

Effect of Electrical Stimulation on Quadriceps Muscle Strengthening Following Reconstructive Surgery of the Anterior Cruciate Ligament

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ABSTRACT. The purpose of this study was to compare the effectiveness of both electrical stimulation and isometric exercise with that of isometric exercise alone on the quadriceps muscle in 30 patients who had undergone anterior cruciate ligament (ACL) reconstruction. The 30 patients were divided into two groups. The electrical stimulation (ES) group (N=18) carried out isometric contraction with ES. The non-ES group (N=12) performed isometric contraction only. The patients were examined clinically in terms of thigh circumference and time from surgery to disappearance of extension lag and giving way. The ES group had better muscle function within these clinical parameters. This study indicated that ES is a useful technique for muscle strengthening after ACL reconstruction.

Key words: electrical stimulation — quadriceps — muscle strengthening — co-contraction — anterior cruciate ligament

Atrophy and weakness of the quadriceps muscle develop rapidly after knee ligament trauma.¹⁾ Morrisey²⁾ reported between 40% and 80% reduction in quadriceps strength following six weeks of immobilization after ACL reconstruction, and indicated that it is difficult for such patients to regain quadriceps strength. Quadriceps strengthening is therefore important in rehabilitation following ACL reconstruction. However, early quadriceps strengthening exercises after ACL reconstruction are contraindicated because of the risk of rupture of the reconstructed ligament resulting from anterior tibial displacement.

ES has been used as an alternative method for muscle strengthening. Several investigators have reported increased muscle strength, improved muscular contraction, and reduced muscle atrophy in patients after knee surgery. The extent of the increase in muscle strength depends on the general condition of the subject and the stimulation parameters. It has ranged from 4.5% to 200%³⁻¹⁰⁾ (Table 1).

TABLE 1. The extent of increase in muscle strength by ES

Source	Degree of increase (%)
Massey 1965	10
Johnson 1977	25-200
Currier 1979	21
Eriksson 1979	4.5
Halbach 1980	22
Owens 1983	30-60
McMiken 1983	22
Laughman 1983	22

The purpose of this study was to evaluate the effectiveness of ES on the quadriceps muscle during knee rehabilitation after ACL reconstruction as compared to the results in a non-ES group.

MATERIALS AND METHODS

Thirty patients who had undergone ACL reconstructive surgery were selected, Eighteen were designated as the ES group, and 12 as the non-ES group. The characteristics of the subjects in the ES and non-ES groups are summarized in Table 2. The central one-third of the patellar tendon was used for the reconstruction of the ACL.

TABLE 2. Characteristics of the subjects

	ES group	non-ES group
Number of cases	18	12
Average age (yrs)	24.6±3.1	29.1±2.5
Average period from injury to surgery (months)	23.6±8.4	20.3±6.2

Electrodes were placed over the vastus medialis muscle and medial hamstring muscles just after surgery. The carbon electrodes measured 40 by 45 mm. Water soluble gel was placed between the skin and the electrode. All patients were immobilized with 60 degrees of knee flexion after the surgery (Fig. 1).

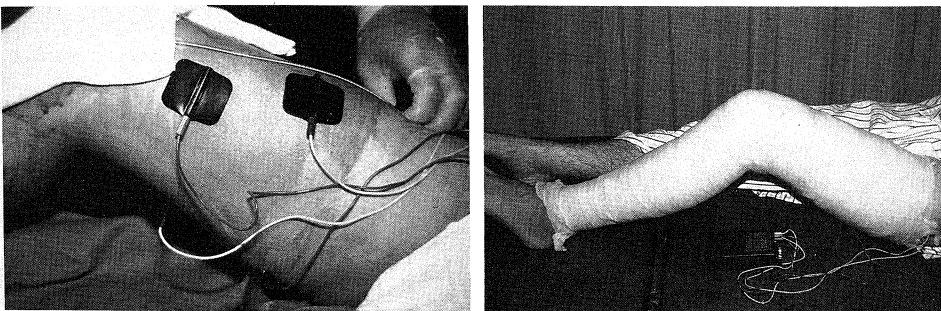


Fig. 1. Showing ES for patient with ACL reconstruction

Respond® (Medtronic Inc., Minneapolis, MN) was used for the stimulation. The protocol was as follows; frequency 30 Hz, duration 0.2 msec, wave form rectangular, "on time" 5 sec, "off time" 5 sec. The intensity of stimulation was controlled by the patients, with tolerable intensity ranging from 60 to 80 mA (Table 3).

