Effect of Tourniquet Use in Ankle Arthroscopic Surgery on Postoperative Recovery: A Prospective Non- Randomized Controlled Study

Tingting Huang

Wenzhou Medical College Second Affiliated Hospital: Wenzhou Medical University Second Affiliated Hospital

Haixiao Liu

Wenzhou Medical College Second Affiliated Hospital: Wenzhou Medical University Second Affiliated Hospital

Yuezheng Hu

Wenzhou Medical College Second Affiliated Hospital: Wenzhou Medical University Second Affiliated Hospital

Xinxian Xu (✉ a379806041@163.com)

Second Affiliated Hospital of WenZhou Medical University <https://orcid.org/0000-0002-6484-9551>

Research

Keywords: ankle arthroscopy, tourniquet, joint swelling, pain, ischemia- reperfusion injury (IRI)

Posted Date: October 14th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-89991/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

The aim of this prospective non-randomized controlled study was to explore the effect of tourniquet use on joint swelling, pain, functional outcome, and tourniquet-related ischemia-reperfusion injury (IRI) during ankle arthroscopic surgery. 52 patients who received ankle arthroscopy were allocated to have the procedure done with the tourniquet inflated (the Control group, $n = 27$) or without the tourniquet inflated (the NT group, $n = 25$). The main outcome measures were: (1) The amount of swelling of the ankle; (2) Pain as measured by a visual analog scale (VAS); (3) The levels of MDA, IMA, TOS, TAS and OSI at 10 min before incision (T1) after the completion of surgery (T2), and 30 min after tourniquet deflation (T3); (4) The functional outcome as measured by American Orthopaedic Foot and Ankle Society (AOFAS) ankle hindfoot score; (5) The rate of complication. All patients were reviewed at a mean follow-up of 14.2 months (range, 12-19 months). The mean circumferences of the ankle in the NT group were significantly lower than those in the Control group on postoperative day 2 and 5 ($p < 0.05$). The mean level of VAS in the Control group was significantly higher on postoperative day 2 ($p < 0.05$). The outcomes of AOFAS ankle hindfoot score were comparable between groups postoperatively ($p > 0.05$). The levels of MDA, IMA, TOS and OSI were all significantly lower in the NT group compared at T2 and T3 ($p < 0.05$), and the level of TAS was significantly lower in the NT group at T3 ($p < 0.05$). The complication rates of two groups were comparable ($p > 0.05$). With the use of tourniquet during ankle arthroscopic surgery, there was increased joint swelling and pain postoperatively, and a trend toward increased levels of MDA, IMA, TOS, TAS and OSI intraoperatively. Thus, we do not recommend using a tourniquet in this type of procedure.

Introduction

Ankle arthroscopic surgery is a minimally invasive procedure performed for a variety of ankle pathologies. This technique enables direct observation of the intra-articular lesions and pathological changes without additional extensive approaches, resulting in reduced postoperative morbidity and pain. Additionally, it has several advantages when compared with conventional open surgery, such as reduced hospitalization, reduced wound-related complications, improved cosmesis and an earlier return to daily activities [1]. At present, ankle arthroscopy is commonly conducted using a tourniquet to decrease bleeding, which potentially improves visibility and shortens operative time [2]. However, there is controversy regarding this issue, and the potential benefits of use of a tourniquet must be weighed against the risks.

Many previous reports have revealed a tourniquet is not necessary to be used in minimally invasive surgeries like arthroscopic procedures, as it might cause associated potential adverse effects, such as nerve palsy, muscular lesion and vascular injury [3–4]. A recent meta-analysis also provided evidence that use of tourniquet does not show any advantage to arthroscopic procedures, when comparing intraoperative visualization and operative time [5]. However, Smith et al revealed tourniquet use could improve surgical visualization during arthroscopic anterior cruciate ligament (ACL) reconstruction [6]. When performing ankle arthroscopic surgery, Zaidi R et al found that inflation of a tourniquet did not result in increased surgical duration, maximum irrigation fluid pressures and postoperative complications

[7]. Similarly, Dimnjakovic et al found comparable functional outcomes with or without a tourniquet when performing anterior ankle arthroscopy [8].

