Original Article

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A Novel External Fixator Designed for a More Comfortable and Secure Hip Arthroscopy

Daha Rahat ve Güvenli Kalça Artroskopisi için Yeni Bir Eksternal Fiksatör Tasarımı

Anıl PULATKAN, Vahdet UÇAN, Fatih YILDIZ, İbrahim TUNCAY

Bezmialem Vakıf University Faculty of Medicine, Department of Orthopedics and Traumatology, İstanbul, Turkey

ABSTRACT

Objective: To evaluate the functional results of a novel external fixator (EF) designed for joint distraction and prevention of traction table-related hip arthroscopy complications

Methods: After obtaining promising results in a cadaveric study, 21 hips of 20 patients underwent EF-assisted arthroscopic hip surgeries for femoroacetabular impingement (FAI) and/or labral tear treatments. Patients were operated on a standard operating table in the supine position. A novel EF was used to distract the joint for central hip arthroscopy. The time needed for EF application and joint distraction and the amount of joint distraction were recorded. Preoperative functional scores were retrospectively compared to the postoperative 5-year follow-up results using the Harris Hip and Western Ontario and McMaster Universities Index scores.

Results: All patients underwent peripheral and central arthroscopy. The mean time for EF application and joint distraction was 19 min (range: 8-21). The mean amount of joint distraction was 13.2 mm (range: 12-18). None of the arthroscopic procedures had to be converted to open surgery. Functional results of all patients were improved at the 5-year follow-up ($p<0.01$). Only one patient required hip arthroscopy revision due to residual FAI. No other major or minor complication was found that is related to the EF or arthroscopy itself.

Conclusion: Mid-term outcomes following EF-assisted hip arthroscopy demonstrate significant improvement in the functional outcomes without traction table-related complications. EF can be used as an alternative to traction table to maintain adequate hip

ÖZ

Amaç: Kalça artroskopisinde traksiyon masası ile ilişkili komplikasyonların önlenmesi ve eklem distraksiyonu için tasarlanmış yeni bir eksternal fiksatörün (EF) fonksiyonel sonuçlarını araştırmaktır.

Yöntemler: Kadavra çalışmasında ümit verici sonuçlar elde ettikten sonra 20 hastanın 21 kalçasına femoroasetabuler sıkışma (FAS) ve/veya labral yırtık tedavisi için EF destekli kalça artroskopi cerrahisi uygulandı. Hastalar sırtüstü pozisyonda standart ameliyat masasında opere edildi. Santral kalça artroskopisinde eklemin distraksiyonu için yeni tasarım EF kullanıldı. EF uygulanması ve eklem distraksiyonu elde edilmesi için gereken süre ile distraksiyon miktarı kaydedildi. Ameliyat öncesi Harris Kalça ve WOMAC fonksiyonel skorları ameliyat sonrası beş yıllık takip sonuçları ile retrospektif olarak karşılaştırıldı.

Bulgular: Tüm hastalara periferik ve santral kalça artroskopisi uygulandı. EF uygulaması ile eklem distraksiyonu için gereken ortalama süre 19 dakikaydı (dağılım: 8 ila 21). Eklem distraksiyonunun ortalama miktarı 13,2 mm (dağılım: 12-18) idi. Artroskopik prosedürlerin hiçbirinde açık cerrahiye geçilmek zorunda kalınmadı. Ameliyat sonrası beş yıllık takipte tüm hastaların fonksiyonel sonuçları ameliyat öncesine göre iyileşti ($p<0,01$). Sadece bir hastada rezidüel FAS nedeniyle revizyon kalça artroskopisi yapıldı. EF veya artroskopinin kendisi ile ilgili başka bir majör veya minör komplikasyon görülmedi.

Sonuç: EF destekli kalça artroskopisini takiben traksiyon masası ile ilişkili komplikasyon riski olmaksızın fonksiyonel sonuçlarda

Address for Correspondence: Anıl PULATKAN, Bezmialem Vakıf University Faculty of Medicine, Department of Orthopedics and Traumatology, İstanbul, Turkey
E-mail: anilpulatkan@gmail.com **ORCID ID:** orcid.org/0000-0003-0083-901X

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distraction in arthroscopic hip surgery. In addition to the rotation, a novel designed EF allows hip joint flexion during distraction contrary to traction table.

