Tourniquet Use Does Not Affect Rehabilitation, Return to Activities, and Muscle Damage After Arthroscopic Meniscectomy: A Prospective Randomized Clinical Study

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Purpose: The purpose of this prospective randomized trial was to examine the effect of tourniquet use on rehabilitation rate, return to work and sport activities, and muscle damage after arthroscopic meniscectomy. **Methods:** Eighty patients who underwent arthroscopic partial meniscectomy were randomly allocated to the use of an inflated (group A, n = 40) or deflated (group B, n = 40) pneumatic tourniquet. Patients with concomitant ligamentous deficiency or grade III and IV chondral lesions were excluded. The primary outcome measures were pain, measured with a visual analog scale (VAS), and knee range of motion (ROM) on days 8 and 15 postoperatively; time required for patients to discontinue the use of crutches; time to return to light activities and moderate sporting activities such as jogging; and serum creatine phosphokinase (CPK) levels monitored preoperatively and on days 1, 8, and 15 postoperatively. **Results:** The 2 groups did not differ in terms of age; male-female ratio; body mass index; and preoperative International Knee Documentation Committee, Tegner, and Lysholm scores. Operative time was not significantly different between groups (mean, 27.5 for group A and 31.2 for group B; $P = .83$). VAS pain scores and knee ROM were not significant between groups (minimum $P = .22$). The patients progressed to weight-bearing without crutches within 13.4 and 12.9 days for groups A and B, respectively ($P = .9$). Return to work and jogging did not differ significantly between groups (minimum $P = .34$). Serum CPK values were also not significantly different between or within groups during consecutive measurements ($P = .3$). Tourniquet time did not significantly affect postoperative ROM, VAS pain scores, or serum CPK levels (minimum $P = .14$). **Conclusions:** Tourniquet use for less than 30 minutes during arthroscopic meniscectomy does not affect postoperative pain or return to light work and jogging. In addition, tourniquet-induced muscle damage after arthroscopic meniscectomy, though potentially present locally, is not detectable in the systemic circulation. **Level of Evidence:** Level I, prospective randomized trial.

Arthroscopic meniscectomy is a minimally invasive, low-morbidity surgery that has been popularized because of improved instrumentation and techniques, as well as widespread arthroscopic training. Pneumatic tourniquets are routinely used in arthroscopic knee surgery to improve surgical field visibility and consequently reduce operative time and achieve a more accurate diagnosis and optimal treatment. In a recent survey among members of the Arthroscopy Association of North America, approximately 50% of the respondents favored the routine use of tourniquets during simple arthroscopic procedures.[1]

Over the past decades, tourniquet technology has improved considerably to ensure safety, efficacy, and reliability in the use of tourniquets.[2] However, numerous complications have been associated with

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The authors report that they have no conflicts of interest in the authorship and publication of this article.

Received February 6, 2012; accepted June 20, 2012.

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0749-8063/1282/$36.00

http://dx.doi.org/10.1016/j.arthro.2012.06.017

tourniquet use, including nerve palsy, venous thromboembolism, arterial embolization, skin ulceration, swelling, and joint stiffness.[3,4] In addition, electrophysiologic and histologic studies have associated tourniquets with decreased quadriceps muscle endurance and functional weakness, histologic changes, increased serum creatine phosphokinase (CPK) levels, and electromyographic changes that may persist for up to 6 months.[5-7]

Although, to date, several studies have focused on the benefits of tourniquets in intraoperative visibility during extremity surgery,[8,9] their effect on rehabilitation after knee arthroscopy remains only partially elucidated. A recent meta-analysis of 9 studies identified numerous methodologic limitations in the existing literature that impaired an exact appraisal of the relative advantages and drawbacks of tourniquet-assisted arthroscopic knee surgery.[10] In particular, the current evidence base has seldom assessed the impact of tourniquet use on return to work and sporting activities.[9] Moreover, limited studies have focused on the use of tourniquets in simple arthroscopic procedures such as partial meniscectomy, which involve a shorter surgical time and reduced risk of intraoperative bleeding compared with more complex procedures, such as anterior cruciate ligament reconstruction or synovectomy.

