Outcome Comparison of Arthroscopic versus Mini-open Technique for Ankle Arthrodesis

CURRENT STATUS: POSTED

Junliang Wang
Hainan Branch of Military General Hospital of Beijing PLA

junliangzq@126.com Corresponding Author
ORCiD: https://orcid.org/0000-0001-8443-4903

WENPING GE
beijing road medical center, general hospital of xinjiang military region

WENSHAN HU
hainan hospital of general hospital of PLA

FENG LIN
hainan hospital of general hospital of PLA

YUJIE LIU
hainan hospital of general hospital of PLA

10.21203/rs.3.rs-24173/v1

SUBJECT AREAS
Orthopedic Surgery

KEYWORDS
Arthroscopy Mini-open Ankle arthrodesis; Case-control study
Abstract

Background
Ankle arthrodesis is considered to be the gold standard for the treatment of end-stage ankle diseases. At present, the commonly used methods of ankle arthrodesis include open ankle arthrodesis, arthroscopic ankle arthrodesis and mini-open ankle arthrodesis. The authors analyze and compare the clinical efficacy and related complications of arthroscopic ankle arthrodesis and mini-open ankle arthrodesis in the treatment of end-stage ankle disease.

Methods
From January 2007 to June 2018, 56 patients with end-stage ankle joint pathology were treated with arthroscopic ankle arthrodesis and mini-open ankle arthrodesis. There were 30 cases in arthroscopy group, including 19 males and 11 females with an average age of 49.6 years old (ranged, 32 to 71); while 26 cases in mini-open group, including 18 males and 8 females with an average age of 48.3 years old (ranged, 43 to 65). The operative time was calculated with use of computerized operative and anesthetic records. The pain visual analogue score (VAS), American Orthopedic Foot and Ankle Society ankle and hind foot score (AOFAS), fusion rate, complications rate, length of hospital stay, operation time, and tourniquet time were compared between the two groups of patients.

Results
51 patients were followed up for 15–35 months (mean, 22.5 ± 1.5) months. The bony fusion was achieved in all patients. The average time to fusion was 12.4 weeks (range, 10–16 weeks). The VAS score 3 days post-operation was (6.37 ± 0.69) points in the arthroscopy group and (7.61 ± 1.05) points in the mini-open group, there was significant difference between the two groups (P < 0.05). The VAS score and AOFAS score between the two groups pre- and post-operation have statistically significant differences (P < 0.05). At the last follow-up, VAS score was (1.55 ± 0.57) in the arthroscopy group and (1.43 ± 0.73) in the mini-open group, and there was no significant difference between the two groups (P > 0.05). The AOFAS score was (85.32 ± 2.96) points in the arthroscopy group and (86.72 ± 3.05) points in the mini-open group, and there was no significant difference between the two groups (P > 0.05). Arthroscopic ankle fusion was associated with a shorter tourniquet time and shorter length of hospital stay compared to mini-open ankle fusion (P < 0.05); however, there was no
significant difference between two groups in terms of operation time (P > 0.05). Wounds healing was satisfying during the follow-up in the arthroscopy group. But the wounds healing was delayed in two patients of the small incision group. All patients were satisfied with the surgery.

Conclusion
Arthroscopic ankle arthrodesis and mini-open ankle arthrodesis have satisfactory curative effect and fusion rate. Arthroscopic assisted ankle arthrodesis has more advantages, including small incision, less injury, and low morbidity.

Background
Ankle arthrodesis is an effective method for the treatment of end-stage ankle diseases. At present, many different surgical procedures have been described[1]. The commonly used methods of ankle arthrodesis include open ankle arthrodesis, arthroscopic ankle arthrodesis and mini-open ankle arthrodesis. Open ankle arthrodesis surgery is mainly used for patients with obvious malalignment of ankle joint, which has the advantage of better correction of force line, but the recovery period of open surgery is longer, and extensive peeling during operation is easy to cause poor wound healing after operation.
In recent years, with the continuous popularization of minimally invasive concept and the continuous development of arthroscopic technology, arthroscopic ankle arthrodesis and mini-open ankle arthrodesis have been widely used because of their high fusion rate and low incidence of complications [2, 3]. Nonetheless, to our knowledge, comparison between arthroscopic and mini-open technique for ankle arthrodesis has not been reported in a series of patients.
The purpose of the study was to evaluate and compare the clinical efficacy of arthroscopic ankle arthrodesis and mini-open ankle arthrodesis. A series of 56 cases of end-stage ankle diseases treated with arthroscopic ankle fusion and mini-open ankle fusion from January 2007 to June 2018 were retrospectively analyzed.