Keywords: Arthroscopy, external fixator, hip, traction, complication

anlamlı düzelme görülmektedir. EF artroskopik kalça cerrahisinde yeterli distraksiyon sağlanması amacıyla traksiyon masasına alternatif olarak kullanılabilir. Yeni tasarım EF distraksiyon sırasında kalça ekleminin rotasyonuna ek olarak fleksiyona da izin verir.

Anahtar Sözcükler: Artroskopi, eksternal fiksatör, kalça, traksiyon, komplikasyon

Introduction

Hip arthroscopy was firstly performed in 1931; however, arthroscopic hip surgery has been popularized in the last two decades with the development of specific instruments, arthroscopic tools, and better hip joint pathology understanding (1-4). The anatomical of hip joint constraints make its scope more challenging than the other joints. Adequate joint distraction should be obtained and maintained to visualize the joint inside, especially the central compartment, and to intervene inside the hip (5-8). Therefore, traction tables are widely used. However, some specific complications, such as pudendal nerve palsy and perineal soft tissue necrosis, which are directly related to the distraction or increase perineal post pressure on the skin, have been reported (6,9). Additionally, traction or perineal post-related nerve dysfunction after hip arthroscopy is an under-reported complication (10). Another disadvantage of the traction table is its limitation on the hip joint motions during the surgery. These difficulties and complications make this procedure more challenging. Thus, an external fixator (EF) is designed to eliminate the complications due to traction table and to allow hip flexion and rotation during distraction to perform a more secure and comfortable hip arthroscopy.

A two-stage retrospective study was designed to evaluate the safety and outcomes of our novel external distraction device for patients undergoing hip arthroscopy. The first stage was a cadaveric study and the second stage was the application of EF in patients.

The study hypothesized that joint distraction with the use of an EF can be a safe and alternative method to a traction table with similar success rates and less risk of traction table-related complications in arthroscopic hip surgeries. This study aimed to evaluate the effectiveness and safety of a novel EF for joint distraction in the arthroscopic treatment of hip pathologies.

Method

After a satisfactory cadaveric study, instructional review board and local ethical committee approvals were obtained for the clinical retrospective study. Detailed information about the surgical interventions was provided to all patients and each patient signed an informed consent form, including the treatment alternatives, operative technique, and complications.

Patient Selection

Between December 2010 and October 2012, 36 consecutive patients undergoing hip arthroscopy were proposed to participate in this study. Patients, who were informed about the study and then accepted the EF application, were included. Patients over 60 years old were excluded due to possible fracture risk around the Schanz screws secondary to osteoporosis. Twenty-seven patients fulfilled the inclusion and exclusion criteria mentioned above and agreed to participate in our study and seven patients were lost to follow-up. Of 20 consecutive patients (10 male and 10 female) with a mean age of 34.1 (range: 19-46) years, 21 hips (10 right and 11 left) underwent EF-assisted arthroscopic hip surgery. The etiologies include isolated cam-type femoroacetabular impingement (FAI) in six patients, cam-type FAI and concomitant labral tear in five patients, pincer type FAI in one patient, mixt type (cam + pincer) FAI and concomitant labral tear in three patients, and isolated labral tear in six patients.

Only cam resection was performed in six patients, cam resection and labral tear debridement in five patients, pincer resection in one patient, labral repair with suture anchors and cam and pincer resection in three patients, and labrum debridement in six patients with an isolated labral tear.

External Fixator

The EF was made of stainless steel, weighing 1,750 grams, 280 mm in width, 235 mm in height at the distal part, 130 mm in height at proximal part, and 83 mm in depth. The novel EF can carry an 800 N (80 kg) load and can be distracted up to 105 mm with the help of a distraction device. The fixator has two hinge clickers, one in the proximal and one in the distal part, a vertically oriented clamp on its proximal part for the insertion of two or three half-pins to the supra acetabular region, and a T-shaped clamp on its distal end for fixation of the Schanz screws to the femoral diaphysis (Figure 1).