The purpose of this prospective randomized trial was, therefore, to examine the effect of tourniquet use on rehabilitation rate, return to activities, and muscle damage after arthroscopic meniscectomy. On the basis of the alleged association of tourniquet use with muscle ischemia and weakness, our primary hypothesis was that the use of a pneumatic tourniquet would result in delayed rehabilitation and return to activities, as well as increased serum CPK values.

METHODS

Patient Selection and Randomization

For a prospective randomized comparison, consecutive patients who were assigned to undergo arthroscopic meniscectomy during a recruitment period of 14 months (January 2010 through March 2011) were randomly allocated to the use of an inflated (group A) or deflated (group B) pneumatic tourniquet. Randomization was performed with a computer random sequence generator by an independent researcher. Exclusion criteria were age older than 40 years and younger than 16 years, chronic meniscal tears and tears amenable to repair, concomitant ligamentous deficiency, chondral defects requiring a cartilage restoration procedure, and other lower limb vascular or neuro-musculoskeletal pathology. Patients unwilling to complete functional score questionnaires and those with Workers' Compensation insurance claims were also excluded. All the participants signed an informed consent form approved by the institutional review board to participate in the study. Baseline patient characteristics are depicted in Table 1.

Table 1. *Baseline Patient Characteristics*

	Tourniquet (n = 40)	No Tourniquet (n = 40)
Age (mean ± SD) (yr)	34.8 ± 8.3	31.7 ± 8.9
Gender (men/women)	26/5	24/7
Body mass index (mean ± SD) (kg/m^2)	24.3 ± 2.1	25.6 ± 2.0
Right/left knee	18/13	20/11
Dominant/nondominant limb	17/14	18/13
International Knee Documentation Committee score (mean ± SD)	44.6 ± 12.2	48.8 ± 16.1
Lysholm score (mean ± SD)	60.2 ± 14.5	68.7 ± 15.3
Tegner activity score (mean ± SD)	5.36 ± 1.4	4.7 ± 1.68

Preoperative International Knee Documentation Committee, Lysholm, and Tegner scores were obtained. The primary outcome measures were pain, measured with a visual analog scale (VAS), with a pain score ranging from 0 to 10, and knee range of motion (ROM) on days 8 and 15 postoperatively; time required for the patients to discontinue the use of crutches; time to return to light activities (housework, yard work) and moderate sporting activities such as jogging; and serum CPK levels monitored preoperatively and on days 1, 8, and 15 postoperatively.

Surgical Technique

All the procedures were performed with patients under combined femoral and sciatic nerve block. Intravenous or local anesthetics were not administered. The patients were positioned supine on the operative table. A cylindrical tourniquet cuff of standard width (18 cm) was placed at the mid thigh of all patients. When used, the tourniquet was inflated at 320 mm Hg after exsanguination of the limb by elevating it for 3 minutes. A pressure pump was used, and the knee was inflated with 0.9% saline solution at 70 mm Hg of pressure that was maintained during the entire procedure. All the patients underwent standard 2-portal

knee arthroscopy by the senior surgeon, who was blinded to surgical time. Partial meniscectomy was performed without the use of intra-articular cautery. First- and second-degree chondral lesions were debrided. Drains were not routinely used.

Postoperative instructions were standardized and provided to each patient in writing. The patients were advised to progress to full weight bearing without crutches whenever they considered themselves ready. Pain inhibitors and physical therapy were not routinely prescribed. The patients were followed on an outpatient basis on days 8, 15, 30, and 60 postoperatively, and the treating surgeon, blinded to their tourniquet status, recorded the postoperative outcome measures. At the 15-day follow-up evaluation, the patients were advised to return to work and athletic activity whenever they considered themselves ready.