On the other hand, tourniquet use during limb surgery involving occlusion of the blood flow and the subsequent restoration of perfusion, which may result in ischemia-reperfusion injury (IRI) [9]. This process inevitably initiates the generation of reactive oxygen species (ROS) and triggers oxidative reaction, and in turn results in the production of macromolecules, such as hydrochloric acid, malonyldialdehyde (MDA) and ischaemia-modified albumin (IMA), thus leading to cellular necrosis and apoptosis and hence organ dysfunction [10–11]. Although skeletal muscle is relatively resistant to IRI when compared to other organs, it has been reported that irreversible damage will occur after a long time of complete ischemia, such as muscular dysfunction and tissue necrosis [9, 11]. However, this effect during ankle arthroscopic surgery has not been well documented.

In the present study, the effect of tourniquet use on joint swelling, pain, functional outcome and tourniquet-related IRI by determining MDA, IMA, total oxidative status (TOS), total antioxidant status (TAS) and oxidative stress index (OSI) levels in patients undergoing ankle arthroscopic surgery was examined. We hypothesized that tourniquet use during this procedure may increase postoperative swelling and pain, induce tourniquet-related IRI and adversely affect functional outcome.

Methods

Between May 2013 and April 2019, we conducted this non-randomized, controlled study at our department. Over the 6-year period, 84 patients sustained a unilateral lateral ankle instability and received arthroscopic all-inside lateral collateral ligament repair were prospectively included. This protocol was approved by the Institutional Review Board of Wenzhou Medical University, and each participant gave informed written consent before enrollment.

The diagnosis of chronic lateral ankle instability was confirmed mainly by clinical examination and magnetic resonance imaging (MRI) [12]. Exclusion criteria were cases with a follow-up less than one year, open injuries at or near the surgical site, ankle fracture, serious synovitis, peripheral vascular and neuromuscular disorders. Then 32 cases were excluded, resulting in the enrolment of 52 cases, in which 27 patients who were treated surgically with the tourniquet inflated were grouped into the Control group, and 25 cases with the tourniquet applied, but not inflated during operation were grouped into the non-tourniquet (NT) group.

All procedures were performed by one of two experienced surgeons. The normal saline in a 3-L bag without any other additional agent was used as the irrigation fluid. The arthroscopic pump (Arthrex Inc, Naples, FL, USA) for fluid management was applied with the intra-articular pressure set to 40 mmHg. A thigh tourniquet was applied in all patients. But it was inflated to 350 mmHg in Control group only. In NT group, the tourniquet was not inflated and served as a security device in case of acute massive bleeding. After adequate anaesthesia, the patient was kept in the supine position and operated arthroscopically through standard anteromedial and anterolateral portals with the help of anatomic landmarks.

Diagnostic arthroscopy was performed firstly through the anteromedial portal, and associated intra-articular lesions were managed accordingly, such as the osteochondral lesions of the talus were treated by chondroplasty, and anterior tibial osteophytes were treated by cheilectomy. An accessory anterolateral portal was established approximately 1 cm proximal to the fibular tip and just anterior to it. Then the anterior talofibular ligament (ATFL) was completely detached off the fibular origin and the fibular footprint areas were observed. After preparing the bone bed, a 3.5-mm bioabsorbable suture anchor (Arthrex, Naples, FL, USA) was inserted, which was placed approximately 0.5 to 1 cm proximal to the distal tip of the anterior-inferior fibula. An 18G hollow needle with a 2-0 nylon thread was introduced into distal ATFL. Then a nylon loop was made and enlarged, and retrieved through the accessory anterolateral portal, and the needle was withdrawn. One end of the sutures was passed through the loop, and the loop was pulled to introduce the mid-portion of the suture through the ATFL. After that the free end of the suture was passed through the loop and pulled to create a self-cinching stitch. The other end of anchor suture was used to draw the self-cinching stitch tightening the ATFL. Finally, additional knots (2 square knots and 2 granny knots) were applied to increase the fixation strength. No intra-articular injection of local anaesthetic or analgesia was used. A negative pressure drainage was applied, which was withdrawn on postoperative day 2. All patients were kept non-weight-bearing for 2 weeks, and subsequently started partial weight-bearing with crutch assistance. Beginning at the fourth week, patients began weight-bearing and started to access normal activity. Full return to sports or heavy labour was permitted after 3 months postoperatively.

