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Ankle Arthroscopy as an Adjunct to the Management of Ankle Fractures

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Abstract

Background: Ankle fractures are one of the most common injuries managed by orthopedic surgeons. Although the etiology of posttraumatic osteoarthritis in anatomically reduced ankle fractures is not completely known, several studies suggest that undetected intra-articular pathology at the time of injury may play a role. The purpose of this study is to report the operative findings of ankle arthroscopy as an adjunct to ankle fracture open reduction and internal fixation.

Methods: A retrospective review was performed of all ankle fractures treated consecutively at our institution by a single surgeon from August 2010 to October 2019, which were found using *Current Procedural Terminology* codes. A total of 84 patients met our inclusion criteria for whom patient demographics and clinical history were collected. Pre- and post-operative diagnoses from every operative report were noted as well as intra-articular intervention made during the time of arthroscopy.

Results: The study included 49 men (58.3%) and 35 women (41.7%), with a mean age of 39.0 (range, 12-69; SD = 15.0) years. Sixty-three patients (75%) had new diagnoses detected by the addition of ankle arthroscopy. The most common new pathology seen arthroscopically were osteochondral lesions (n = 36, 41.9%) and posterior malleolus fractures (n = 28, 32.6%). Thirty-four patients had a total of 40 additional arthroscopic procedures in conjunction with their fracture management. Complications were noted in 13 patients, with hardware removal (n = 8) being the most common (62%).

Conclusion: Ankle arthroscopy can act as a significant diagnostic and prognostic tool and can help address intra-articular injuries without adding considerable cost or serious adverse events.

Level of Evidence: Level IV, retrospective case series.

Keywords: ankle fracture, ankle arthroscopy, arthroscopy assisted ankle fracture

Introduction

Ankle fractures are one of the most common injuries managed by orthopedic surgeons, occurring in 0.1% to 0.2% of the population annually,[7] and can lead to posttraumatic osteoarthritis (PTOA), which is a frequent cause of disability.[4] Several studies with short- to intermediate-term follow-up cite that 10% to 20% of patients have fair or poor outcomes after open reduction and internal fixation (ORIF) of ankle fractures.[5,9,13,18] A 5-year follow-up study revealed that approximately 1% of patients status post ORIF of ankle fracture developed end-stage joint arthritis and underwent a total ankle replacement or ankle fusion.[22] Despite an anatomic reduction, however, intermediate to long-term outcome data reveal poor and fair outcomes in up to 40% to 60% of these postoperative patients.[8,13,20]

Although the etiology of PTOA in anatomically reduced ankle fractures is not completely known, several studies suggest that undetected intra-articular pathology at the time of injury may play a role.[13,19,23] Cartilage injury has been confirmed at the time of arthroscopy-assisted fracture fixation in 60% to 80% of ankle fractures.[14,17,19,23] In addition, Adams et al[3] found an increase of proinflammatory cytokines and matrix-degrading proteins in the synovial fluid of acutely fractured ankles when compared to their uninjured ankle. Further, this acute change in the synovial fluid was

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found to lead to an intra-articular catabolic environment by 10 days after injury, which may further contribute to the development of PTOA and may be prevented by an ankle lavage.[2] Ankle arthroscopy has also been found to be more sensitive in identifying syndesmotic disruption in Weber B fibula fractures because of 3-dimensional assessment of the syndesmosis.[6] Thus, ankle arthroscopy as an adjunct to the management of ankle fractures can act as a diagnostic and prognostic tool,[21] aid in addressing intra-articular pathology, and may play a role in the prevention of PTOA.

Despite these benefits, an evidence-based review of this issue concluded that there was poor to fair evidence to support ankle arthroscopy at the time of ankle fracture fixation and could not make a recommendation for or against it.[12] In addition, a national database study from 2005-2011 concluded that only about 1% (313 patients out of 32 307) of Medicare patients with ankle fractures were concomitantly undergoing an ankle arthroscopy.[1] Although there are significant potential benefits, surgeons may prefer not to perform arthroscopy due to concerns regarding increased cost, operative time, and increased complications such as iatrogenic articular cartilage damage, soft tissue fluid extravasation, superficial peroneal nerve injury, or compartment syndrome to name a few.[13,15]

The purpose of this study is to report the operative findings of ankle arthroscopy as an adjunct to ankle fracture ORIF. We hypothesized that ankle arthroscopy would serve an important diagnostic and therapeutic role by detecting intra-articular pathology that can be succinctly addressed with minimal complications or additional cost.

