

The effect of adding plantar flexors isometric exercise on calf circumference in patient with post open reduction internal fixation non-articular tibia fracture



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ABSTRACT

Background: Post-operative non-articular tibia fracture some problems that often occur include pain, muscles atrophy, muscles weakness, and joint stiffness that makes patients limited in their daily activities. Several factors that play a role in muscles atrophy and weakness prolonged immobilisation and lack of exercise. Plantar flexor isometric exercise might effectively prevent the problem. Not yet known the effect isometric exercise of plantar flexor on calf circumference in patients post open reduction internal fixation of tibia fractures, due to the lack of studies in this field. The aim of investigating the effect of isometric exercise plantar flexor on calf circumference in patients post open reduction internal fixation non-articular tibia fracture.

Methods: Study design using an experimental model with pre-test and post-test control group design divided into two groups, group A obtained treatment of isometric exercises of the plantar flexor muscles, range of motion knee and ankle joint while group B obtained a range of motion knee and ankle joint.

Results: Descriptive analysis in group A there were 13 (81.3%) samples which increased calf circumference and 3 (18.7%) samples did not change while group B there were 4 (25%) samples increased calf circumference, 1 (6%) sample did not change and 11 (69%) samples were reduced calf circumference. The study was found increase mean calf circumference in group A was 0.76 cm and reduction mean calf circumference group B was 0.44 cm. Independent samples differences with α of 0.05 and confidence interval 95% was obtained p-value = 0.003, which has shown there is a significant difference in increased calf circumference group A obtained isometric exercises plantar flexor compared to group B without isometric exercises plantar flexor in patients post open reduction internal fixation of a non-articular tibia fracture.

Conclusion: The study found plantar flexor isometric exercise in patients post open reduction internal fixation non-articular tibia fracture enhances calf circumference that will prevent muscle calf atrophy and weakness.

Keywords: isometric exercise, plantar flexor, calf circumference, tibia fracture.

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INTRODUCTION

The incidence of non-articular tibia fractures increases from year to year. Tibia is the bone most often broken because of the superficial structure and position. The increased number of tibial fractures over time results in increased morbidity and disability rates. Fracture is one of the problems that humans are faced with in a risky life because of the development of the industrialisation of society, the increasing number of vehicles, and increased activity.^{1,2} The incidence of tibial fracture is recorded at 16.9/100,000 person per year.¹¹ The average hospitalisation length of stay due to tibial fracture 7.2 days.³ The most common causes of cases of tibia fractures are due to traffic accidents, falls from stairs, skateboarding, and sports. Tibial bone fractures often occur in men aged 15 to 29 years.¹⁵ Fractures in the tibia are often accompanied by soft tissue damage.⁴

The problem that usually occurs in patients with tibia fractures is the length of the healing process, muscle atrophy, muscle weakness, reduced bone density, delayed union and non-union.^{29,30} One of the most predictable consequences of open reduction internal fixation is loss of calf circumference. The extent of loss calf circumference is related to duration of immobilisation.^{5,6} The most concern is the fact that the deleterious effects of immobilisation do not appear preventable or even fully recoverable.⁷⁻⁹ The process of fracture healing is influenced by several factors such as osteoblast activity, fracture type, nutritional status, care, psychological conditions, time of medical intervention and immediate rehabilitation.^{9,21,22}

Patients after open reduction and fixation of the tibia fracture require immobilisation for several weeks without relieving which can cause

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complications in the form of calf muscle atrophy, calf muscle weakness, osteopenia, limited motion of the knee joint and ankle joint.^{1,16,23} Programs and types of muscle training must be designed accurately and so that complications do not occur and the healing time can be achieved quickly. We investigated the long-time effects of plantar flexor isometric exercise on calf circumference in person with post open reduction internal fixation non-articular tibia fracture. One of the major problems in assessing muscle plantar flexor strength after tibia fracture and exercise is overcoming the patient fear of re-fracture.

MATERIALS AND METHODS

Study design and population

Study design using true experimental with pre-test and post-test control group design. Group A with treatment of plantar flexor isometric exercises and standard exercises range in motion of the knee and ankle joints while group B is only with standard exercises the range of motion of the knee and ankle joints.

The study was carried out in the Department of Physical Medicine and Rehabilitation at Zainoel Abidin General Hospital Banda Aceh Indonesia. The study included 34 patients over a period of 30 days. Subject was recruited from Orthopaedic inpatient ward with post-open reduction internal fixation non-articular tibial fracture after obtaining written informed consent and approval of institutional ethical committee of Medical Faculty Syiah Kuala University. Patients included in the study were those of age group 20-45 years, normal body mass index with isolated post open reduction internal fixation non-articular tibial fracture. The exclusion criteria were patient with loss of consciousness, diabetic, anaemia, and multiple fractures.