Statistical Analysis

An a priori power analysis was performed. For a repeated-measures analysis, including between-subjects and within-subject interactions, between 2 independent groups with a minimum effect size of 0.20 and at least 2 consecutive measurements, a total sample size of 80 was calculated to have greater than 80% power to address the test hypothesis. An independent *t* test was used to examine group differences in baseline patient characteristics, preoperative functional scores, and time to return to activities. Repeated-measures analysis of variance was used to identify between-groups and within-group differences in consecutive measurements of VAS scores, ROM, and serum CPK values. Pair-wise comparisons were computed to further explore the interaction. A post hoc power analysis was also performed, and observed power for all primary outcome comparisons was computed. The significance level was set at $P < .05$.

RESULTS

The disposition of the study participants is shown in Fig 1. A total of 102 patients were enrolled in the study. Overall, 18 patients were excluded and another 4 were lost to follow-up. Consequently, the 2 study groups consisted of 40 patients each. The 2 groups did not differ significantly in terms of age; male-female ratio; body mass index; side affected; limb dominance; and preoperative International Knee Documentation Committee, Tegner, and Lysholm scores (minimum $P = .15$).

Intraoperative findings regarding meniscal and cartilage pathology are depicted in Table 2. No complications were met either intraoperatively or postoperatively. No group B cases required the tourniquet to be inflated during arthroscopy. Partial medial meniscectomy was the most common procedure performed. Bucket-handle and posterior horn tears were the most common. First- and second-degree chondral lesions were found in 19 group A and 18 group B patients. The medial femoral condyle and trochlea were the most commonly affected. The operative time did not differ significantly between groups (27.5 ± 12.5 minutes for group A and 31.2 ± 12.1 minutes for group B, $P = .83$).

Mean values and standard deviations of all primary outcome measures are depicted in Table 3. VAS scores were not significantly different between the 2 groups on days 8 and 15 postoperatively ($P = .22$ and $P = .43$, respectively; observed power $\alpha = .81$). As expected, a decrease in VAS scores was noted in both groups from the first to the second postoperative week, although it was not significant ($P = .073$). On the 15th postoperative day, 27 group A and 24 group B patients reported having no knee-related pain. Knee ROM was also not significantly different between the 2 groups on days 8 and 15 ($P = .91$ and $P = .96$, respectively; $\alpha = .85$). A substantial increase in knee ROM was evident on day 15 in both groups.

The patients in groups A and B progressed to full weight bearing without crutches after 13.4 days and 12.9 days, respectively ($P = .9$, $\alpha = .36$). Similarly, time to return to light work and sports did not differ significantly between groups ($P = .34$ [$\alpha = .46$] and $P = .23$ [$\alpha = .64$], respectively). Light jogging was the first athletic activity most patients undertook. Eight group A and 9 group B patients chose not to assume any athletic activity for the first postoperative months without reporting any problem or symptom that would restrict them from doing so and were consequently excluded from reporting only this outcome. Preoperative baseline characteristics and the remaining outcome measures did not differ significantly between these patients and the residual study population (minimum $P = .12$).

Preoperative and postoperative serum CPK values were also not significantly different between or within groups during consecutive measurements ($P = .3$, $\alpha = .82$) (Table 3). Mean values did not exceed the upper normal serum levels at any of the measuring time points. A steady decline in CPK values was evident postoperatively. Lower values were found in group A compared with group B patients on days 8 and 15 postoperatively, but without reaching the level of statistical significance ($P = .093$ and $P = .079$,