TABLE 3. Stimulation protocol

Frequency	: 30 Hz
Duration	: 0.2 msec
Wave form	: Rectangular
"On" time	: 5 sec
"Off" time	: 5 sec
Intensity	: 60-80 mA

ES was begun on the fifth postsurgical day. The patients received ES for 15 minutes a day, six days a week, for about three months after surgery, until the resolution of extension lag. The patients were instructed to maintain isometric co-contraction of the quadriceps and hamstrings during ES. Four weeks after surgery, the cylinder cast was removed, and the range of motion exercise for the hamstrings was begun. Eight weeks after surgery, resistive exercises for the quadriceps and weight bearing for operated leg were begun (Fig. 2).

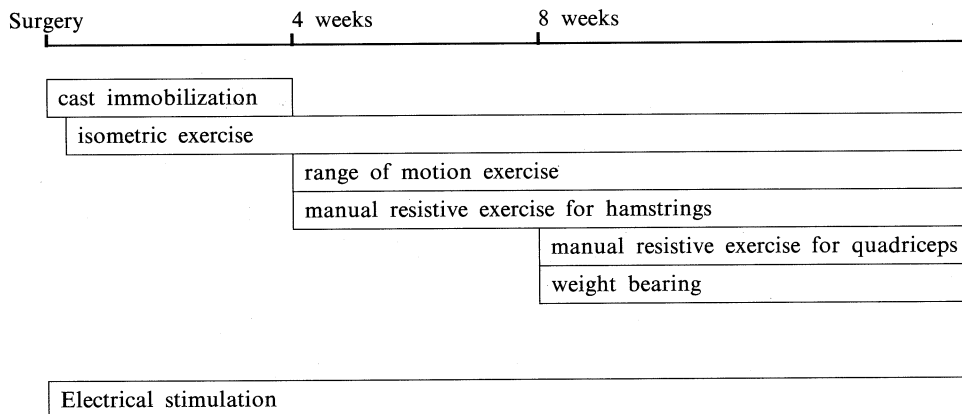


Fig. 2. Rehabilitation program following reconstructive surgery of the ACL

The measurement procedures were as follows;

1. The thigh circumference was measured at 10 cm proximal to the upper edge of the patella just prior to surgery and just after removal of the cast (four weeks).
2. The time period from surgery to disappearance of extension lag was recorded.

TABLE 4. Results

	ES group (N=18)	non-ES group (N=12)	p-Value
Decrease in thigh circumference (cm)	2.3±1.7	3.6±1.6	p<0.05
Time period for disappearance of extension lag (months)	3.0±1.0	5.1±2.0	p<0.05
Time period for disappearance of giving way (months)	3.3±0.7	5.9±2.9	p<0.05

3. The time period from surgery to disappearance of giving way was recorded. Data were analyzed using the student's t-test. A level of 0.05 was considered significant throughout the analysis.

RESULTS

The results are presented in Table 4.

A clear difference was found between the two groups of patients.

1. The decrease in the mean thigh circumference from surgery to removal of the cast was 2.3±1.7 cm for the ES group and 3.6±1.6 cm for the non-ES group.
2. The period until disappearance of extension lag averaged 3.0 months for the ES group and 5.1 months for the non-ES group.
3. The period until disappearance of giving way averaged 3.3 months for the ES group and 5.9 months for the non-ES group.

All differences in the data were statistically significant.

DISCUSSION

Regaining strength in the knee extensor muscles has been reported to be an important factor in rehabilitation following ACL reconstruction. Many reports²⁻¹⁰ have indicated that ES is a beneficial method for retarding muscle atrophy and strengthening the muscles during the postsurgical period of limited mobility. There were no cases of rupture of the reconstructed ligament during this study. We believe that co-contraction of the quadriceps and hamstrings by ES improved strength without risk of rupture of the reconstructed ligament. Since ES is effective for the treatment of pain, it is possible that some of the beneficial effects noted in this study could be due to the pain relief provided by ES. Although there is a risk of burns at the site of skin attachment due to the electrodes with ES, the patients in our study suffered no untoward effects beyond mild muscle fatigue.

Further research using other ES parameters is being planned to shorten the rehabilitation period following ACL reconstructive surgery.

CONCLUSION

Results of this study support the following conclusion: Early co-contraction exercise of the quadriceps and hamstrings by ES is a useful technique for muscle strengthening following ACL reconstruction.

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