Materials and Methods

After obtaining exemption from our institutional review board for our retrospective study, data were collected. All ankle fractures (n = 337) treated consecutively at our institution by a single surgeon from August 2010 to October 2019 were identified using the following ankle ORIF *Current Procedural Terminology* (*CPT*) codes: 27814, 27822, 27823, 27792, 27766, 27827, and 27828. The criteria of inclusion/exclusion for this study were as follows: (1) ankle arthroscopy performed as an adjunct to the ankle ORIF, (2) isolated acute ankle fracture treated within 6 weeks of injury, (3) age <70 years, and (4) no history of previous surgery of the ankle joint on the operative ankle. The ankle arthroscopy *CPT* codes 29898, 29895, 29894, and 29891 were used to identify patients that had a concomitant ankle arthroscopy at the time of fracture fixation.

Of the 337 patients we identified, 251 did not have a concomitant arthroscopy. Reasons for not performing a concomitant ankle arthroscopy at the time of fracture fixation included history of prior trauma and degenerative changes of the ankle joint, open or grossly unstable injury precluding arthroscopy, patient size (body mass index > 45), patient limitations (baseline nonambulatory), patient comorbidities complicating anesthesia and operative healing (American Society of Anesthesiologists grade ≥4), and infrequently, insurance or arthroscopy equipment failure and/or unavailability.

Hence, our study was composed of 84 of the 337 patients that met these criteria (25%) and underwent adjunctive ankle arthroscopy at the time of ORIF of the ankle. Of the 84 patients in this study, 49 were male (58%) and 35 female (42%), with a mean age of 39.0 years (range, 12-69; SD = 15.0). Full patient demographic details are displayed in Table 1.

Table 1. Patient Demographics.

Gender, n (%)	
Female	35 (41.7)
Male	49 (58.3)
Age, y, mean (range; SD)	39.0 (12-69; 15.0)
Race, n (%)	
White	24 (28.6)
Asian	1 (1.2)
African American	3 (3.6)
Unspecified	56 (66.7)
Ethnicity, n (%)	
Hispanic	19 (22.6)
Not Hispanic	47 (56.0)
Unspecified	18 (21.4)
Social history, n (%)	
Tobacco use	12 (14.3)
Alcohol use	16 (19.1)
Comorbidities, n (%)	
BMI >35	17 (20.2)
Diabetes mellitus	4 (4.8)
Immunosuppressive medications	2 (2.4)
Diabetic neuropathy	1 (1.2)
Peripheral vascular disease	1 (1.2)
Inflammatory arthritis	1 (1.2)
HIV/AIDS	0 (0)
ESRD	0 (0)
ESLD	0 (0)

Abbreviations: BMI, body mass index; ESLD, end-stage liver disease; ESRD, end-stage renal disease.

Clinical Data Collection

Retrospective data collection was performed from review of electronic medical records on 86 consecutive patients who underwent ankle arthroscopy at the time of ankle ORIF. Two patients were excluded because it was determined that they were not acute fractures (>6 weeks from date of injury). Patient records were reviewed to document the postoperative course and any complications until the final follow-up visit. Patient demographic data including age, gender, body mass index, and social history were obtained. Clinical history that may affect intra-articular pathology was also documented (inflammatory arthritis, use of immunosuppressive medications, peripheral vascular disease, diabetes mellitus, diabetic neuropathy, and comorbidities). Preoperative and postoperative diagnoses from every operative report were noted as

Figure 1. The positioning of the leg in a thigh holder as part of a noninvasive stirrup traction device used for ankle arthroscopy.

well as any intra-articular intervention made during the time of arthroscopy.

Operative Technique

Every patient included in the study underwent standard anterior ankle arthroscopy prior to ankle ORIF using standard anteromedial and anterolateral portal incisions. The patients were taken to the operating room and following administration of regional anesthesia; the lower extremity was prepped and draped in the usual sterile fashion. The thigh tourniquet was placed prior to prepping and draping the patient but was not inflated until the arthroscopy portion of the procedure was completed and the thigh holder was removed. Preoperative antibiotics were administered, and an operative timeout was performed. During the arthroscopy portion of the procedure, each ankle was placed in external traction with the lower extremity suspended in a thigh holder (Figure 1). Because of the unstable fracture, mild distraction is often all that is required using this noninvasive stirrup traction method to allow for visualization and instrumentation of the working space. A standard 21-point diagnostic ankle arthroscopy was performed[10] in each patient followed by arthroscopic intervention if needed. If a focal full-thickness articular cartilage lesion was noted, any unstable flaps were debrided, the calcified cartilage layer was then debrided from the base of the lesion and microfracture was performed. Partial-thickness articular cartilage lesions underwent a debridement chondroplasty, removing any unstable flaps. After removal of the thigh holder, the tourniquet was inflated and the open reduction internal fixation part of the procedure was performed.