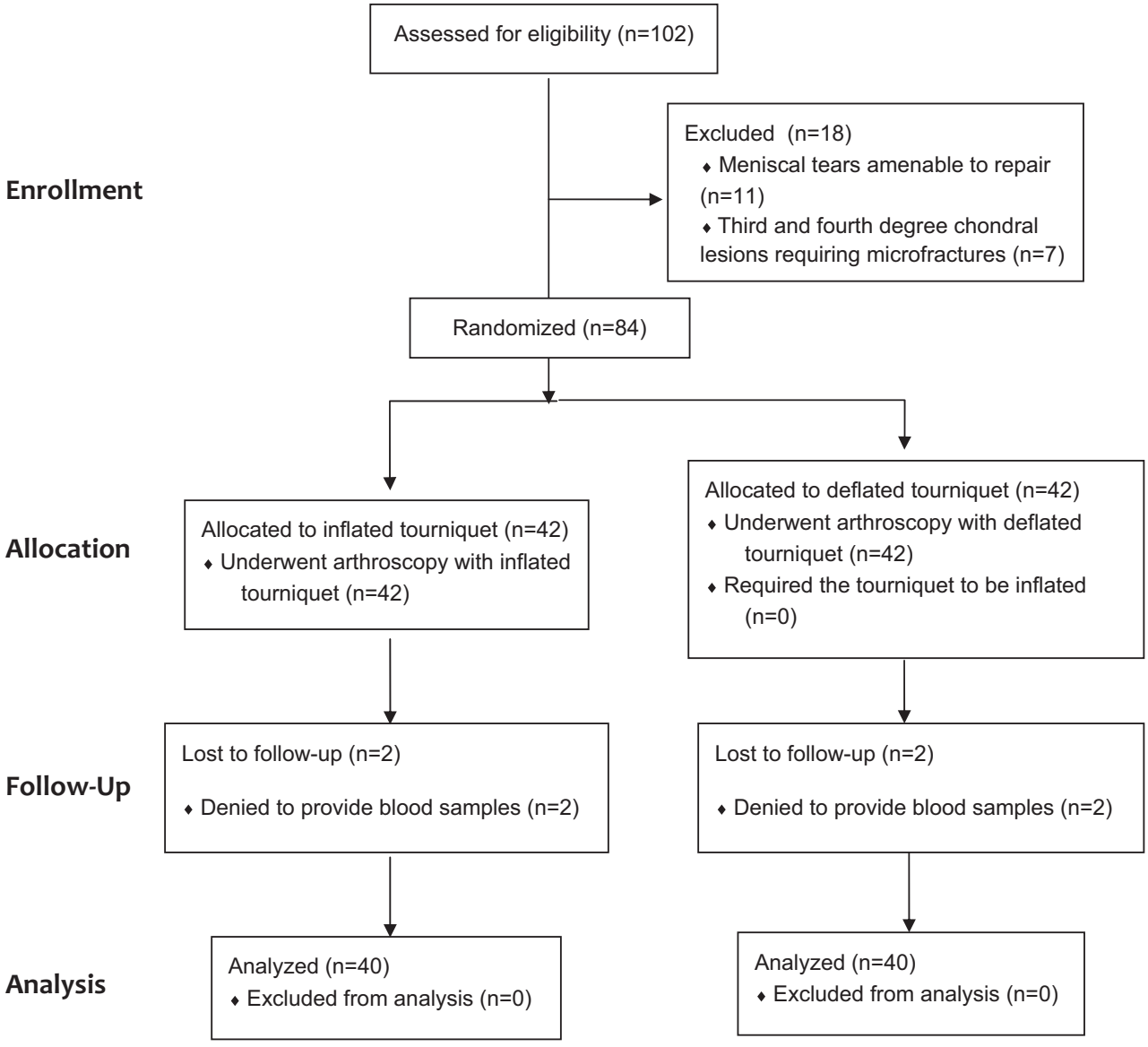

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram of study.

respectively). Finally, tourniquet time did not correlate with postoperative ROM, VAS scores, or CPK levels (minimum $P = .14$).

DISCUSSION

This study examined the effect of pneumatic tourniquet use during arthroscopic partial meniscectomy using a pressure pump on rehabilitation rate, return to activity, and muscle damage. There was no significant difference in VAS scores and knee ROM in the acute postoperative period between the inflated and deflated tourniquet groups. Similarly, the time needed for the patients to discontinue the use of crutches and return to light work and jogging was not significantly different between groups. Preoperative and postoperative serum CPK values were also not significantly different between or within groups.