Materials And Methods

Patients
The inclusion criteria of this study were end stage of ankle osteoarthritis, Kaschin-Beck disease and traumatic arthritis, which were ineffective after conservative treatment, and were not accompanied
with severe ankle valgus and rotation deformity. A total of 56 patients were divided into two groups according to the surgical methods, including arthroscopy group (n = 30) and mini-open group (n = 26). There were 19 males and 11 females with an average age of 49.6 years old in arthroscopy group and 26 patients in mini-open group (18 males and 8 females with an average age of 48.3 years old). Baseline demographic and clinical information of the study populations (age, gender, clinical presentation of the study participants) were showed in Tab.1. There was no significant difference in gender, age, VAS score and AOFAS score between the two groups (P > 0.05).

**Surgical procedure and postoperative care**

The operation was performed under general anesthesia or epidural anesthesia. Patients were taken supine position, and bony markers, blood vessels and nerves of ankle joint were routinely marked before operation. Pneumatic tourniquet was prepared on the root of affected thigh, and tourniquet was pressurized to 280mmHg before operation.

In the arthroscopic fusion group, sterile saline was injected into the ankle cavity, anterior-lateral and anterior-medial portals were established. Attention was paid to avoid injury to anterior tibial vessels, nerves and tendons. 4.0 mm 30° arthroscopy was routinely used. The imaging system and water inlet and outlet pipes were connected and epinephrine saline was maintained continuous infusion during the operation. First, ankle arthroscopy was performed and evaluation was performed to clean the loose body in the joint cavity. Shaver and radio frequency probe were used to clean the synovial in the joint cavity and enlarge the visual field of operation. After the ankle joint cavity was fully exposed, the articular cartilage surface of distal tibia and talus dome was cleaned with grinding drill, curette. The cartilage surface of medial and lateral malleolus was removed thoroughly by the same method.

In the small incision fusion group, two 4cm longitudinal incisions were made on the anterolateral and anteromedial sides of the ankle joint, and the skin and subcutaneous tissue were dissected in turn. The tendons and neurovascular bundles on the anterior side of the ankle joint were protected, the joint capsule was cut longitudinally to expose the ankle joint. The retractor was used to increase the exposure, and the articular cartilage surfaces of the lateral malleolus, the lateral talus and the lateral half of the tibiotalar articular cartilage were cleared with curettes and bone knives under direct vision.
through the anterolateral incision. The same method was used to clean the cartilage surface of the medial half, medial malleolus and medial talus through the anterior medial incision.

Under the C-arm monitoring, we keep ankle in the neutral position of flexion and extension, 5° of valgus and external rotation, then two cross guide pins was drilled. Confirming the ideal fixed position under C-arm, two 6.5mm cannulated screws were screwed in along the guide pins. After placing the drainage tube, the incisions were closed routinely.

After operation, short leg plaster or brace was fixed. The affected limb was raised up to reduce limb swelling. Weight-bearing was allowed gradually after 4 weeks. X-ray films were reviewed regularly to evaluate fusion. Plaster or brace could be removed to participate in daily activities after complete bony fusion.

**Outcome assessment**

Ankle pain, incision healing, ankle X-ray, complications and ankle function were evaluated during the follow-up period; pain score was evaluated by pain visual analogue scale (VAS). The pain scores of 3 days post-operation and the last follow-up were recorded respectively. Length of hospital stay, operative time, and tourniquet time were compared. The operative time was calculated with use of computerized operative and anesthetic records. At the last follow-up, according to ankle function score (AOFAS score), pain, spontaneous activity, walking distance, ground walking, range of motion, and stability and joint alignment were evaluated.

