RESEARCH PAPER

The effect of tourniquet on early postoperative quadriceps muscle wasting in ACL arthroscopic surgery

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Abstract

Background: The main goals of anterior cruciate ligament (ACL) reconstruction and rehabilitation are to reestablish knee function. Quadriceps weakness is one of the most important complications associated with ACL injury and represents a major rehabilitation challenge. This study is designed to test the early effect of tourniquet on muscle wasting and to differentiate weather it is because muscle disuse or injury.

Methods: Twenty six male patients who submit to arthroscopic ACL reconstruction were randomly assigned to the use of an inflated (group T, n _ 13) or deflated (group NT, n _ 13) tourniquet. Patients with preoperative quadriceps wasting or abnormal electro conductive studies were excluded. The primary measures were thigh girth preoperatively and after two weeks, serum creatinine phosphokinase (CPK) preoperatively and one day postoperatively and electro conductive studies preoperatively and 1 month postoperatively.

Results: Patients' mean age was comparable in both groups. There was a significant difference between T and NT groups in term of thigh girth, CPK and electro conductive studies. Mean thigh girth in T group was 2.6 ± 0.5 while in NT group 1.4 ± 0.5. Mean CPK in T group was 813 ± 149 while in NT group 520 ± 203.

Mean femoral latency was 1.85 ± 0.4 in T group and 1 ± 0 in NT group; mean femoral conduction velocity was 1.77 ± 0.4 in T group and 1 ± 0 in NT group; mean muscle denervation was 1.92 ± 0.3 in T group and 1.54 ± 0.5 in NT group; mean motor unit number estimation was 1.9 ± 0.3 in T group and 1.5 ± 0.5 in NT group.

Conclusion: This comparative study show that tourniquet play a significant role in direct muscle injury proved by measurement of postoperative CPK and thigh girth in T group comparing it with NT group.

Keywords: arthroscopic surgery, Tourniquet, Outpatients

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Introduction

The primary aim of anterior cruciate ligament reconstruction (ACL) and rehabilitation are to reestablish knee function to its level before injury and maintain supple joint for long duration. One of the insistent neuromuscular deficiencies linked

with ACL injury is the quadriceps muscle wasting which represent a big rehabilitation challenge for both patients and surgeons. Thus, even when surgery and rehabilitation are completed successfully and patients came back to sport; full muscle strength often has not been accomplished. The review of the current studies proposes that quadriceps wasting can be more than 20% at six months after ACL reconstruction, a time when many athletes are return to activity[1].In the most common orthopaedic procedures for the extremities, a tourniquet is used to increase clearance of the surgical field and thus improve the accuracy of the procedure and decrease surgery time. The present study is designed to test the early effect of tourniquet on muscle wasting and to differentiate weather it is due to muscle disuse and defect in rehabilitation protocol and patient compliance or it is due to muscle injury direct or indirect.

Evaluation of muscle strength can be done by:

1. *Clinical method:*

a. Thigh girth: Circumference measurements are usually used in clinical practice to evaluate the relationship of thigh circumference to muscle strength and power.[2] these measurement depend on assessment of thigh girth bilaterally and depend on the uninjured side for comparison fixed point selected from the joint line and extend 7 or 10cm proximally where thigh circumference recorded by tape measure.

b. Dynamometer: One of the method to assess the muscle strength is the dynamometers by which we depend on fixed reading of special movement of the parts need to be examined. [3].

2. *Laboratory method:*

a. Creatinine phosphokinase*:* indicator of damage of CK-rich tissues such as in myocardial infarction, rhabdomyolysis, muscular dystrophy, autoimmune myositis, and acute kidney injury. [4]

b. Lactate dehydrogenase: Because it is released with tissue damage, it is considered as a marker of tissue destruction and common diseases like heart failure.[5]

3. *Imaging method: MRI cross sectional area:* This method depend on measuring the cross section of thigh requiring expert personnel by using MRI with determination of number of slices and the thickness of slice. [6]

Electromyography (EMG): EMG is an electro diagnostic procedure depends on measuring the electrical activity created by skeletal muscles. [3] It is achieved by using an apparatus known as an electromyography to yield a record called an electromyogram. An electromyography measure the electric potential made by muscle cells.[7] When these cells are neurologically or electrically stimulated. The signals can be analyzed to record medical problems, activation level, or recruitment order. EMG testing has a range of clinical and biomedical uses. There is another electro diagnostic test that records the conducting function of nerves usually done in association with EMG. This is known as a nerve conduction studies (NCS). Needle EMG and NCSs are needed when there is pain in the extremeties, muscle weakness from compression

of spinal nerve, or suspicion of some other neurologic injury or diseases.[8] Needle EMG may be of value in the diagnosis of nerve root injury (like sciatica), nerve compression or injury (like carpal tunnel syndrome), and with other disorders of the muscles or nerves

