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The effect of a single dose of intravenous tranexamic acid on visual clarity in knee arthroscopic meniscectomy without a tourniquet

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Ethics Committee Approval
The study was approved by the institutional ethics committee of Medipol University (08/02/2021, E-10840098-772.02-4395).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Tranexamic acid (TXA) is known to reduce intra-articular bleeding during arthroscopic procedures, which can improve visibility and reduce postoperative pain and knee joint swelling from hemarthrosis. However, insufficient data supports the routine use of TXA in arthroscopic meniscectomy. This study aimed to evaluate the effect of a single dose of intravenous (IV) TXA on visual clarity in arthroscopic meniscectomy without a tourniquet.
Methods: A randomized, double-blind, controlled trial was conducted to assess the use of TXA for visibility in routine arthroscopic meniscectomy without a tourniquet. Between January 2021 and February 2022, 53 patients undergoing arthroscopic meniscectomy were randomly assigned to either the TXA group (n=27), who received 1 g IV-TXA, or the control group (n=26), who received 100 ml of normal saline. Visual clarity was evaluated using a Numeric Rating Scale (NRS). Patients were also assessed for the need for a tourniquet, tourniquet time, total operative time, volume of irrigation fluid, postoperative pain, hemarthrosis, and knee function on postoperative day 3 and weeks 1, 2, and 4, using the Lysholm knee scoring scale.
Results: There was no significant difference in intra-operative arthroscopic visibility between the TXA and control groups (P=0.394). Tourniquet was required in three cases in the TXA group and four cases in the control group (P=0.646). There was no significant difference between the two groups regarding postoperative pain, grade of postoperative hemarthrosis, knee motion, or the Lysholm Knee Score after the operation.
Conclusion: The administration of IV-TXA in arthroscopic meniscectomy without a tourniquet did not provide any benefits such as enhanced surgical visualization, reduction in the need to inflate the tourniquet due to obstructed visibility, or decrease in hemarthrosis, VAS pain score, or improved range of motion of the knee in the postoperative period when compared to the control group.

Keywords: arthroscopic meniscectomy, tranexamic acid, visual clarity, pneumatic tourniquet, cold intra-articular irrigation

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Introduction

Despite its advantages, knee arthroscopy can be associated with preventable and unpreventable complications [1,2]. Pneumatic tourniquets are frequently used in arthroscopic knee surgery to facilitate the procedure, improve visualization, reduce operative time, and achieve optimal outcomes. However, tourniquet use has been linked to various complications, including nerve palsy, venous thromboembolism, arterial embolization, skin ulceration, swelling, quadriceps or hamstring weakness, and joint stiffness [3-5].

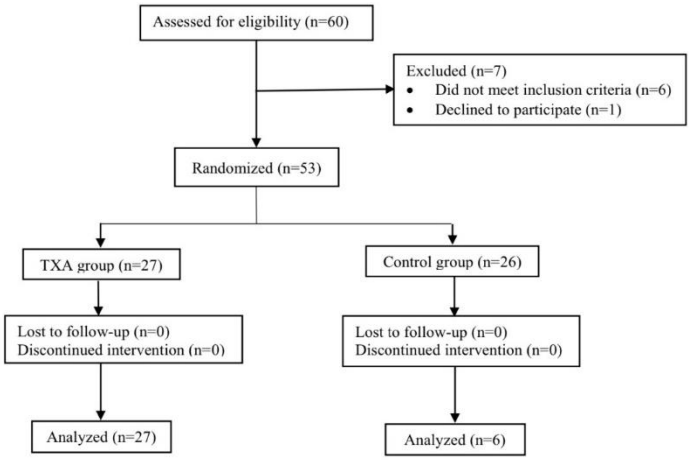
In knee arthroscopy, the absence of a tourniquet can lead to uncontrolled bleeding, a major factor affecting visual clarity [6-8]. Adequate visual clarity is essential for accurate diagnosis and optimal treatment during arthroscopic procedures [8,9]. Several methods have been developed to improve visualization during arthroscopy, including controlled hypotension, thermal coagulation, pump irrigation systems, and adding epinephrine to the irrigation fluid [6,10]. Additionally, hemarthrosis and pain can negatively impact the functional outcome of knee arthroscopy [11]. Tranexamic acid (TXA) has become popular in orthopedic practice due to its ability to reduce intra-articular bleeding during arthroscopic procedures, improve visibility, and decrease postoperative pain and knee joint swelling from hemarthrosis [12-16]. However, insufficient data supports the routine use of TXA in arthroscopic meniscectomy.