**Statistical analysis**

SPSS17.0 statistical software package was used for statistical analysis. The quantitative data were expressed by mean ± standard deviation. Comparison of preoperative to postoperative VAS scores and AOFAS scores were performed by use of an independent t test. Two independent samples t-test was used to determine statistical significance between groups. P < 0.05 was considered statistically significant.

**Results**

28 patients in the arthroscopy group and 23 patients in the mini-open group were followed up for 35 months with an average of (22.5 ± 1.5) months, and the ankle pain and function of all patients were
relieved and bony fusion was obtained. The average time to fusion was 12.4 weeks (range, 10-16 weeks).

The VAS score 3 days post-operation was (6.37 ± 0.69) points in the arthroscopy group and (7.61 ± 1.05) points in the mini-open group, there was significant difference between the two groups (P < 0.05). The VAS score and AOFAS score between the two groups pre- and the last follow-up have statistically significant differences (P < 0.05). At the last follow-up, VAS score was (1.55 ± 0.57) in the arthroscopy group and (1.43 ± 0.73) in the mini-open group, there was no significant difference between the two groups (P > 0.05). The AOFAS score was (85.32 ± 2.96) points in the arthroscopy group and (86.72 ± 3.05) points in the mini-open group, there was no significant difference between the two groups (P > 0.05) (Table 2). Arthroscopic ankle fusion was associated with a shorter tourniquet time and shorter length of hospital stay compared to mini-open ankle fusion (P < 0.05); however, there was no significant difference between two groups in terms of operation time (P > 0.05) (Table 3). Wounds healing was satisfying during the follow-up in the arthroscopy group. But the wounds healing was delayed in two patients of the mini-open group.

Discussion
If various ankle diseases are not treated effectively in the early stage, they will gradually cause severe ankle pain, deformity and dysfunction. Surgical treatment must be considered, if conservative treatment is ineffective. In recent years, joint replacement technology has been developed rapidly, hip and knee replacement surgery has been very mature, and the surgical effect is excellent. Ankle replacement has also been applied in clinic [4-6]. But because of the special anatomical and physiological characteristics of ankle joint, the long-term effect is far inferior to knee joint and hip replacement [7, 8]. So for advanced ankle diseases, ankle arthrodesis is still the "gold standard" of end-stage ankle disease[9], and it is also the mainstream treatment in clinic[10]. Open ankle arthrodesis is a predictable, time-tested procedure with consistent results when performed in appropriate patients [11]. The traditional open ankle fusion surgery has large incision, extensive peeling, large amount of bleeding and large trauma, and often needs to amputate the fibula, so the duration of postoperative pain is long. There are many incision complications, and the incidence of
infection is high, also the recovery period is longer. With the popularization of the concept of rapid rehabilitation and the development of minimally invasive technology represented by arthroscopy, small incision and arthroscopic arthrodesis have been gradually carried out in clinic, showing more obvious advantages than traditional open surgery [12-15]. Arthroscopic ankle arthrodesis has gained increasing popularity, with reports of shorter hospital stays, shorter time to solid fusion, and equivalent union rates when compared with open arthrodesis. Townshend et al evaluated the results of open and arthroscopic ankle arthrodesis in a comparative case series of patients and proved arthroscopic arthrodesis resulted in a shorter hospital stay and showed better outcomes at one and two years[16]. Nielsen et al evaluated the results of arthroscopic guided ankle arthrodesis with open surgery arthrodesis. They found the patients in the arthroscopic group were discharged on average 2.27 days earlier than the patients operated by open technique. Ninety percent of the patients in the arthroscopic group and 57% in the open group showed bony union after 12 weeks. The rate of union after 1 year was 95% in the arthroscopic group and 84% in the open group[17]. Yasui et al showed that although open ankle arthrodesis is more commonly performed, it is associated with a greater incidence of subsequent adjacent joint arthrodesis specifically in the hindfoot[18]. O'Brien et al achieved comparable fusion rates with arthroscopic ankle arthrodesis compared to open ankle arthrodesis, with significantly less morbidity, shorter operative times, shorter tourniquet times, less blood loss, and shorter hospital stays, and concluded arthroscopic ankle arthrodesis is a valid alternative to traditional open arthrodesis of the ankle for selected patients with ankle arthritis[19]. Compared arthroscopic fusion with small incision, the surgical trauma is further reduced, and the visual field of arthroscopic surgery is clear, which can produce almost "bloodless" visual field, so the removal of cartilage is more thorough. It is beneficial to create good conditions for bone fusion. Honnenahalli et al demonstrates that arthroscopic ankle fusion may be associated with a higher fusion rate, shorter tourniquet time, and shorter length of stay compared to open ankle fusion[20]. Duan et al used arthroscopic ankle arthrodesis without bone graft. On average, all patients achieved bony fusion at an average of 12.1 weeks, and the AOFAS score was significantly improved [21]. DeLeeuw et al also achieved a 100% fusion rate in 40 patients using posterior ankle arthroscopic
arthrodesis [22]. Woo et al conclude that the arthroscopic group displayed better clinical outcomes compared to the open group at the 24months follow-up. The advantages of arthroscopic ankle arthrodesis include significantly less perioperative pain, higher AOFAS Ankle-hindfoot scores at 24months, shorter length of stay, fewer postoperative complications[23]. In our study, it was also found that the incidence of complications of arthroscopic joint fusion was lower, and the postoperative recovery was faster. Cottino and others also found similar findings in their studies[24]. Arthroscopic ankle arthrodesis requires the operator to master arthroscopic technology[25], high surgical equipment and high technical threshold. Mini-open ankle arthrodesis is only the minimally invasive operation of routine surgery, and the operator can be carried out on the basis of foot and ankle surgery, and the operation cost is obviously lower than arthroscopy fusion. No matter arthroscopic ankle arthrodesis or mini-open ankle arthrodesis, it has the disadvantage of insufficient exposure and cannot correct severe ankle deformities, so we routinely perform imaging examination to evaluate the ankle force line before operation. The ankle valgus and valgus of the selected patients were no more than 20 degrees, and there was no serious rotation deformity. For patients with valgus deformity more than 20 degrees, severe rotation deformity and severe bone defect, we recommend routine open ankle arthrodesis.