Preliminary Cadaveric Study

A preliminary cadaveric study was performed with this novel designed EF to check if it easily works and provides an adequate hip joint distraction. Four hips of two male fresh frozen cadavers (with ages 54 and 64 years) were prepared. According to the plain radiographs, the cadavers without obvious degeneration or arthrosis signs in their hip joints were included and those with hip deformity were excluded. The EF was fixed to the pelvis on the supra acetabular region and the mid diaphysis of the femur using two half-pins for each region. Turning the distractor of the fixator under fluoroscopic control resulted in increased femoroacetabular distance. After obtaining an adequate amount

of joint space, central and peripheral regions were evaluated through standard arthroscopic portals.

Surgical Technique

Patients were placed in a supine position on a standard operating table, and the fluoroscopic view of the operative hip joint was checked under general or regional anesthesia. Fluoroscopy, image intensifier screening, and arthroscopy system were placed on the opposite side of the operative leg that faces the surgeon. Two 6 mm half-pins were applied, 2 cm above the supra acetabular region joint in about 30˚ abducted position to prevent impingements of the arthroscopy instruments to the Schanz screws around the hip and reach into the central compartment easily (Figure 2). The screws were fixed to the proximal clamp of the fixator. Another two 6 mm half-pins were inserted perpendicular to the mid diaphysis of the femur after 30˚ abduction of the operative leg and predrill in the insertion site of the screws, and they were fixed to the T-clamp of the fixator.

After EF application, the EF distractor was rotated in a counter-clockwise direction until the adequate widening of the hip joint, under the fluoroscopic control, was obtained (Figures 3 and 4). Subsequently, the central and peripheral regions of the hip joints were evaluated, and arthroscopic intervention was performed through standard arthroscopic portals. To reach far areas in the peripheral or central compartment, flexion or rotational movements of the distracted hip joint were possible with the novel EF (Figure 5). After carrying out the operation in the central compartment, the distractor was released and intervention in the peripheral compartment was performed without distraction as standard. The EF and half-pins were removed at the end of the arthroscopic procedure and arthroscopy portals and screw entry sites were sutured using absorbable monofilament materials.

Operation Findings Assessment

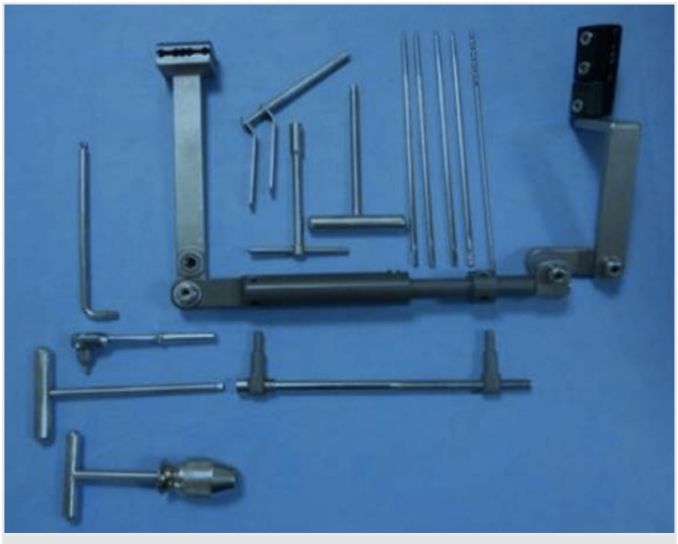

Figure 1. The novel designed EF, its distractor, half-pins, and other instruments for the set-up
EF: External fixator

The outcome parameters include the required time for EF application and adequate distraction and the amount of joint distraction. The distance between the most superolateral edge of the acetabulum and the femoral head was measured on the fluoroscopy images before and after the distraction in the same leg position. The radius of the 6 mm Schanz screws placed at the supra acetabular area was also measured on the fluoroscopy images and the rate of magnifier was found for each patient. The difference between the post- and preoperatively measured lengths was multiplied with the magnifier ratio and the corrected distraction value was found.