The current study hypothesized that administering TXA without a tourniquet would improve visual clarity in routine arthroscopic meniscectomy. The primary objective was to evaluate the effect of a single dose of intravenous (IV) TXA on visual clarity, while the secondary objective was to determine whether administering 1 g IV-TXA prior to arthroscopic meniscectomy reduces hemarthrosis and postoperative pain and allows for earlier restoration of active range of motion.

Materials and methods

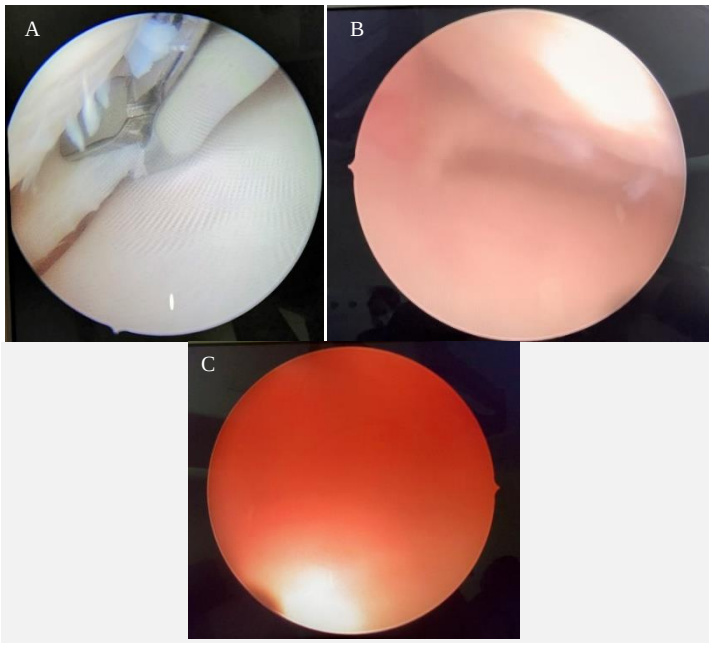
A randomized, double-blind controlled trial was conducted at the Department of Orthopedic Surgery, Istanbul Medipol University, between February 2021 and January 2022, after obtaining approval from the ethics committee [17]. Patients with chondral defects requiring a cartilage restoration procedure, meniscal suturing at the time of surgery, uncontrolled hypertension (systolic pressure >140), or coagulation or bleeding disorders were excluded from the study. Patients over 18 years old with a meniscal tear, with or without cartilage degeneration, underwent partial meniscectomy. All patients provided additional informed consent to participate in the study. Patient randomization was performed using a computer-generated code, printed, and sealed in unmarked envelopes. A total of 53 patients who underwent arthroscopic meniscectomy were assigned to either the TXA group (n=27), who received 1 g IV-TXA in 100 ml of normal saline, or the control group (n=26), who received 100 ml of normal saline without TXA administered 15 min before surgery at the same rate and by the same route. The study flowchart is presented in Figure 1. Although the surgeon, observer, and patients were blinded, the anesthetist administering the TXA or placebo was not blinded.

Figure 1: Flowchart of patient inclusion. (TXA: tranexamic acid)



All patients were positioned in the supine position and administered general or spinal anesthesia. In all cases, a tourniquet was applied but not previously inflated. If the surgeon encountered impaired vision intraoperatively due to bleeding reducing visibility into the knee joint, the tourniquet pressure was maintained at 300 mm Hg. The decision to inflate the tourniquet was made by the surgeon responsible for the procedure. No pressure pump or intra-articular cautery was used in any case. All patients underwent standard 2-portal knee arthroscopy with the gravity technique to administer a continuous flow of cold (4°C) saline irrigation solution from a three-liter saline bag elevated to 2.5 meters above the floor. Intraoperative visual clarity was evaluated using a Numeric Rating Scale (NRS), with a score of 1 indicating a complete lack of visibility and a score of 10 indicating the highest level of clear vision at the end of the operation, as previously described by van Montfoort et al. [8] and Avery et al. [17] (Figure 2). All patients were discharged home on the day of the surgery.