Blood samples from the medial malleolus vein were obtained at 10 min before incision (T1), after the completion of surgery (T2), and 30 min after tourniquet deflation (T3) for measurement of MDA, IMA, TOS, TAS and OSI levels. All samples were centrifuged at 3000 rpm, and the serum and plasma samples were stored at -80°C until further biochemical analysis.

MDA concentration was measured using the method as described by Yagi [13]. In brief, 2.4 ml of N/12 H_2SO_4 and 0.3 ml of 10% phosphotungstic acid were mixed into 0.3 ml of serum. After being kept at room temperature for 5 min, the mixture was centrifuged at 1600 g for 10 min. Then the supernatant was removed, and the sediment was suspended in distilled water. After addition of 1 ml of 0.67% thiobarbituric acid, the mixture was heated at 100°C for 60 min and subsequently centrifuged at 1600 g for 10 min. The absorbance of the organic layer was read at 532 nm. MDA levels were calculated as nmol/ml, with tetramethoxypropane used as the control.

IMA level was analyzed using the method as described Bar-Or et al [14]. 200 μl of serum was mixed with 50 μL of 0.1% cobalt chloride ($\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$; Sigma, St Louis, Missouri, USA). After 10 minutes of sufficient cobalt albumin binding, 50 μl of dithiothreitol (DTT; Sigma, 1.5 mg/ml H_2O) was added. Subsequently, the mixture was quenched for 2 min and 1.0 mL of 0.9% NaCl was added. A colorimetric control was prepared, in which distilled water was substituted for the same volume of 1.5 mg/ml of DTT. Sample absorbency was analyzed at 470 nm using a spectrophotometer (Thermo Scientific, Massachusetts, USA). Finally, the colour of the DTT-containing specimens were compared with that of the control ones, and the outcomes were described as absorbance units (ABSUs).

TOS and TAS levels were determined using the commercial colorimetric kits (Rel Assay Diagnostics, Shanghai, China) following the manufacturer's instruction. Their outcomes were calculated as $\mu\text{mol H}_2\text{O}_2$ equiv/L and mmol Trolox equiv/L, respectively. OSI level was determined as the TOS: TAS ratio and expressed as a percentage $[(\text{TOS}, \mu\text{mol H}_2\text{O}_2 \text{ equiv/L}) / (\text{TAS}, \text{mmol Trolox equiv/L}) \times 0.1]$.

Demographic data including age, gender, Body Mass Index (BMI), American Society of Anesthesiologists (ASA) grade, and associated medical comorbidities (alcohol or tobacco use, hypertension, diabetes mellitus, respiratory and cardiovascular disease) were documented. And peri-operative characteristics including anaesthesia method, surgical duration, co-existing injuries, postoperative drainage volume, and length of hospital stay.

The main outcome measures were recorded as following: (1) The amount of swelling of the ankle, by measuring the circumference at the level of the malleoli (preoperative, postoperative Days 2 and 5); (2) Pain, measured by a visual analog scale (VAS), with scores ranging from 0 (no pain) to 10 points (worst imaginable pain) (preoperative, postoperative Days 2 and 5); (3) The levels of MDA, IMA, TOS, TAS and OSI measured as described above; (4) The functional outcome, as measured by American Orthopaedic Foot and Ankle Society (AOFAS) ankle hindfoot score (preoperative, postoperative Month 1 and Year 1) [15]; (5) Complication rate [wound leakage, wound infection, superficial nerve injuries, joint stiffness and deep vein thrombosis (DVT)]. A wound leakage was defined based on the consensus of the Work group of the Musculoskeletal Infection Society (WMIS), which is any leakage longer than 72 hours after wound closure [16]. Identification of wound infection was determined based on the standard Centers for Disease Control (CDC) definitions [17]. A wound culture was performed following the onset of an infectious complication.

Statistically analysis

The statistical analysis was performed using SPSS software (Version 20.0; SPSS, Chicago, IL), all statistical tests were two – sided and P-values < 0.05 were considered significant. Continuous variables were presented as means $\pm$ standard deviation (SD) and were analyzed with t test if normally distributed or Mann-Whitney U test if not normally distributed. Categorical variables were presented as frequencies and percentages were analyzed using the chi-square test or Fisher's exact test. The sample size was calculated based on the level of ankle circumference postoperatively. Based on our previous data, a sample of 50 patients (25 in each group) was adequate to detect a 10% difference between groups at 80% power and a p-value of 0.05.