The findings of this study showed that the use of a tourniquet did not result in delayed rehabilitation or return to work and sporting activities. In general, arthroscopic knee surgery is associated with a rapid recovery and quick return to activities. In a recent cohort, Lubowitz et al.[11] showed that almost 100% of

TABLE 2. *Intraoperative Findings During Knee Arthroscopy Regarding Meniscal and Cartilage Pathology*

	Tourniquet (n = 40)	No Tourniquet (n = 40)
Medial/lateral meniscus	35/5	34/6
Type of meniscal pathology		
Bucket-handle tear	20	19
Posterior horn tear	14	13
Other	6	8
Chondral lesions		
None	17	19
First degree	14	12
Second degree	9	9

patients who underwent knee arthroscopy had no knee-related activity restriction by 1 month postoperatively. However, the impact of tourniquet use on rehabilitation and return to activities after knee arthroscopy currently remains controversial. Concerns have recently been raised regarding a potential detrimental effect on rehabilitation when tourniquets are applied. Tourniquet-induced neuropathy and local muscle damage due to compression and ischemia are considered to play a pivotal role in impaired rehabilitation.[12,13] However, the current evidence base on arthroscopic knee procedures, though limited, has not supported this notion. Kirkley et al.[9] found no significant difference in time to return to work or sports between tourniquet and non-tourniquet groups. Interestingly, using isokinetic dynamometry, Thorblad et al.[6] found a decrease in postoperative quadriceps torque in their non-tourniquet group. They attributed this finding to increased pump flow and pressure that caused extravasation of fluid and consequently increased postoperative pain and stiffness.

The biochemical basis of tourniquet-induced muscle damage during arthroscopic knee procedures has been examined previously. In a biochemical study that did not include a control group, Refaai et al.[14] found significant increases in ischemia-modified albumin and myoglobin concentrations after tourniquet release, which they considered indicative of detectable myocyte necrosis. Koca et al.[15] showed an increase in biochemical markers of oxidative stress due to tourniquet-induced ischemia-reperfusion injury in routine arthroscopic knee surgery. Evidence of a tourniquet-induced systemic inflammatory response with transient neutrophil and monocyte activation has also been reported.[16] Serum CPK levels have scarcely been examined in this setting.[6] Serum CPK levels rise with increasing muscle tissue damage resulting from either metabolic or mechanical causes. They depend on age, gender, race, muscle mass, physical activity, and climatic conditions.[17] An approximate 2-fold increase above baseline levels is considered to occur within 8 hours after the induction of muscle damage. In our study serum CPK levels were not significantly different between or within groups during consecutive measurements. Our findings therefore indicate that despite the potential for local muscle tissue injury, the use of tourniquets during arthroscopic meniscectomy does not result in the elevation of systemic markers of muscular damage.

Tourniquet time, along with tissue type, has been acknowledged as a major contributor to tourniquet-induced muscle damage and postoperative pain. Tourniquet-related complications increase as tour-

TABLE 3. *Primary Outcome Measures*

	Tourniquet (n = 40)	No Tourniquet (n = 40)
VAS		
Eighth day postoperatively	2.07 ± 1.9 (0-6)	1.25 ± 1.4 (0-5)
15th day postoperatively	0.7 ± 0.6 (0-2)	0.6 ± 1.26 (0-2)
ROM (°)		
Eighth day postoperatively	107.5 ± 17.8 (98-130)	105 ± 26.5 (95-132)
15th day postoperatively	142 ± 7.5 (130-148)	139.3 ± 11.4 (124-147)
Full weight bearing without crutches (d)	13.4 ± 3.35 (8-18)	13.2 ± 4.7 (8-21)
Return to light work (d)	23.2 ± 5.3 (16-31)	24.6 ± 6.1 (15-36)
Return to jogging (d)	35.7 ± 6.2 (24-48)	37.8 ± 7.3 (26-51)
Serum CPK levels (U/L)		
Preoperatively	143.8 ± 29.2 (59-203)	171.2 ± 72.1 (52-290)
First day postoperatively	100.9 ± 49.6 (41-211)	129.6 ± 45.2 (79-215)
Eighth day postoperatively	79 ± 24.3 (51-139)	163.5 ± 55.8 (69-211)
15th day postoperatively	61.3 ± 12.5 (46-89)	134.7 ± 28.9 (63-165)