Figure 2: A demonstration of clarity of view scored using the NRS through the anterolateral portal (NRS: Numeric Rating Scale). (A) The view scored 10 indicates; the highest clear vision. (B) The view scored 5 indicates; bleeding mixed with the irrigation fluid, which can impede the visibility to perform surgery, but it can be acceptable for knee arthroscopy. (C) The view scored 1 indicates; complete lack of visibility.



All patients were assessed for the need for a tourniquet, duration of tourniquet time, total operative time, the volume of intraoperative irrigation fluid used, systolic blood pressure, intraoperative complications, postoperative pain, hemarthrosis,

and knee function at postoperative day 3 and postoperative weeks 1, 2, and 4. Knee hemarthrosis was clinically graded according to the classification of Coupens and Yates (CY), subjectively graded from 0 to 4 (Table 1) [18]. Knee aspiration was considered in cases of severe pain and persistent and severe hemarthrosis (CY grade 3–4). Pain score was recorded using a visual analog scale (VAS) ranging from 0 to 10, and the Lysholm Knee Score [19] was used to record knee function. The knees' active range of motion (ROM) was measured using an orthopedic goniometer. Patients were clinically examined for leg swelling or calf pain, and those with clinical suspicion of deep venous thrombosis underwent Doppler ultrasonography.

Table 1: Clinical grading of hemarthrosis according to the classification of Coupens and Yates (CY).

Grade	
0	No detectable fluid
1	Fluid present, no fluid wave
2	Palpable fluid wave
3	Ballotable patella
4	Tense hemarthrosis

Statistical analysis

Data were described using mean (standard deviation [SD]) and analyzed using NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA). Normality was tested using the Shapiro-Wilk test. The independent t-test was used to compare normally distributed continuous variables between groups, while the Chi-square test was used to analyze qualitative comparative parameters. The nonparametric Mann-Whitney U test was used to analyze non-normally distributed data. Statistical significance was considered when the *P*-value was below 0.05.

Results

Fifty-three patients undergoing arthroscopic meniscectomy were evaluated, with 27 patients in the TXA group and 26 in the control group. The mean age was 46.3 (10.79) years in the TXA group and 47.54 (12.9) years in the control group (Table 2).

Table 2: Patients' demographics data.

Variables	TXA group (n=27)	Control group (n=26)	*P*-value
Age (year)	46.3 (10.79)	47.54 (12.9)	0.705*
Sex			
Male	13 (48.15%)	11 (42.31%)	0.669+
Female	14 (51.85%)	15 (57.69%)	
BMI (kg/m²)	28.97 (4,26)	29.04 (5.32)	0.964*
Side			
Right	11 (40.74%)	10 (38.46%)	0.865+
Left	16 (59.26%)	16 (61.54%)	
Anesthesia type			
General	5 (18.52%)	4 (15.38%)	0.761+
Spinal	22 (81.48%)	22 (84.52%)	
Mean arterial pressure (mm Hg)	10.25 (1.2)	9.86 (1.08)	0.218*
Operative time (minute)	32.7 (6.93)	33.35 (6.43)	0.728*
Change of serum Hb concentration (g/dL)	1.04 (0.56)	1.11 (0.4)	0.640*
Amount of fluid used (L)	3.55 (1.14)	3.8 (1.31)	0.459*
The need for a tourniquet (n)	3 (11.11%)	4 (15.38%)	0.646*
Tourniquet time, minute	12.67 (2.08)	15.25 (1.71)	0.130*

Values presented as mean (standard deviation) and *P* calculated by using *unpaired t test and + chi square test. BMI: Body mass index.

There was no significant difference in intraoperative arthroscopic visibility between the TXA group and the control group (P=0.394), with visibility rated at 7.41 (1.91) in the TXA group and 6.92 (2.19) in the control group (Table 3). Visibility was enhanced in seven cases after tourniquet inflation. The tourniquet was required in three cases in the TXA group and four cases in the control group. No statistically significant difference was observed between the groups regarding the need for delayed tourniquet inflation (P=0.646). The mean tourniquet time in the TXA group was 12.67 (2.08) min and 15.25 (1.71) min in the control group, although this result did not reach statistical significance (P=0.130).

Table 3: The quality of intra-operative visibility of the TXA group and the control group.