Results

All patients were reviewed at a mean follow-up of 14.2 months (range, 12–19 months). The baseline demographic characteristics and preoperative clinical data were comparable between two groups (Table 1), as no significant differences in demographic variables, including age, gender, BMI, ASA grade,

and medical comorbidities, as well as peri- operative data, including anesthesia method, surgical duration, co-existing injuries, drainage volume and the length of hospital stay were observed ($p > 0.05$).

Table 1
Demographic data and peri- operative characteristics

	Control Group (n = 27)	NT Group (n = 25)	<i>P</i>
Age (yr)	35.2 ± 10.8	32.8 ± 10.0	0.421
Gender			0.562
Male	19	15	
Female	8	10	
BMI (kg/m ²)	21.7 ± 2.9	22.2 ± 2.5	0.520
ASA grade			0.676
I	11	13	
II	14	11	
III	2	1	
Medical comorbidities			
Alcohol use, [n (%)]	7 (25.9)	5 (20.0)	0.746
Tobacco use, [n (%)]	8 (29.6)	5 (20.0)	0.528
Hypertension, [n (%)]	6 (22.2)	4 (16.0)	0.729
Diabetes mellitus, [n (%)]	2 (7.4)	3 (12.0)	0.662
Respiratory disease, [n (%)]	2 (7.4)	1 (4.0)	1.000
Cardiovascular disease, [n (%)]	1 (3.7)	1 (4.0)	1.000
Anaesthesia method			0.267
General anesthesia	16	10	
Spinal anesthesia	11	15	
Surgical duration (min)	44.6 ± 6.6	47.0 ± 8.2	0.255
Co-existing injuries			
Osteochondral lesion of the talus	4 (14.8)	6 (24.0)	0.492
Anterolateral impingement	5 (18.5)	3 (12.0)	0.705
Anterior bony impingement	3 (11.1)	2 (8.0)	1.000
Postoperative drainage volume (ml)	48.2 ± 26.3	56.8 ± 29.4	0.268
Length of hospital stay (day)	5.4 ± 1.4	5.3 ± 1.4	0.755

The main outcome measures were provided in Table 2. The mean preoperative circumferences of the ankle in the Control and NT groups were 20.0 ± 1.6 mm and 19.6 ± 1.4 mm (no significant difference; $p > 0.05$). But the levels in the NT group were significantly lower than those in the Control group, measured at 22.0 ± 1.5 mm vs. 21.1 ± 1.3 mm on postoperative day 2 and 21.2 ± 1.7 mm vs. 20.2 ± 1.4 mm on postoperative day 5 ($p < 0.05$). No significant differences were identified between groups preoperatively in terms of VAS and AOFAS ankle hindfoot score ($p > 0.05$), But both groups improved significantly after operation ($p < 0.05$). The mean level of VAS in the Control group was significantly higher than that in the NT group on postoperative day 2 (4.3 ± 1.0 vs. 3.5 ± 0.7 , $p < 0.05$), but no significant difference was observed on postoperative day 5 (1.5 ± 1.0 vs. 1.6 ± 1.3 , $p > 0.05$). For the outcomes of AOFAS ankle hindfoot score, no significant differences were identified on postoperative Month 1 and Year 1 and included 77.6 ± 9.7 in the Control group vs. 7.9 ± 13.0 in the NT group and 92.9 ± 7.4 in the Control group vs. 90.4 ± 8.1 in the NT group, respectively ($p > 0.05$).

Table 2
The main outcome measures

	Control Group (n = 27)	NT Group (n = 25)	<i>P</i>
The circumference of the ankle (mm)			
Preoperative	20.0 ± 1.6	19.6 ± 1.4	0.343
Postoperative Day 2	22.0 ± 1.5	21.1 ± 1.3	0.023
Postoperative Day 5	21.2 ± 1.7	20.2 ± 1.4	0.026
VAS			
Preoperative	4.2 ± 1.0	4.3 ± 0.9	0.516
Postoperative Day 2	4.3 ± 1.0	3.5 ± 0.7	0.002
Postoperative Day 5	1.5 ± 1.0	1.6 ± 1.3	0.797
AOFAS ankle hindfoot score			
Preoperative	61.7 ± 10.9	63.1 ± 11.5	0.642
Postoperative Month 1	77.6 ± 9.7	79.1 ± 13.0	0.624
Postoperative Year 1	92.9 ± 7.4	90.4 ± 8.1	0.260
Complication rate			
Wound leakage, [n (%)]	6 (22.2)	4 (16.0)	0.729
Wound infection, [n (%)]	3 (11.1)	1 (4.0)	0.611
Superficial nerve injuries, [n (%)]	2 (7.4)	3 (12.0)	0.662
Joint stiffness, [n (%)]	2 (7.4)	1 (4.0)	1.000
DVT, [n (%)]	1 (3.7)	1 (4.0)	1.000