Results

Fracture characteristics are given in Table 2; the most common fracture type was bimalleolar (47.6%). Twenty-seven

Table 2. Fracture Characteristics.

Ankle of injury, n (%)	
Dominant	39 (45.9%)
Non-dominant	46 (54.1%)
Fracture type, n (%)	
Weber B or C bimalleolar equivalent	6 (7.1%)
Bimalleolar	40 (47.6%)
Trimalleolar	19 (22.6%)
Unspecified	19 (22.6%)
Time from injury to surgery, d, mean (range; SD)	10.7 (0-57; 10.1)

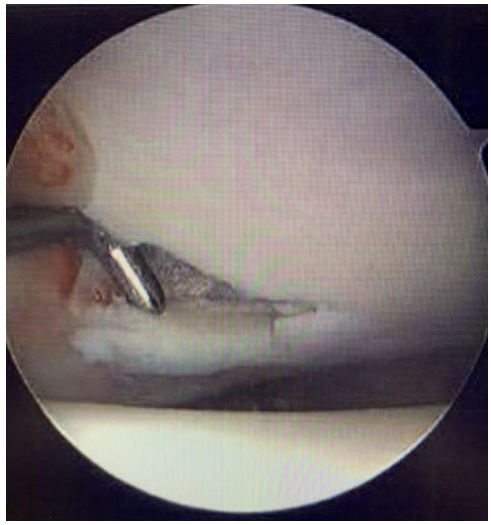

Figure 2. Arthroscopic image depicting an osteochondral lesion noted on the tibial surface of the joint.

(32.1%) patients required overnight admission to the hospital, whereas 57 (67.9%) patients were discharged on the same day.

Sixty-three patients had a total of 86 new diagnoses added after ankle arthroscopy. The most common additional diagnoses detected by arthroscopy and not known to be present preoperatively were osteochondral lesions as seen in Figure 1 and Figure 2 (n = 36, 41.9%) and posterior malleolus fracture (n = 28, 32.6%). Table 3 lists all additional pathology detected by including an arthroscopy prior to open treatment. Thirty-four patients underwent 40 adjunctive arthroscopic procedures including partial synovectomy, loose body excision, microfracture, and chondroplasty (Table 4**)**. The average additional cost per case associated with arthroscopy was $253.77.

Complications were noted in 13 of 84 patients (15.5%), and 12 patients had a total of 13 reoperations as displayed in Table 5. Hardware removal (HWR) for symptomatic hardware was the most common complication (62%). All 8 patients with symptomatic hardware had pain laterally over the fibular plate and screws, and their symptoms were resolved following HWR. Three patients were noted to have superficial peroneal nerve pathology, but 2 of the 3 had

Table 3. Additional Diagnoses Found by Ankle Arthroscopy Prior to Open Treatment.

OCD	36
Posterior malleolus fracture	28
Loose body	14
Syndesmosis disruption	5
OCD and loose body	1
Other	2
Total	86

Abbreviation: OCD, osteochondral defect.

Table 4. Arthroscopic Procedures Performed Prior to Open Reduction and Internal Fixation.

Chondroplasty	19
Microfracture	17
Loose body excision	15
Partial synovectomy	7
Other	1
Total	40

Table 5. Complications (n = 13).

Symptomatic hardware	8
SPN pathology	3
Nonunion	1
Infection	1
Additional surgery	
Second operation	12
HWR for symptomatic hardware	8
Reinjury	2
Revision for nonunion	1
I&D for Infection	1
Third operation	1
Repeat I&D and HWR for infection	1

Abbreviations: HWR, hardware removal; I&D, irrigation and debridement; SPN, superficial peroneal nerve.