Methods

This is a case control study conducted during the period from February 2016 until September 2017. Twenty six male, active, young patients, their mean age was 26.4 ± 4.6, proved to have ACL injury confirmed clinically and by MRI. Were enrolled for arthroscopic ACL reconstruction selected randomly and classified into two groups, Group **NT** (13 patients) were operated without tourniquet use and Group **T** (13 patients) were operated with tourniquet use. Written informed consent was obtained from each patient. All patients were subjected to a questionnaire, full history, systemic and regional examination, laboratory and imaging study (radiograph and MRI).

Inclusion criteria: young, active patient with ACL rupture less than two years duration proved clinically and by MRI with obvious knee instability during daily activities. Patient should have full range of motion of the knee joint (Flexion and extension); nearly Equal thigh circumference, Isolate ACL injury with or without meniscal tear. Medically fit for surgery and anesthesia.

Exclusion criteria: patient with trauma for more than 2 years, presence of degenerative changes, muscle disorder or associated ligament injury. Patient with clinical evidence of lumber radiculopathy, Patient with history of injury to the affected and contralateral limb, Patient with abnormal EMG finding preoperatively.

The same surgeon and team group performed a single bundle six strand arthroscopic ACL reconstruction in all twenty six patients using autologous hamstring graft fixed by "cortical suspension" method (triple point fixation method).

Results

Between February 2016 and September 2017, 30 patients who met the inclusion criteria consented to participate in the study. Group NT (nontourniqueted) comprised 13 male patients whose average age 26 years ± 5.5. All ligaments injuries occurred during athletic activities. All patient underwent ACL reconstruction using the arthroscopic technique, 8 patients in this group have associated meniscal tear treated either by repair, shaving or partial meniscectomies. Group T (tourniqueted) comprised 13 patients whose average age was 27 years ± 3.8, all had ACL reconstruction with endoscopic technique, 9 of them had associated meniscal injuries treated by shaving or partial meniscectomies.

The CPK level mean was 813 u/l in 1st postoperative day in group T. in group NT the postoperative CPK mean was 520 u/l. These result suggest a difference between the groups that achieve statistical significance (p= 0.000). (Figure 1)

In group T thigh girth mean measured at 10 cm proximal to the joint 14 days after the surgery was 2.6. In contrast to the group NT, where thigh girth mean was 1.4. This record suggest a difference between both groups that achieve statistical significance (p =0 .000) as shown in (figure 2).

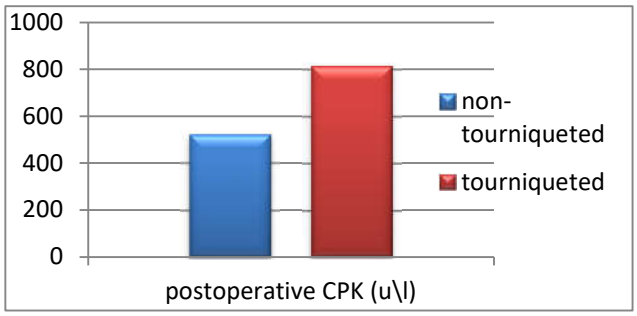

Figure 1

At one month postoperatively EMG finding recorded in form of 4 parameters (femoral latency, femoral CV, denervation and motor units number estimation (MUNE)). As we choose the quadriceps muscle in our study these parameters asses the presence of effect on femoral nerve and the muscle or both and even can measure the amount of damage. The nerve and muscle EMG finding suggest a difference between the two groups that achieve statistical significance as shown in (Figure 3):