As shown in Fig. 1–5, there were no significant differences between groups preoperatively (T1) in terms of MDA, IMA, TOS and OSI ($p > 0.05$). But the levels of these indicators were all significantly lower in the NT group compared with the Control group at T2 and T3 [T2, (MDA) 1.65 ± 0.18 vs. 1.87 ± 0.16 , (IMA) 0.24 ± 0.03 vs. 0.26 ± 0.03 , (TOS) 15.98 ± 3.31 vs. 9.40 ± 2.33 , (OSI) 0.66 ± 0.26 vs. 0.42 ± 0.17 ; T3, (MDA) 1.59 ± 0.20 vs. 1.73 ± 0.18 , (IMA) 0.23 ± 0.03 vs. 0.25 ± 0.03 , (TOS) 12.53 ± 2.64 vs. 7.88 ± 1.87 , (OSI) 0.58 ± 0.17 vs. 0.44 ± 0.14 ; Respectively; $p < 0.05$]. For the outcome of TAS, though no statistical differences were observed preoperatively and at T2 (1.92 ± 0.42 vs. 2.10 ± 0.58 , 2.58 ± 0.62 vs. 2.38 ± 0.54 ; Respectively; $p > 0.05$), it was significantly lower in the NT group at T3 (2.26 ± 0.46 vs. 1.84 ± 0.38 , $p < 0.05$).

The complication rates of two groups were comparable, as summarized in Table 2. Wound leakage was resolved with local incision care without any surgical intervention, and wound infection was controlled well by use of oral or intravenous antibiotics without any additional treatment. 2 cases were diagnosed with DVT of the lower extremities, but no adverse events such as massive pulmonary embolism or serious limb ischemia occurred during the one- year follow- up period.

Discussion

The major findings of the present study were that arthroscopic ankle surgery can be done without the use of tourniquet, which decreases postoperative swelling and pain, and has an advantage in reducing tourniquet- related IRI, with no interference with postoperative functional outcome nor complication.

Tourniquet has been widely used in arthroscopic surgery to reduce intraoperative bleeding and improved operative field visibility, which potentially reduces operative time [18–19]. However, recently, with the increase of the flow of irrigation fluid, local or systemic application of tranexamic acid, or adding epinephrine to the irrigation solution, achieving a satisfactory visualization without having to inflate the tourniquet is possible [18, 20]. Also, a recent systematic review and meta-analysis of randomized controlled trials had provided evidence that arthroscopic surgery without tourniquet does not appear to prolong operative time [18]. In ankle arthroscopy, there were only a few researches focusing on this issue. Zaidi et al conducted a prospective nonrandomized study to explore the effects of tourniquet use in ankle arthroscopy, they noted that tourniquet use showed no clinical disadvantages in regard to duration of operation, maximum intraoperative fluid pressures or visibility, and announced ankle arthroscopy was possible without the use of a tourniquet [22]. Dimnjakovic et al also found that inflation of a tourniquet did not result in increased duration of operation, maximum intraoperative fluid pressures or visibility after anterior ankle arthroscopy [8]. Our outcomes corresponded well to both studies above, in which the results of surgical duration were comparable between two groups. On the other hand, previous studies revealed that maintaining intra-articular fluid pressure at 50 mmHg was safe and applicable in arthroscopic surgery [7, 21]. In the present study, we detected no case in the non- tourniquet group needed subsequent inflation of the tourniquet or to increase pressure when setting the pressure at 40 mmHg, indicating this figure is sufficient to achieve a satisfactory visualization.