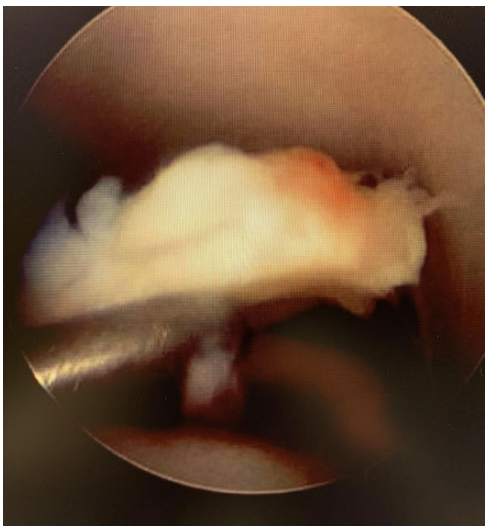

Figure 3. Arthroscopy image detecting an osteochondral lesion noted in the medial talus.

complete resolution of their symptoms by last follow-up. Only 1 patient had a postoperative infection. This patient initially underwent an irrigation and debridement (I&D) but subsequently returned with a deep infection that was successfully treated with a second I&D and HWR requiring no further treatment. One patient developed a nonunion and required revision surgery. There were no malunions, and no patients developed compartment syndrome.

Discussion

The standard ORIF treatment of ankle fractures have yielded good to excellent outcomes in only 70% to 80% of patients. Stufkens et al[24] published a systematic review of the literature and reported on 1822 patients with ankle fracture who underwent traditional ORIF with a mean follow-up time of 5.1 years. Despite anatomic reduction, they found that only 79% of patients had good to excellent long-term outcomes that did not necessarily correlate to the severity of the fracture. Egol et al[9] reported on a prospective study where they followed 198 patients status post standard ankle fracture ORIF and evaluated patient functional outcomes at a minimum of 1-year follow-up. They found that after 1 year, 90% of patients either had no limitations or limitations in recreational activities only and that 88% of patients had mild to no ankle pain. Conversely, Ponzer et al[20] reported functional outcome data on 41 patients after standard ankle fracture ORIF with 2-year follow-up. They noted that after 2 years, only 36% (13 of 36) of patients had complete recovery, with 44% (16 of 36) reporting work-related problems and 61% (22 of 36) claiming issues with sport activities. Overall, the data vary as far as patient outcomes after standard ankle fracture ORIF, but every study shows that there is room for improvement. In addition, Lambers et al[16] reported that 14% of patients following ORIF of ankle fractures with syndesmotic injury had osteochondral lesions on postoperative CT assessment, the majority of which they felt would have been amenable to treatment at the index surgery. Hintermann et al[14] reported the arthroscopic findings of a prospective consecutive series of 288 ankle fractures where 79% were found to have articular cartilage lesions. Hence, concomitant intra-articular injuries are often present with ankle fractures, and it is possible that they are a cause of poor outcomes justifying the role of arthroscopy.

This desire for improvement motivated a novel strategy of adding ankle arthroscopy as an adjunct to standard ankle ORIF to help better assess and address intra-articular pathology[21] in addition to cleaning out the joint of proinflammatory markers. Thordarson et al[26] produced a small prospective randomized study on the operative treatment of malleolar fractures with or without ankle arthroscopy. Nineteen patients with an average follow-up of 21 months

were selected and randomized to either ankle fracture ORIF or arthroscopy and ORIF. Nine patients were randomized to the ankle arthroscopy and ORIF group, and 8 of them were found to have articular damage to the dome of the talus via arthroscopy. There were no identified outcome differences between the 2 groups at final follow-up, and the 9 patients with cartilage injury did not have significant intervention addressing the joint pathology. Similarly, Fuchs et al[11] reported on 93 patients with unstable ankle fractures. They found that the 42 patients who underwent ankle arthroscopy open reduction and internal fixation (AAORIF) had no difference in Patient Reported Outcomes and Information System (PROMIS) scores compared with the 51 patients who underwent ORIF alone at 1-year follow-up. However, they concluded that AAORIF should be performed over ORIF alone when possible as it presents multiple benefits with minimal complications while not adding a significant amount of time to the case.

On the other hand, Takao et al[25] published a prospective randomized study of 72 patients with an average follow-up of 3.5 years who had distal fibular fractures at the level of the syndesmosis. The study compared patient outcomes with AAORIF or ORIF alone. In the AAORIF group, arthroscopy revealed osteochondral lesions in 73.2% (30 of 41) of cases and tibiofibular ligament disruptions in 80.5% (33 of 41). They had no complications in the AAORIF group, and AOFAS scores were significantly higher in this group (91.0) as compared to the ORIF group (87.6) ($P = .01$). The study deduced that patients fared better when intra-articular pathology was diagnosed and addressed with arthroscopy at the time of ankle ORIF.