Procedure detail

Range of motion exercise group A and B

Range of motion exercise was started on second-day post-surgery. Patient is lying supine with the lower limbs straight and the ankle joint in a neutral position or 0°. The therapist helps the dorso ankle flexion movement to the pain limit or the patient's ability then return to its original position, this movement is repeated up to 10 times. Furthermore, the therapist helps move ankle flexion to the extent of the pain or the patient's ability then return to original position, this movement is repeated up to 10 times. Knee at position 0°, therapist helps to flex the knee joint to the limit of pain or patients ability then returns the extension to original position, this movement is repeated up to 10 times. Every day a training session is conducted, where each exercise session moves the knee and ankle joints 10 times.

Plantar flexor isometric exercise group A

Isometric exercise plantar flexor was started on second-day post-surgery. Patient is lying on his back with the position of the lower leg straight and the ankle joint in a neutral position or 0°, used ankle-foot orthosis modified (Figure 1). Patient performs an isometric contraction of the plantar flexor muscle. Assessment of plantar muscle contraction is done by palpating the calf muscle belly. Long contraction in a matter of 10 seconds and rest 10 second used a stopwatch Casio HS3. Every day three sessions were carried out, one training session carried out 10 repetitions with a break every 10 seconds. Every session with resting period two minute. Educational exercises are carried out first on healthy feet.

Calf circumference measurement

Calf circumference was measured to the nearest 1 mm with flexible plastic tape. Patient lying supine and hold the knee angle position 90°, ankle angle 90° and the soles of feet touch the flat surface of the mattress. Determine the measurement point 10 cm below the tibial tuberosity. The tape was put around the calf and displaced along the calf to measure the greatest circumference without compressing the subcutaneous tissue. The first calf circumference measurement in both groups was carried out on the third day after surgery and tape were put around the calf and displaced along the calf to measure the greatest circumference without compressing the subcutaneous tissue. Second measurement calf circumference in both groups on 31 days after surgery.

Statistical analysis

Univariable descriptive model to describe proportion of data in the form of mean and standard deviation. Homogeneity of variance analysis against age and body mass index. Paired sample t-test for



Figure 1 Ankle foot orthosis modified

condition before and after intervention in both groups. All value considered significant if $p < 0.05$.

RESULT

The study population consisted group I of 13 (81%) males and 3 (19%) females with majority in the age

group of 36-40 years 6(37%) followed by 25-29 years 4(25%), 41-45 years 3(19%), 30-35 years 3(19%) age groups. Group II(Control) of 12 (75%) males and 4 (25%) females with majority in the age group of 36-40 years 6(38%) followed by 30-35 years 5(25%), 25-29 years 4(25%), 41-45 years 1(6%) age groups (Table 1).

Homogeneity test results age and body mass index with a 0,05 and 95 % confidence intervals were obtained as follow. Homogeneous test conducted on the both groups shows age in both groups obtained a value of $p = 0.418$ which show that the age in both groups is homogeneous. Body mass index in both groups obtained $p = 0.652$ which show that body mass index in both groups is homogeneous. Haemoglobin in the both groups obtained $p = 0.158$ which show that body mass index in both groups is homogeneous (Table 2). The results of this study showed that the first and second calf circumference in group A generally increased, whereas in group B there was a decrease in calf circumference (Table 3).

Descriptive analysis in group A there were 13 samples (81.3%) which increased calf circumference and 3 samples (18.7%) did not change calf circumference, and 0 sample (0%) reduce calf circumference while group B there were 4 samples (25%) increased calf circumference, 1(6%) sample

Table 1 Characteristics sample

Characteristics	Group A	Group B
Age group (years) (n, %)		
25-29	4 (25%)	4 (25%)
30-35	3 (19%)	5 (32%)
36-40	6 (37%)	6 (37%)
41-45	3 (19%)	1 (6%)
Gender (n, %)		
Male	13 (81%)	12 (75%)
Female	3 (100%)	4 (25%)

Table 2 Homogeneity test of age and BMI between group A and B

Variable	Mean differences	Std. error	p
Age	1.688	2.06	0.418
Body mass index	0.175	0.38	0.652
Haemoglobin	0.225	0.16	0.158

Table 3 Calf circumference

GROUP A				GROUP B			
Sample number	Calf Circumference First	Calf Circumference Second	Change	Sample number	Calf Circumference First	Calf Circumference Second	Change
1	41	42.2	1.2	2	45	44.6	- 0.4
3	45.5	46	0.5	4	44.5	44	- 0.5
5	48.7	49.5	0.8	6	45.8	45	- 0.8
7	43	43.3	0.3	8	42	41	- 1.0
9	45	44.5	-0.5	10	43.3	44	0.7
11	48.5	48.5	0	12	45.8	46	0.2
13	50	50.8	0.8	14	42	41.5	- 0.5
15	42	42.4	0.4	16	43.3	45.8	2.5
17	42.5	42.5	0	18	45.8	41.6	- 4.2
19	43	44.5	1.5	20	43	44.2	1.2
21	44.2	45.7	1.5	22	44.5	44	- 0.5
23	39.8	40.2	0.4	24	43	43	0
25	42	42.6	0.6	26	46.3	45.5	- 0.8
27	43	43.8	0.8	28	42.6	42	- 0.6
29	44.5	46.5	2	30	45	44	- 1.0
31	46	46.8	0.8	32	out	out	out
33	out	out	out	34	46.2	44.8	- 1.4