The effect of tourniquet on the amount of limb swelling has been investigated by many authors [22–23]. Because of increased reactive hyperemia and postanoxic edema, tourniquet use will inevitably result in aggravated swelling. In this study, the amount of swelling measured at the level of the malleoli was a main parameter. There were reduced levels of swelling of the involved ankle in the cases without a tourniquet on postoperative days 2 and 5. This may be a reason for a higher level of VAS in the tourniquet group in the first postoperative 48 hours. Because of increased swelling and skin tension, a persistent ischemia may occur on the skin and subcutaneous tissue, which may have predisposed those patients to higher amount of pain and wound healing complications [24]. However, use of a tourniquet did not affect the functional outcome, as the results of AOFAS score was similar between the groups, this outcome is consistent with the study performed by Dimnjakovic et al [8].

Clinical studies have revealed that temporary occlusion of blood flow and the subsequent reestablishment of perfusion after tourniquet deflation will result in IRI in limb surgery, and in turn leads to the production of toxic metabolites, like MDA and IMA [23, 25]. MDA is an important intermediate product involved in lipid peroxidation, and is usually used as an indicator of free radical formation [26]. As a response to hypoxia, IMA is a product generated from albumin. Previous studies have defined IMA as a new marker for ischemic diseases, as its level is markedly rising in acute ischemic conditions, such as myocardial, cerebral and pulmonary ischemia [25, 27]. Recently, increasing studies have been focused on the changes of MDA and IMA levels involving use of tourniquet, and found a non- tourniquet technique could reduce the levels and IRI associated side effects following knee arthroscopic surgery [25]. Additionally, the oxidative stress has also recently been the subject of intense research in IRI models and proposed as a sensitive marker using various methods [28–29]. In our study, the measurement methods based on TOS, TAS and OSI, which are easier and more affordable than separately measuring the oxidants and antioxidants, were adopted. To the best of our knowledge, this study is the first to investigate the effect of tourniquet on acute muscular IRI following ankle arthroscopic surgery. We obtained the blood samples locally from the operated leg, as previous evidence indicated that oxidative stress markers obtained locally are more accurate and representative than the ones measured systemically [30], and found that tourniquet use markedly increased the levels of IRI- related biomedical markers, suggesting reperfusion of ischemic skeletal muscles might lead to local injuries during rapid reoxygenation when tourniquet was inflated. Normally, many associated symptoms could be applied to assess its severity, including joint swelling, range of motion (ROM) and wound pain [23]. In our series, increased postoperative joint swelling and pain were observed, which was in accordance with the above results.

Major complications associated with tourniquet use such as compartment syndromes and massive pulmonary embolism have ever been reported, but none was occurred in our patients due to the relatively short operation duration and light surgical trauma [31–32]. Meanwhile, no significant differences were observed in the incidence of general complications postoperatively. But this may be attributable to the relatively small sample size, then the safety still remains unknown, and should be demonstrated with more clinical data.

Some limitations of the present study should be mentioned. This was a prospective non-randomized research with limited sample size and the follow-up of mean 14.2 months was still short, a randomized one with a longer follow-up period will provide more referable outcomes. Additionally, the AOFAS score is not a validated outcome scale to evaluate ankle function, and consequently, some key aspects may have been overlooked [33]. A specific one to assess ankle function would have increased the validity. Also, we only measured the levels of MDA, IMA, TOS, TAS and OSI. To confirm our hypothesis and findings, measurements of other associated indicators may also be helpful.

In conclusion, with the use of tourniquet during ankle arthroscopic surgery, there was increased joint swelling and pain postoperatively, and a trend toward increased levels of MDA, IMA, TOS, TAS and OSI

intraoperatively. According to these outcomes, we do not recommend using a tourniquet in this type of procedure.

Declarations

Disclosure of interest

The authors declare that they have no competing interest.

Funding:

None

Contributions

Tingting Huang performed study design and data collection, analysis and interpretation, and wrote the article. Haixiao Liu contributed to study design and helped to write the article. Yuezheng Hu contributed to data collection. Xinxian Xu performed study design and data collection, analysis and interpretation.