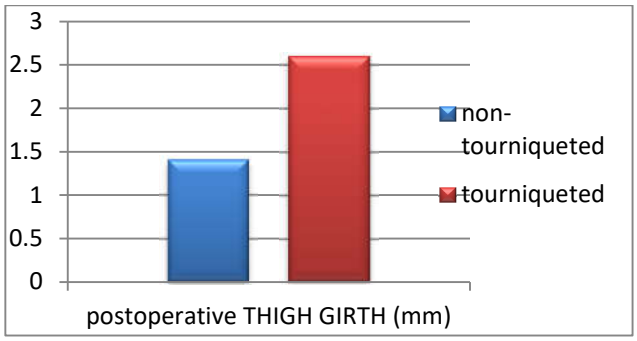

Figure 2

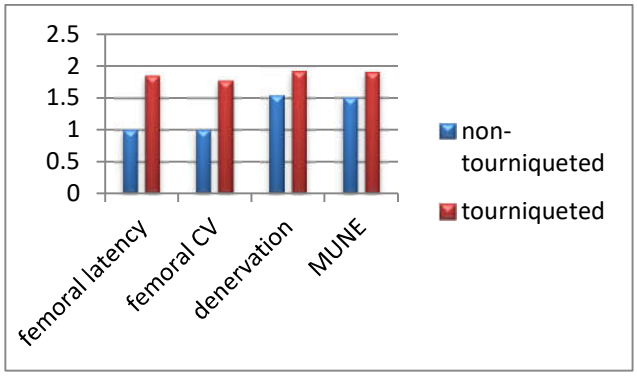

Figure 3

Discussion

Pneumatic tourniquet use is considered a usual aid in upper and lower limb surgical procedures[9, 10]. several factors were approved to be of great value in the outcome of ACL arthroscopic reconstruction like duration of surgery, associated injuries and their managements, graft source (hamstring tendon versus patellar tendon), approach type (open or two incision, arthroscopically assisted or one-incision endoscopic) as well as the postoperative rehabilitation protocol have all been studied as to their effects on recovery and final outcome [11,12,13,14,15]. After successful ACL reconstruction surgery the important goal is to rehabilitate the patient to the pre-injury status starting from the 1st day and extended up to 6 months. In the last 10 years a lot were written about the role of tourniquet and its effects on quadriceps muscle wasting and the slow response of post-operative rehabilitation but most of these studies investigate the delayed effect after 6 months and 1 year post-operatively were the effect of tourniquet minimized or absent [16, 17, 9, 15, 1]. In the present study we are focusing on the early effects of tourniquet specifically during the 1st month.

In 1979 Saunders et al. (57) examined the EMG abnormalities three to four weeks following knee arthrotomy. The result of this prospective randomized study have shown that tourniquet compression on proximal neuromuscular structures play an important role in quadriceps muscle wasting and poor response to rehabilitation programs after surgery. The results of creatinine phosphokinase (CPK) in the 1st postoperative day were elevated more in T group (NT mean = 520 ± 203u\l, T mean = 813 ± 149u\l) with p value < 0.001 suggesting more muscle

damage in T group. Thigh girth results 2 weeks after surgery show more muscle wasting in T group (NT mean = 1.4± 0.5, T = 2.6± 0.5). In 1996 Arciero et al. [18] reported a prospective randomized study where 40 consecutive patients were distributed rondomly into two groups: Group I (tourniquet) and Group II (no tourniquet). Preoperative assessment involves EMG, thigh girth measurement and serum CPK. Initial evaluations after surgery included serial CPK determinations. One day postoperatively, they found CPK level increased in tourniqueted group, thigh girth also was decreased in tourniqueted group although in both not achieving statistical significance.

In 2001 Nicholas et al[11], found that ACL arthroscopic surgery using patellar tendon bone graft result in a significant decrease in thigh girth in tourniqueted group ($P < 0.01$).

The EMG and NCS findings were more complex and here we depended on 4 parameters: femoral latency, femoral conduction velocity, muscle denervation and motor units number estimation (MUNE) to evaluate the presence and type of injury. In T group, two or more parameters were abnormal in all patients indicating abnormal electro conduction study while NT group findings were variably abnormal with regard to denervation and MUNE in some of our patients.

Rorabeck and Kennedy [70] stated that tourniquet-induced EMG and nerve-conduction velocity changes in the common peroneal and tibial nerves directly next to knee ligament surgery. This experimental investigation has verified that an inflated pneumatic tourniquet leads to decreasing in conduction velocity of the sciatic nerve. The extent of slowing and recovery time varies depending on inflation pressure and the time of applied pressure. The conduction velocity every time returned to normal as long as the tourniquet was inflated for 2 hours or less, and pressures were less than 500 mm Hg.