Functional Outcome Assessment

The Harris Hip Score (HHS) and the Western Ontario and McMaster Universities Index (WOMAC) scores were evaluated

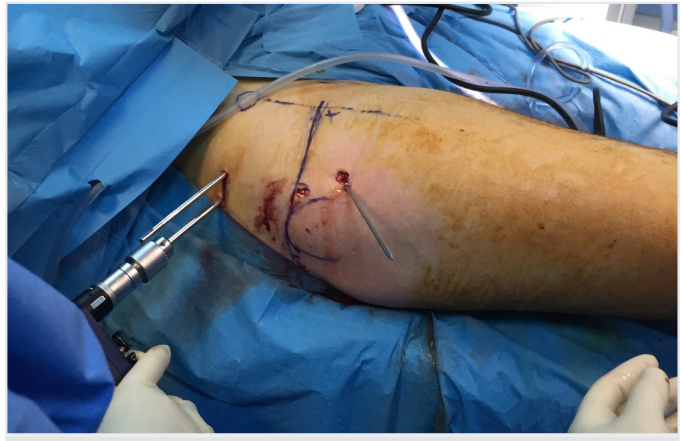

Figure 2. Application of the proximal Schanz screws to the supra acetabular region

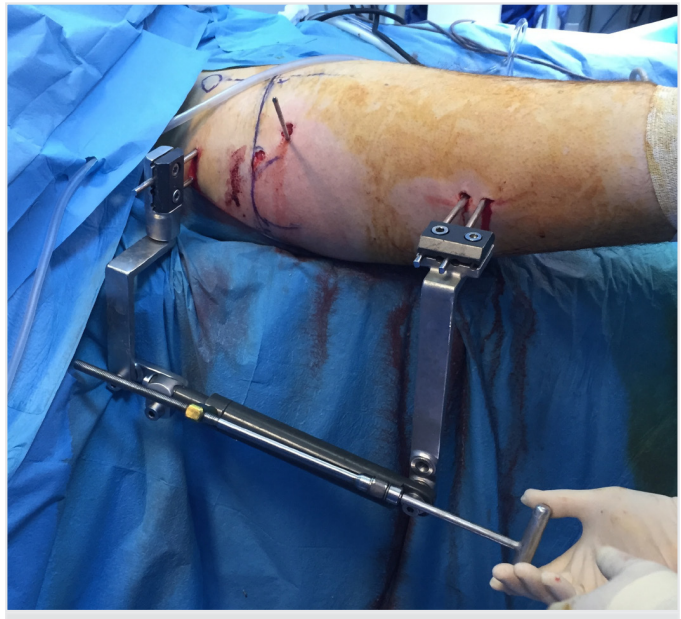

Figure 3. After the Schanz screw insertion and EF set-up, the distractor was rotated in a counter-clockwise direction to achieve joint distraction using its T-handle
EF: External fixator

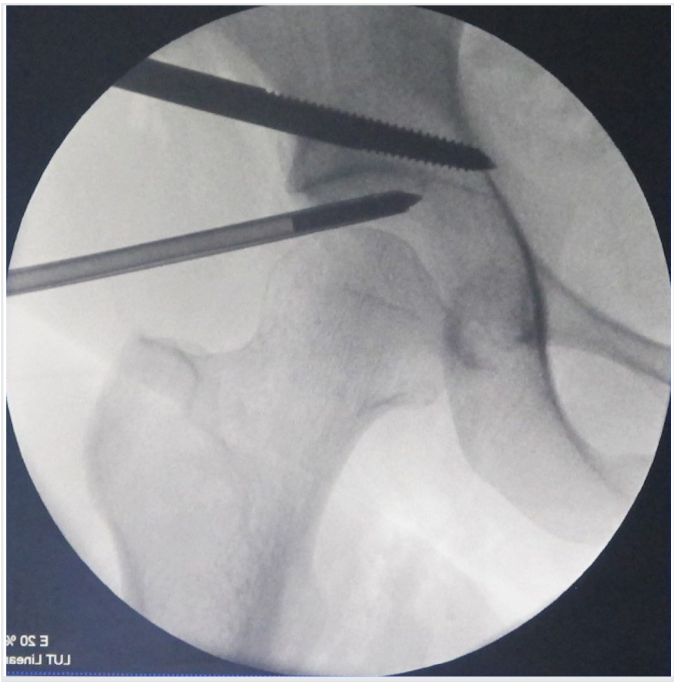

Figure 4. The amount of distraction, half-pin positions, bony integrity under distraction forces, and arthroscopy instrument placement controlled under fluoroscopy

by a research physiotherapist without prior knowledge of the surgical reports and radiological imaging pre- and postoperatively at the 5-year follow-up. Pre- and postoperative functional results were statistically compared.