Variable	TXA group (n=27)	Control group (n=26)	*P*-value
Overall score	7.41 (1.91)	6.92 (2.19)	0.394*

Values presented as mean (standard deviation) and *P* calculated by using *unpaired t-test.

There was no significant difference in the mean operative time between the two groups (P=0.728). The mean operative time was 32.7 (6.93) min in the TXA group and 33.35 (6.43) min in the control group. Moreover, the amount of irrigation fluid used during the surgery was not statistically significant between the two groups (P=0.459). The mean amount of irrigation fluid in the TXA group was 3.55 (1.14) L, and 3.8 (1.31) L in the control group.

No statistically significant difference was observed between the TXA and control groups regarding the degree of VAS pain at each time point after the operation. Similarly, there was no significant difference between the two groups regarding the grade of postoperative hemarthrosis, ROM, and the Lysholm Knee Score at each time point after the operation (Table 4). One knee in the TXA group required postoperative knee aspiration, although this result did not reach statistical significance between the two groups (P=0.509). All patients regained their knee ROM within four weeks after surgery, and no evidence of infection or deep venous thrombosis was reported in either group.

Table 4: Comparison of secondary study results of the TXA group and the control group.

Variable	TXA group (n=27)	Control group (n=26)	*P*-value*
Lysholm score			
Preoperative	53.48 (9.42)	51.38 (8.92)	0.410*
POW 1	68.11 (10.52)	66.73 (8.3)	0.599*
POW 2	81.15 (7.74)	79.92 (6.08)	0.526*
POW 3	91.26 (4.76)	90.38 (4.05)	0.475*
VAS score			
Preoperative	7.15 (0.66)	7.27 (0.72)	0.477‡
POD 3	5.3 (0.91)	5.5 (1.33)	0.506‡
POW 1	4.41 (0.84)	4.46 (0.76)	0.744‡
POW 2	3.52 (0.75)	3.58 (0.64)	0.738‡
POW 3	2.37 (0.79)	2.42 (0.86)	0.855‡
ROM			
Preoperative	124.81 (12.88)	122.65 (11.26)	0.519*
POD 3	93.07 (4.87)	91.19 (6.51)	0.238*
POW 1	106.85 (5.87)	105.62 (5.89)	0.448*
POW 2	117.41 (5.79)	116.69 (6.25)	0.667*
POW 3	131.67 (6.79)	131.92 (5.87)	0.884*
CY value			
POD 3	1.67 (0.68)	1.69 (0.68)	0.854‡
POW 1	1.44 (0.75)	1.46 (0.71)	0.843‡
POW 2	0.7 (0.54)	0.77 (0.65)	0.775‡
POW 3	0.22 (0.42)	0.23 (0.43)	0.941‡
PO aspiration	1 (37%)	0 (0%)	0.509+

Values presented as mean (standard deviation) and p calculated by using *unpaired t test, ‡Mann Whitney U test, and +chi Square. POD: Postoperative day, POW: Postoperative week, VAS: Visual analog scale. ROM: Range of motion, CY: Coupens and Yates. PO: Postoperative.

Discussion

The most significant finding of this study is that the administration of IV-TXA (1 g) in arthroscopic meniscectomies without a tourniquet did not enhance surgical visualization or reduce the need to inflate the tourniquet due to obstructed visibility when compared to the control group.

A bloodless field is crucial for optimal visibility during arthroscopic surgery [15,20]. TXA has been used to promote adequate visualization in intra-operative arthroscopy [15,20,21]. However, there is a lack of sufficient data on using TXA in

arthroscopic procedures and whether it enhances visibility during surgery. A recent randomized controlled trial found that administering IV-TXA improved surgical clarity during arthroscopic rotator cuff repair without increasing the risk of side effects [15]. Similarly, Ersin et al. [21] demonstrated that IV-TXA led to improved visual clarity during shoulder arthroscopy. However, the effect of IV-TXA on visual clarity during arthroscopic knee surgery is not well known. To our knowledge, no study has investigated the impact of IV-TXA on surgical clarity during knee arthroscopic meniscectomy without a tourniquet. In this study, we hypothesized that administering TXA would provide better visibility during arthroscopic meniscectomy without a tourniquet. However, at the end of the study, compared to the control group, the administration of IV-TXA did not provide enhanced surgical visualization.