Table 4 Analysis calf circumference group A and B

Group	n	Increase		Permanent		Reduce	
		Frequency	%	Frequency	%	Frequency	%
A	16	13	81.3	3	18.7	0	0
B	16	4	25	1	6	11	69

Table 5 Paired t-test change calf circumference group A and B

	Group A			Group B			p
	N	Mean	Standard deviation	N	Mean	Standard Deviation	
Calf Circumference	16	0.76	0.55	16	-0.44	1.40	0.003

did not change calf circumference and 11 samples (69%) were reduced calf circumference (Table 4).

In group A increase in calf circumference average 0.76 cm, whereas in group B average decrease calf circumference of 0.44 cm was found. The calculation results paired t-test that was carried out on 2 groups was obtained change calf circumference in group A and group B with α 0.05 and CI 95% p value= 0.003 which showed a significant difference in the increase in mean calf circumference in the group that do plantar flexor isometric exercises compare with those who do not do plantar flexor isometric exercise in patients post open reduction internal fixation of non-articular tibia fractures (Table 5).

DISCUSSION

The number of samples of patients with non-articular tibia fractures in this study we found 25 male (78%) and 7 female (22%). The highest age was 36-40 years old as many as 12 people (38%). Other researchers also reported more tibial fractures in male than female.^{13,19} Chauhan et al. reported that the results of epidemiological studies of tibia fracture were found in male as much as 78% (n = 156) and female 22% (n = 43) with the highest age in the range of 21-30 years. The study conducted by Amin et al. in Pakistan out of 2120 cases of tibia fractures, 1980 male (93.4%) and 140 female (6.6%) with an average age of 33.28 ± 21.02 years. Clelland et al. 2016 reported that the results of research on male incidents were almost four times higher than women. The incidence of male is more dominant because more work activities outside the home so that the risk of having an accident is greater. The incidence of non-articular tibia fractures is generally in the productive age or working-age.^{10,11,12}

This study shows that significant loss of calf circumference muscle occurs in patients with

non-articular tibial shaft fracture treated by open reduction internal fixation used plate screw and range of motion exercise. Reduce size of the calf circumference reflects the shrinkage of calf muscles mass also called atrophy.^{14,16,18} Khalid et al. reported significant loss of calf muscle bulk in patient with tibial shaft fracture treated by cast immobilization. One of the most predictable consequences of cast immobilization is loss of muscle bulk, but operative treatment also cannot guarantee a complete increase in calf circumference.¹⁶ Muscle atrophy can be associated with slow-to-fast or fast-to-slow fibre shift.^{17,28,30} Calf muscles are skeletal muscle fibre subtypes are otherwise sensitive to specific pathological atrophic signals. Oxidative type I muscle fibres have a higher turnover of protein synthesis and degradation and are more resistant to fasting than type II glycolytic fibres.^{10,24,25} Contrarily, type I muscle fibres are much sensitive to inactivity, microgravity, and denervation-induced atrophy. Mac Douglall et al. also reported up to a 41% decrease in isometric strength after immobilization of the upper extremity for 5 to 6 weeks with significant decreases in muscle fibre area by 33% and 25% for fast and slow-twitch fibres respectively. In this study another factor that has been shown to play an important role in maintaining muscle mass was isometric exercise plantar flexor.²⁰ Decrease calf circumference is generally reflected as a decrease in muscle plantar force.¹² In functional activities, it will make walking unbalanced, heel off and toe-off phase interruption occurs in the gait cycle.^{26,27}

At isometric exercise, plantar flexor available muscle mass is the result of a balance between muscle anabolic and catabolic processes. Muscle anabolism is driven by Insulin-like growth hormone, IGF-1, testosterone, and mediated by the appropriate physical activity stimulus.^{26,27} Muscle catabolism is mediated by endocrine, inflammatory and oxidative stress factors. Whether reductions on anabolic or increases in catabolic processes dominate in net muscle loss may be dependent on duration of the disuse. As discussed early disuse (<10 days) is characterised by a rise in muscle protein breakdown and a decline in synthesis, while in prolonged disuse (>10 days) with protein breakdown rates unchanged, atrophy might be primarily attributed to a decline of protein myosin and actin synthesis rates.

CONCLUSION

Isometric exercise plantar flexor 30 times every day for 30 days increased calf circumference in patients post open reduction internal fixation of non-articular tibia fractures. This exercise

will prevent calf muscles atrophy and weakness in patient post open reduction internal fixation non-articular tibia fractures.

CONFLICTING OF INTEREST

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