NOTE. Data are presented as mean ± SD (range).

niquet time increases.[18] Local and distal mechanisms, including muscle and nerve injury due to direct pressure, ischemia, and reperfusion, have been found to increase pain when tourniquets are used in extremity surgery. However, most experimental and clinical studies have correlated tourniquet-related complications with considerably increased ischemia time.[19] Kirkley et al.[9] suggested the presence of a time factor during knee arthroscopy for tourniquet-related pain, which was less in the deflated-tourniquet group for procedures lasting longer than 30 minutes. Findings of this study did not identify any difference in postoperative pain with tourniquet use. In addition, no correlation was evident between postoperative pain and tourniquet time. Because the operative time did not exceed 30 minutes on average in any of the study groups, our findings support the notion that, with tourniquet time less than 30 minutes, the time-dependent effect of tourniquets on pain and muscular injury is probably diminished.

Intraoperative visibility was not a primary outcome measure of this study. However, indirect signs of visual field disturbance were that surgical time was not significantly different between the 2 groups and that no case in group B required the tourniquet to be inflated intraoperatively because of reduced visibility. Our findings therefore indirectly support the outcomes of a recent meta-analysis that found no significant difference between tourniquet and non-tourniquet procedures in operative visual field disturbance.[10] Interestingly, such a difference was established during anterior cruciate ligament reconstruction procedures.[10] Many of the studies, however, have used the need to inflate the tourniquet as an endpoint. In general, performing knee arthroscopy without a tourniquet has been associated with portal bleeding. In addition, numerous technical tips have been described, such as increasing the flow of infusion fluid, using intermittent suction on the arthroscope cannula, and establishing a separate drainage portal, to improve visibility before ultimately inflating the tourniquet. Given that tourniquet use during arthroscopic meniscectomy does not result in delayed rehabilitation and return to activities, we advocate its routine use, particularly during the learning curve, to simplify the procedure and potentially improve diagnosis and outcomes.

Recent research has added valuable knowledge on the characteristics of different tourniquet cuffs.[2] Studies have shown that basing cuff pressure on systolic blood pressure alone does not result in optimum cuff pressure.[20] The minimum pressure required to stop the blood flow distal to the cuff has also been correlated with tourniquet cuff design and application method, limb circumference and shape, and tissue characteristics at the cuff site. Cuff pressures considerably lower than those routinely used in extremity surgery have been shown to maintain an acceptable bloodless field.[20] However, in this study, tourniquet pressure was kept at 320 mm Hg and cuffs of standard width and configuration were applied to better represent what is in common practice for knee arthroscopy today. In addition, a typical infusion pump was used instead of a gravity flow system to standardize fluid pressure and flow and consequently minimize bias.

Our study has certain limitations. First, muscular strength evaluation was not included in our study design. Although this would evidently be useful, it was considered that an isokinetic evaluation during the first postoperative weeks would have been biased by pain or patient guarding and therefore would not produce reliable results. Moreover, it would possibly affect the serum CPK values measured, which was an important part of our study design. Second, portal bleeding and increased venous filling provide a strong clue as to whether the tourniquet has been inflated. Therefore the performing surgeon could not realistically be blinded during surgery, in contrast to follow-up evaluations. Finally, despite randomization, our results may have been biased by the probability of self-administering pain inhibitors postoperatively and by individual variations in physical therapy intensity.

CONCLUSIONS

Our study showed that tourniquet use for less than 30 minutes during arthroscopic meniscectomy performed by a surgeon with expertise does not affect postoperative pain or return to light work and jogging. In addition, tourniquet-induced muscle damage after arthroscopic meniscectomy, though potentially present locally, is not detectable in the systemic circulation.

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