Conclusion

This comparative study shows that tourniquet plays a significant role in direct muscle injury proved by measurement of postoperative CPK, thigh girth and electro conductive studies. And conclude that arthroscopic ACL reconstruction without the use of tourniquet can minimize the postoperative quadriceps muscle wasting which may permit more rapid rehabilitation and early return to sport activities.

Conflict of interest: The authors declare no conflict of interest.
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References

1. Palmieri-Smith RM, Thomas AC, Wojtys EM. Maximizing quadriceps strength after ACL reconstruction. Clinics in sports medicine. 2008;27(3):405-24.
2. Parmet J, Horrow J, Rosenberg H, Berman A, Harding S. Thromboembolism coincident with tourniquet deflation during total knee arthroplasty. The Lancet. 1993;341(8852):1057-8.
3. Daniel DM, Malcom LL, Losse G, Stone ML, Sachs R, Burks R. Instrumented measurement of anterior laxity of the knee. JBJS. 1985;67(5):720-6.
4. Jarrett PM, Ritchie IK, Albadran L, Glen SK, Bridges AB, Ely M. Do thigh tourniquets contribute to the formation of intra-operative venous emboli? ACTA ORTHOPAEDICA BELGICA. 2004;70(3):253-9.

5. Rama KRBS, Apsingi S, Poovali S, Jetti A. Timing of tourniquet release in knee arthroplasty: meta-analysis of randomized, controlled trials. JBJS. 2007;89(4):699-705.

6. Soderberg GL, Ballantyne BT, Kestel LL. Reliability of lower extremity girth measurements after anterior cruciate ligament reconstruction. Physiotherapy Research International. 1996;1(1):7-16.

7. Armstrong AW, Golan DE. Pharmacology of hemostasis and thrombosis. Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy 3rd ed Philadelphia: Lippincott Williams & Wilkins. 2011:372-400.

8. Arangio GA, Chen C, Kalady M, Reed III JF. Thigh muscle size and strength after anterior cruciate ligament reconstruction and rehabilitation. Journal of Orthopaedic & Sports Physical Therapy. 1997;26(5):238-43.

9. Nitz AJ, Dobner JJ, Matulionis DH. Pneumatic tourniquet application and nerve integrity: motor function and electrophysiology. Experimental neurology. 1986;94(2):264-79.

10. Trojaborg W. Prolonged conduction block with axonal degeneration. An electrophysiological study. Journal of Neurology, Neurosurgery & Psychiatry. 1977;40(1):50-7.

11. Nicholas SJ, Tyler TF, McHugh MP, Gleim GW. The effect on leg strength of tourniquet use during anterior cruciate ligament reconstruction: a prospective randomized study. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 2001;17(6):603-7.

12. Jacob AK, Mantilla CB, Sviggum HP, Schroeder DR, Pagnano MW, Hebl JR. Perioperative Nerve Injury after Total Knee ArthroplastyRegional Anesthesia Risk during a 20-Year Cohort Study. The Journal of the American Society of Anesthesiologists. 2011; 114(2):311-7.

13. Noordin S, McEwen JA, Kragh Jr CJF, Eisen A, Masri BA. Surgical tourniquets in orthopaedics. JBJS. 2009;91(12):2958-67.

14. Thorblad J, Ekstrand J, Hamberg P, Gillquist J. Muscle rehabilitation after arthroscopic meniscectomy with or without tourniquet control: a preliminary randomized study. The American journal of sports medicine. 1985;13(2):133-5

15. Gutin B, Warren R, Wickiewicz T, O'Brien S, Altchek D, Kroll M. Does tourniquet use during anterior cruciate ligament surgery interfere with postsurgical recovery of function? A review of the literature. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 1991;7(1):52-6.

16. Standring S, Ellis H, Healy J, Johnson D, Williams A, Collins P, et al. Gray's anatomy: the anatomical basis of clinical practice. American Journal of Neuroradiology. 2005;26(10):2703.

17. Patterson S, Klenerman L. The effect of pneumatic tourniquets on the ultrastructure of skeletal muscle. Bone & Joint Journal. 1979;61(2):178-83.

18. Arciero RA, Scoville CR, Hayda RA, Snyder RJ. The effect of tourniquet use in anterior cruciate ligament reconstruction: A prospective, randomized study. The American journal of sports medicine. 1996;24(6):758-64.

19. Rorabeck C, Kennedy J. Tourniquet-induced nerve ischemia complicating knee ligament surgery. The American journal of sports medicine. 1980;8(2):98-102