References

1. Martín T B, Durán E I, Campos M S M. Complications after ankle and hindfoot arthroscopy. *Rev Esp Cir Ortop Traumatol* 2016; 60: 387-393.
2. Epstein D M, Black B S, Sherman S L. Anterior ankle arthroscopy: indications, pitfalls, and complications. *Foot Ankle Clin* 2015; 20: 41-57.
3. Kirkley A, Rampersaud R, Griffin S, [Amendola A](#), [Litchfield R](#), [Fowler P](#). Tourniquet versus no tourniquet use in routine knee arthroscopy: a prospective, double-blind, randomized clinical trial. *Arthroscopy* 2000; 16: 121-126.
4. Vandenbussche E, Duranthon L D, Couturier M, Pidhorz L, Augereau B. The effect of tourniquet use in total knee arthroplasty. *Int Orthop* 2002; 26:306-309.
5. Zhang Y, Li L, Wang J, Li Z, Shi Z. Do patients benefit from tourniquet in arthroscopic surgeries of the knee? *Knee Surg Sports Traumatol Arthrosc.* 2013; 21:1125-1130.
6. Smith T O, Hing C B. A meta-analysis of tourniquet assisted arthroscopic knee surgery. *Knee* 2009; 16:317-321.
7. Zaidi R, Hasan K, Sharma A, Cullen N, Singh D, Goldberg A. Ankle arthroscopy: a study of tourniquet versus no tourniquet. *Foot Ankle Int* 2014; 35:478-482.
8. Dimnjakovic D, Hrabac P, Bojanic I. Value of Tourniquet Use in Anterior Ankle Arthroscopy: A Randomized Controlled Trial. *Foot Ankle Int* 2017; 38:716-722.
9. Karaca, M, Hüseyin Ula Pinar, Ahmet Fevzi zgür, Kulaksizolu, S, Doan R. The effect of pregabalin on the tourniquet induced ischemia-reperfusion injury. A Prospective Randomized Study. *Turk J Med Sci* 2019; 49:1693- 1700.

10. Yilmaz H, Kostakoglu U, Demir S, Aksoy F, Mentese A, Karahan S C, Köksal I, Alver A, Yilmaz G. Carbonic anhydrase I–II autoantibodies and oxidative status in long-term follow-up of patients with Crimean–Congo haemorrhagic fever. *Arch Physiol Biochem* 2018; 124: 69-74.
11. Ahiskalioglu E O, Ahiskalioglu A, Aydin P, Arslan Z, Aksoy M, Temiz A. Effects of a single-dose preemptive pregabalin on acute and chronic pain after inguinal hernia repair with mesh under spinal anaesthesia: A randomised controlled trial. *Eur J Anaesthesiol* 2016; 33: 605-607.
12. Acevedo J I, Ortiz C, Golano P, Nery C. ArthroBroström Lateral Ankle Stabilization Technique: An Anatomic Study. *Am J Sports Med* 2015; 43: 2564-2571.
13. Yagi K. Lipid Peroxides and Related Radicals in Clinical Medicine. *Adv Exp Med Bio* 1994; 336: 1-15.
14. Or D B, Lau E, Winkler J V. [A novel assay for cobalt-albumin binding and its potential as a marker for myocardial ischemia—a preliminary report.](#) *J Emerg Med* 2000; 19: 311-315.
15. Hale S A, Hertel J. Reliability and Sensitivity of the Foot and Ankle Disability Index in Subjects With Chronic Ankle Instability. *J Athl Train* 2005; 40: 35-40.
16. Parvizi J, Zmistowski B, Berbari E F, Bauer T W, Springer B D, Valle D C, Garvin K L, Mont M A, Wongworawat M D, Zalavras C G. New Definition for Periprosthetic Joint Infection: From the Workgroup of the Musculoskeletal Infection Society. *Clin Orthop Relat Res* 2011; 469: 2992-2994.
17. Garner J S, Jarvis W R, Emori T G, Horan T C, Hughes J M. CDC definitions for nosocomial infections, 1988. *Am J Infect Control* 1988; 16: 128-140.
18. Kuo L T, Yu P A, Chen C L, Hsu W H, Chi C C. Tourniquet use in arthroscopic anterior cruciate ligament reconstruction: a systematic review and meta-analysis of randomised controlled trials. *BMC Musculoskelet Disord* 2017; 18:358.
19. Hooper J, Rosaeg O P, Krepski B, Johnson D J. Tourniquet inflation during arthroscopic knee ligament surgery does not increase postoperative pain. *Can J Anaesth* 1999; 46: 925-929.
20. Liu Y, Hong C, Hsu K, Kuan F, Chen Y, Yeh M, Su W. Intravenous Administration of Tranexamic Acid Significantly Improved Clarity of the Visual Field in Arthroscopic Shoulder Surgery. A Prospective, Double-Blind, and Randomized Controlled Trial. *Arthroscopy*, 2020; 36: 640-647.
21. Junior L H, Soares L F, Goncalves M B, Gomes T P, Oliveria J R, Coelho M G, Santos R L, Andrade M A, Silva G D, Novais E N. Tourniquet versus no tourniquet use in knee videoarthroscopy: a multicentric, prospective, double-blind, randomized clinical trial. *Rev Bras Ortop* 2010; 45: 415-417.
22. Alexandersson M, Wang E Y, Eriksson S. A small difference in recovery between total knee arthroplasty with and without tourniquet use the first 3 months after surgery: a randomized controlled study. *Knee Surg Sports Traumatol Arthrosc* 2019; 27: 1035-1042.
23. Cao Q, He Z, Fan Y, Meng J, Yuan T, Zhao J, Bao N. Effects of tourniquet application on enhanced recovery after surgery (ERAS) and ischemia-reperfusion post-total knee arthroplasty: Full- versus second half-course application. *J Orthop Surg* 2020; 28:230949901989602.
24. Konrad G, Markmiller M, Lenich A, Mayr E, Ruter A. Tourniquets May Increase Postoperative Swelling and Pain after Internal Fixation of Ankle Fractures. *Clin Orthop Relat Res* 2005; 433: 189-194.