Similarly, our study revealed that 63 of our 84 patients (75%) had intra-articular pathology that would have been otherwise missed without the addition of ankle arthroscopy prior to open fracture management. We found that the most common new diagnoses added were osteochondral lesions (n = 36, 42.4%) and posterior malleolus fracture (n = 28, 32.9%), both of which make a case for performing ankle arthroscopy as an adjunct to ankle fracture ORIF even if this added information is just for diagnostic and prognostic purposes. We found that 34 patients (40.5%) had a total of 40 additional procedures performed during arthroscopy in conjunction with their fracture management. The most common procedures were chondroplasty and microfracture for osteochondral lesions.

Regarding some of the perceived drawbacks of AAORIF, we did not find the added setup nor the additional time for arthroscopy burdensome, and the additional cost was around 250 dollars. Hence, we do not believe that these perceived concerns outweigh the additional diagnostic information gained by arthroscopy. As far as complications are concerned, 13 patients were noted to develop complications and 8 (62%) of these were symptomatic hardware removal, which we do not believe is attributable to the arthroscopy component of the procedure. While one patient developed a nonunion and another a deep infection of the lateral ORIF incision, these complications were likely related to the injury and/or ankle ORIF. There is no way to know whether the 3 patients who had SPN complications developed this as a result of the nerve block, lateral arthroscopic portal placement, or open fibula fracture exposure/fixation. However, none of these patients had abnormal SPN findings preoperatively; hence, the SPN complications certainly resulted from treatment of the ankle fracture. Of note, 2 of the 3 patients did fully recover by their last postoperative follow-up. No patients developed compartment syndrome.

Although this study did not include patient-reported outcome data, we feel that it does contribute to the body of evidence favoring anterior ankle arthroscopy at the time of ankle ORIF. AAORIF contributed additional diagnostic information and may have therapeutic benefit because of treatment of occult intra-articular pathology. Hence, it appears to be a practical option to consider particularly if there is heightened concern for acute intra-articular pathology such as in high-energy ankle fractures.[21] The orthopedic community is aware that the status quo of ankle fracture management is leaving up to 60% of patients with poor to fair long-term outcomes. Thus, we should do whatever we can to improve these outcomes, address all pathology associated with these injuries, prevent PTOA, and provide better diagnostic and prognostic information to the patient.

Limitations

Limitations of this study include its retrospective design and the potential biases that can result from using previously recorded data from medical records. For instance, we were not able to further classify the fracture patterns beyond what is provided in Table 2 because many patients provided outside radiographs that were not kept at our facility. The lack of a control group and patient-reported outcomes lessens its clinical impact. In addition, this study was performed at a private institution, and its findings may not be generalizable to other settings.

Conclusion

The addition of ankle arthroscopy as a diagnostic and therapeutic adjunct to open treatment of ankle fractures has a low complication rate and can detect and treat occult pathology that might otherwise be missed and potentially contribute to persistent symptoms following fracture healing. At the very least, arthroscopic evaluation of ankle fractures may add helpful information as to the extent of the injuries, allowing surgeons to form a more complete diagnosis and better inform patients regarding the extent of their injury.

Ethics Approval

Ethical approval for this study was obtained from the Texas Orthopedic Hospital Institutional Review Board (TOH222e).