Follow-up Protocol

Postoperative rehabilitation protocol included an immediate range of motion (ROM) exercises with the help of a continuous passive motion device for the first 2 days. All patients were discharged on the second day of surgery with a home rehabilitation protocol, which include hip joint ROM exercises and strengthening exercises for the musculature around the hip. Patients, who underwent cam or pincer resection, were allowed non-weight bearing walking with crutches for the first 3 weeks and partial weight-bearing with crutches between the third and sixth week of surgery. After 6 weeks, full weight-bearing was allowed. Full weight-bearing without crutches was allowed for patients who underwent labral debridement alone, whereas patients who underwent labrum repair were allowed non-weight bearing with crutches for the first 6 weeks as standard.

Statistical Analysis

All statistical analysis was performed using the Statistical Package for the Social Sciences statistical software package (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). The Shapiro-Wilk test was used to determine the concordance of the continuous data to normal distribution. Continuous data were presented as median (minimum-maximum) and mean ± standard deviation values. Preoperative and postoperative functional results were statistically compared using the paired t-test. Results were reported as 95% confidence intervals and related p-values, wherein $p<0.05$ was considered statistically significant.

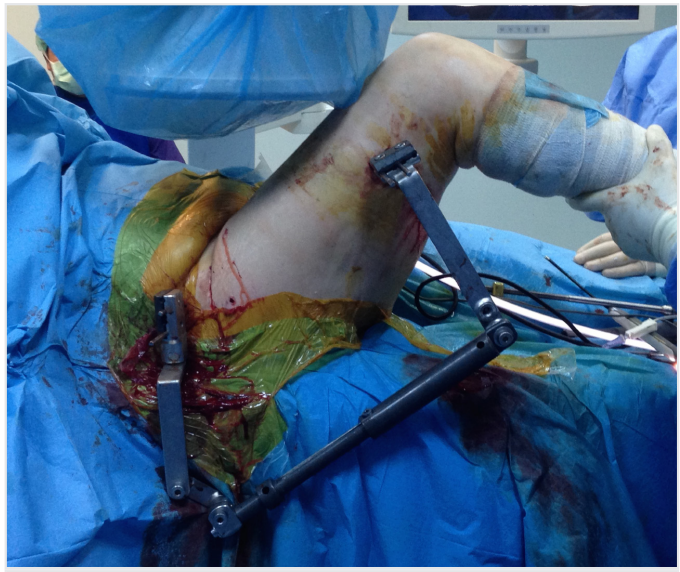

Figure 5. The novel EF allows up to 60 degrees of hip flexion as required
EF: External fixator

Results

Both central and peripheral compartment evaluations and interventions were easily performed in all patients. None of the arthroscopic procedures had to be converted to open surgery.

The mean total amount of required time for EF application and adequate joint distraction was 19 min (range: 8-21). A single fluoroscopy shot was taken at each stage of surgery to control ideal pin placement and effective distraction in all operations. The mean number of fluoroscopy shots was 22 (range: 18-28). The mean amount of effective joint distraction was 13.2 mm (range: 12-18). The mean HHS was improved from 57.1±15.3, preoperatively to 86.5±15.1, postoperatively ($p<0.001$). The mean WOMAC index was increased from 40.4±15, preoperatively to 89±7.3, postoperatively ($p<0.001$). During the surgeries, a minimum of 30˚ external and internal rotations was obtained using the EF while distraction was maintained.

One female patient had complaints of continuing hip pain and impingement symptoms similar to her preoperative status that was diagnosed as residual FAI due to inadequate cam resection required arthroscopic surgery revision. Almost all patients (19 of 20) had lateral hip pain around the pinholes of the supra acetabular and femoral regions. Their complaints were over in 3 days with postoperative anti-inflammatory drug treatment. No other complication related to arthroscopic hip surgery, such as neurological complications, soft tissue problems, heterotopic ossification, or osteoarthritis, was noted.

Discussion

Hip joint distraction is essential for arthroscopic hip procedures (11). Most surgeons place patients in the supine position on the traction table; however, these procedures can be also performed

in the lateral decubitus position (5,7). Meanwhile, successful results of joint distraction with the help of an EF were already reported (12).