25. Kosucu M, Coskun I, Eroglu A, Kutanis D, Mentese A, Karahan S C, Baki E, Kerimoglu S, Topbas M. The Effects of Spinal, Inhalation, and Total Intravenous Anesthetic Techniques on Ischemia-Reperfusion Injury in Arthroscopic Knee Surgery. *BioMed Res Int* 2014; 846570.
26. Erturk E, Cekic B, Geze S, Kosucu M, Coskun L, Eroglu A, Ulusoy H, Mentese A, Karahan C, Kerimoglu S. Comparison of the effect of propofol and N-acetyl cysteine in preventing ischaemia-reperfusion injury. *Eur J Anaesthesiol* 2009; 26:279-284.
27. Pearson J T, Collie N, Lamberts R R, Inagaki T, Yoshimoto M, Umetani K, Davis P, Wilkins G, Jones P P, Shirai M, Schwenke D O. Ghrelin Preserves Ischemia-Induced Vasodilation of Male Rat Coronary Vessels Following β -Adrenergic Receptor Blockade. *Endocrinology* 2018; 159: 1763-1773.
28. Elsurer C, Onal M, Selimoglu N, Erdur O, Yilmaz M, Erdogan E, Kal O, Celik J B, Onal O. Postconditioning Ozone Alleviates Ischemia-Reperfusion Injury and Enhances Flap Endurance in Rats. *J Invest Surg* 2020; 33: 15-24.
29. Dogan G, Ipek H, Bas Y, Dogan G, Kayir S. Experimental study on prophylactic effects of vardenafil in ischemia–reperfusion model with intestinal volvulus injury in rats. *J Pediatr Surg* 2019; 54: 2172-2177.
30. Halladin N, Ekelof S, Alamili M, Bendtzen K, Lykkesfeldt J, Rosenberg J, Gogenur I. Lower limb ischaemia and reperfusion injury in healthy volunteers measured by oxidative and inflammatory biomarkers. *Perfusion* 2015; 30:64-70.
31. Saied A, Ayatollahi Mousavi A, Arabnejad F, Heshmati A A. Tourniquet in Surgery of the Limbs: A Review of History, Types and Complications. *Iran Red Crescent Med J* 2015; 17: e9588.
32. Smith A A, Ochoa J E, Wong S, Beatty S, Elder J, Guidry C, McGrew P, McGinness C, Duchesne J, Schroll R. Prehospital tourniquet use in penetrating extremity trauma: Decreased blood transfusions and limb complications. *J Trauma* 2019; 86: 43-51.
33. Pinsker E, Daniels T R. AOFAS Position Statement Regarding the Future of the AOFAS Clinical Rating Systems. *Foot Ankle Int* 2011; 32: 841-842.

Figures

Figure 1

MDA concentration levels of groups. *P< 0.05.

Figure 2

IMA concentration levels of groups. *P< 0.05.

Figure 3

TOS concentration levels of groups. *P< 0.05.

Figure 4

TAS concentration levels of groups. *P< 0.05.

Figure 5

OSI concentration levels of groups. *P< 0.05.