Declaration of Conflicting Interests

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References

1. Ackermann J, Fraser EJ, Murawski CD, Desai P, Vig K, Kennedy JG. Trends of concurrent ankle arthroscopy at the time of operative treatment of ankle fracture: a national database review. *Foot Ankle Spec*. 2016;9(2):107-112.
2. Adams SB, Reilly RM, Huebner JL, Kraus VB, Nettles DL. Time-dependent effects on synovial fluid composition during the acute phase of human intra-articular ankle fracture. *Foot Ankle Int*. 2017;38(10):1055-1063.
3. Adams SB, Setton LA, Bell RD, et al. Inflammatory cytokines and matrix metalloproteinases in the synovial fluid after intra-articular ankle fracture. *Foot Ankle Int*. 2015;36(11):1264-1271.
4. Brown TD, Johnston RC, Saltzman CL, Marsh JL, Buckwalter JA. Posttraumatic osteoarthritis: a first estimate of incidence, prevalence, and burden of disease. *J Orthop Trauma*. 2006; 20(10):739-744.
5. Burwell HN, Charnley AD. The treatment of displaced fractures at the ankle by rigid internal fixation and early joint movement. *J Bone Joint Surg*. 1965;47(4):634-660.
6. Chan KB, Lui TH. Role of ankle arthroscopy in management of acute ankle fracture. *Arthroscopy*. 2016;32(11):2373-2380.
7. Da Cunha RJ, Karnovsky SC, Schairer W, Drakos MC. Ankle arthroscopy for diagnosis of full-thickness talar cartilage lesions in the setting of acute ankle fractures. *Arthroscopy*. 2018;34(6):1950-1957.
8. Day GA, Swanson CE, Hulcombe BG. Operative treatment of ankle fractures: a minimum ten-year follow-up. *Foot Ankle Int*. 2001;22(2):102-106.
9. Egol KA, Tejwani NC, Walsh MG, Capla EL, Koval KJ. Predictors of short-term functional outcome following ankle fracture surgery. *J Bone Joint Surg Am*. 2006;88(5):974-979.
10. Ferkel RD. *Foot and Ankle Arthroscopy*. Philadelphia, PA: Wolters Kluwer; 2017.
11. Fuchs DJ, Ho BS, Labelle MW, Kelikian AS. Effect of arthroscopic evaluation of acute ankle fractures on PROMIS intermediate-term functional outcomes. *Foot Ankle Int*. 2016; 37(1):51-57.
12. Glazebrook MA, Ganapathy V, Bridge MA, Stone JW, Allard JP. Evidence-based indications for ankle arthroscopy. *Arthroscopy*. 2009;25(12):1478-1490.
13. Gonzalez TA, MacAulay AA, Ehrlichman LK, Drummond R, Mittal V, Digiovanni CW. Arthroscopically assisted versus standard open reduction and internal fixation techniques for the acute ankle fracture. *Foot Ankle Int*. 2016;37(5):554-562.
14. Hintermann B, Regazzoni P, Lampert C, Stutz G, Gächter A. Arthroscopic findings in acute fractures of the ankle. *J Bone Joint Surg Br*. 2000;82(3):345-351.
15. Imade S, Takao M, Miyamoto W, Nishi H, Uchio Y. Leg anterior compartment syndrome following ankle arthroscopy after Maisonneuve fracture. *Arthroscopy*. 2009;25(2):215-218.
16. Lambers KTA, Saarig A, Turner H, et al. Prevalence of osteochondral lesions in rotational type ankle fractures with syndesmotic injury. *Foot Ankle Int*. 2019;40(2):159-166.
17. Leontaritis N, Hinojosa L, Panchbhavi VK. Arthroscopically detected intra-articular lesions associated with acute ankle fractures. *J Bone Joint Surg Am*. 2009;91(2):333-339.
18. Lindsjö U. Operative treatment of ankle fractures. *Acta Orthop Scand Suppl*. 1981;189:1-131.
19. Loren GJ, Ferkel RD. Arthroscopic assessment of occult intra-articular injury in acute ankle fractures. *Arthroscopy*. 2002; 18(4):412-421.
20. Ponzer S, Nåsell H, Bergman B, Törnkvist H. Functional outcome and quality of life in patients with type B ankle fractures: a two-year follow-up study. *J Orthop Trauma*. 1999;13(5): 363-368.
21. Sherman TI. Editorial commentary: optimizing surgical management of ankle fractures: is arthroscopy the answer? *Arthroscopy*. 2020;36(6):1722-1724.
22. SooHoo NF, Krenek L, Eagan MJ, Gurbani B, Ko CY, Zingmond DS. Complication rates following open reduction and internal fixation of ankle fractures. *J Bone Joint Surg Am*. 2009;91(5):1042-1049.
23. Stufkens SA, Knupp M, Horisberger M, Lampert C, Hintermann B. Cartilage lesions and the development of osteoarthritis after internal fixation of ankle fractures: a prospective study. *J Bone Joint Surg Am*. 2010;92(2):279-286.
24. Stufkens SAS, Van Den Bekerom MPJ, Kerkhoffs GMMJ, Hintermann B, Van Dijk CN. Long-term outcome after 1822 operatively treated ankle fractures: a systematic review of the literature. *Injury*. 2011;42(2):119-127.
25. Takao M, Uchio Y, Naito K, Fukazawa I, Kakimaru T, Ochi M. Diagnosis and treatment of combined intra-articular disorders in acute distal fibular fractures. *J Trauma*. 2004;57(6): 1303-1307.
26. Thordarson DB, Bains R, Shepherd LE. The role of ankle arthroscopy on the surgical management of ankle fractures. *Foot Ankle Int*. 2001;22(2):123-125.