This study introduces a novel EF design for joint distraction as part of the arthroscopic hip surgeries, which was considered to eliminate traction table or perineal post-related complications. Additionally, surgery becomes easier using the EF since it allows hip flexion and rotation while maintaining joint distraction. Dienst et al. reported that better hip joint distraction was achieved at 20 degrees of flexion without abduction (13). Therefore, we designed the novel EF and test it in a preliminary cadaveric study. After getting easy and adequate hip joint distractions on the cadavers, a clinical study was started, which obtained satisfactory results without EF-related complications.

Several complications that are directly related to the traction table usage were reported, such as neuropraxia (transient or permanent pudendal, sciatic or common peroneal nerve injuries), soft tissue problems (genitoperineal skin necrosis and vulvar hematoma), crush syndrome, or well-leg compartment syndrome (6,9,11). Ankle fracture, skin irritations, foot and ankle paresthesias, and vascular obstruction at the level of the ankle joint directly related to tight foot fixation in the traction device boot have been reported (14-16), mainly due to traction misuse, inappropriate perineal post use, and hemilithotomy position for the well-leg. Positive correlations were well-presented in several studies between the pudendal nerve palsy incidence and perineal post size, and amount of the traction force (9,17,18). The current study revealed no complications, most probably due to the use of EF and no traction table. Only one patient required hip arthroscopy revision due to the continuing impingement symptoms. In her second look arthroscopy, a residual cam was observed and arthroscopic re-resection was performed. Her complaints were over at the 5-year follow-up. However, the number of patients in our study is too low to conclude that this technique prevents complications.

A prospective study by Flecher et al. (12) described the use of hip distractor in the arthroscopic treatment of FAI and reported the functional results of 23 patients. They indicated no complication in their consecutive series and concluded that using a distractor during hip arthroscopy is a reproducible and reliable technique in FAI treatment. Their hip distractor showed similarities with the novel EF in our study. However, novel EF differs with its ability to allow flexion and rotational movements of the hip joint while maintaining distraction. Moreover, Schanz screw application to the femoral diaphysis provides a wider working area around the hip joint, which facilitates the use of accessory arthroscopic portals when required. Another difference in their study is that all operations were performed in the lateral decubitus position, whereas the patients in our series were operated in a supine position. Additionally, in their study hip arthroscopies were performed only for FAI treatment, whereas ours is not only for FAI but also for labral tears.

Contrarily, Merrell et al. (19) used a deflated beanbag instead of the perineal post to reduce the complications due to the perineal post. They used pillows, blankets, and tape to secure the patient to the beanbag and table. They reported that their technique provides sufficient stability for adequate traction and good visualization while minimizing the risk of pudendal nerve palsy. However, the beanbag that wraps around the abdomen may slip in patients with obesity during surgery. Details of 30 patients in their study were not provided.

Study Limitations

This study has several limitations, including its retrospective nature and lack of a control group. Another limitation is the small number of patients with heterogeneous etiologies and interventions. Some potential EF-related complications, such as fractures or visceral proximal half-pin penetration, may occur in larger series, which was not experienced in our case series. All surgeries were performed by a single senior surgeon and the experience of different surgeons was not included in the study may be another limitation point.

Conclusion

In conclusion, mid-term outcomes of EF-assisted hip arthroscopy demonstrate significant improvement in the functional outcomes with the advantage of avoiding traction table-related complications. EF can be used as a safe, reliable, and reproducible alternative to traction tables to obtain adequate joint distraction in arthroscopic hip surgery. Novel EF allows hip joint rotation and flexion during the distraction, as well as supine position operation. Further prospective randomized controlled comparative studies that involve more patients are necessary to determine which joint distraction technique might be superior in complication rates for arthroscopic hip procedures.

Ethics

Ethics Committee Approval: After a satisfactory cadaveric study, instructional review board and local ethical committee approvals were obtained for the clinical retrospective study.

Informed Consent: Detailed information about the surgical interventions was provided to all patients and each patient signed an informed consent form, including the treatment alternatives, operative technique, and complications.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: İ.T., Concept: F.Y., Design: A.P., Data Collection or Processing: V.U., Analysis or Interpretation: V.U., Literature Search: A.P., Writing: İ.T.

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

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