The use of a tourniquet in knee arthroscopy is still debated despite its ability to provide clarity of surgical visibility [7,24-26]. Hoogeslag et al. [7] reported improved visibility with the use of a tourniquet in routine knee arthroscopy procedures, but 10.2% of patients required inflation of the tourniquet due to fair or poor intra-operative arthroscopic visibility. Olszewski et al. [6] found that dilute epinephrine in normal saline irrigation fluid reduced the need for tourniquet utilization during routine arthroscopic knee surgery, with only 24.6% of patients requiring tourniquet inflation. Similarly, Johnson et al. [23] reported no significant difference in operative views between groups with and without inflated tourniquets during knee arthroscopy.

In this study, using a tourniquet during routine knee arthroscopic meniscectomy was unnecessary. The need for tourniquet inflation was 11.1% in the TXA group and 15.38% in the control group, comparable to the literature. The mean tourniquet time for patients in whom the tourniquet was used was considerably shorter in both groups than in the literature. This could help reduce tourniquet-related complications due to prolonged use. The duration of surgery was also not significantly different between the TXA and control groups. These findings suggest that arthroscopic knee surgery can be performed safely and effectively without the routine use of a tourniquet. However, the administration of IV-TXA did not provide any additional benefit in reducing the need for a tourniquet or improving surgical visualization.

In previous studies, a pressure-controlled pump in arthroscopic knee surgery has been suggested to improve visualization [24,25]. However, using an infusion pump system can result in pain and quadriceps inhibition, potentially leading to muscle weakness and joint distension [26,27]. In some rare cases, using an infusion pump has resulted in complications such as complete femoral nerve palsy [28]. In this study, a pressure pump was not used, and instead, the gravity technique was applied to administer a continuous flow of the saline irrigation solution with cold (4°C), which may constrict the blood vessels around the surgical field. Although the administration of IV-TXA was found to be ineffective in promoting visual clarity when compared to the control group, based on our findings, arthroscopic meniscectomy with the irrigation solution with cold (4°C) can be performed without a tourniquet, which is an alternative way to enhance surgical visualization and reduce the need to inflate the tourniquet due to obstructed visibility during arthroscopic meniscectomy. However, further evaluation is needed to determine whether the irrigation solution with cold (4°C) can enhance surgical visualization and reduce the need for a tourniquet.

TXA has been investigated for its potential to decrease hemarthrosis and pain and increase knee function in patients undergoing anterior cruciate ligament reconstruction (ACLR) [14,29]. Karaaslan et al. [14] demonstrated that administering TXA intravenously before tourniquet inflation and continuing for 3 h after surgery reduced hemarthrosis, decreased pain, and improved knee function in the early postoperative period. However, a more recent study by Fried et al. [29] investigating the use of IV-TXA in patients undergoing ACLR suggested that IV-TXA did not result in a reduction of postoperative pain, range of motion, or hemarthrosis. This conclusion was also reached by Nugent et al. [30], who found no significant improvement in pain scores, range of motion, or hemarthrosis at any of the evaluated time points in their study. In the present study, administering 1 g of IV-TXA with a tourniquet in arthroscopic meniscectomy improved Tegner activity scores at 3 days postoperatively. However, consistent with the literature, the outcomes of the present study demonstrated that TXA did not reduce hemarthrosis, alleviate subjective pain, or improve the range of motion in the postoperative period.

In this study, several limitations should be considered. First, the visual clarity was only recorded at the end of the surgery, which may not reflect the bleeding dynamic during the entire surgery. Second, the dose of TXA was not based on the patient's body weight, which may have resulted in some patients not receiving enough effective drug concentrations. Third, using a pressure-controlled pump may have improved visualization but was not used in this study to reflect the common use of gravity flow in routine knee arthroscopy. Fourth, it is unclear how long the surgeon waited to regain visibility to intraoperatively inflate the tourniquet to perform the procedure due to impeded vision. Lastly, the surgeon rated the visual field's intraoperative clarity subjectively using an NRS, which may have introduced bias.

Conclusion

In conclusion, administering IV-TXA in arthroscopic meniscectomy without a tourniquet did not benefit enhanced surgical visualization or reduce the need to inflate the tourniquet. However, using irrigation solution with cold (4°C) may be an alternative way to enhance surgical visualization and reduce the need for a tourniquet. Furthermore, TXA did not decrease hemarthrosis or VAS pain scores or improve knee range of motion in the postoperative period.

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