data, interpreted data, or analyzed data. The authors read and approved the final manuscript.

Clinical Trial Registration

This study was registered with the Thai Clinical Trials Registry (TCTR), TCTR20260618003.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

Data are available upon reasonable request to the corresponding author.

Ethics Approval and Consent to Participate

The study protocol was approved by the ethics committee for human research, Buriram Hospital, Buriram, Thailand (BR04-01/01.0), and informed consent was given prior to study participation.

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Use of Artificial Intelligence

The authors did not use AI for manuscript writing.

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