Conclusions
To sum up, arthroscopic ankle arthrodesis and mini-open ankle arthrodesis have satisfactory curative effect and fusion rate, and were effective methods for the treatment of end-stage ankle disease. Arthroscopy ankle arthrodesis has more advantages, including small incision, shorter tourniquet time and length of hospital stay, quick recovery and low incidence of complications, but arthroscopy ankle arthrodesis has a certain technical threshold. It is suggested that arthroscopy ankle arthrodesis can be used after mastering conventional ankle arthroscopy.

Declarations

Acknowledgements
We thank the patients for participating in this study. We also are grateful to Dr. Yan-ping Zhao for help in data collection and for comments on the initial manuscript.
Availability of supporting data
All data and materials were in full compliance with the journal’s policy.

Authors’ contributions
WJL and GWP contributed equally to this work and should be considered co-first authors. WJL, GWP and HWS enrolled patients in the study and participated in the interpretation of the data, drafting and editing the manuscript. LYJ and LF is the lead surgeon of the study that he conceived and designed. All authors read and approved the final manuscript.

Ethics approval and consent to participate
This study was approved by the Ethics Committee of the Chinese PLA General Hospital and was performed in accordance with the ethical standards of the Declaration of Helsinki of 1964. Consent to participate was obtained from the participants.

Consent for publication
Signed consent for publishing patient identifiable information, data, figures, and video was obtained.

Competing interests
The authors declare that they have no competing interests.

Funding
None

Authors’ information
Jun-liang Wang¹, Wen-ping Ge², Wen-shan Hu¹, Feng Lin¹, Yu-jie Liu¹
1. Department of Orthopedics, Hainan Hospital of General Hospital of PLA, Sanya 572000, China.
2. Beijing Road Medical Center, General Hospital of Xinjiang Military Region, Urumqi 830013, China.

References
1. Backus JD, Ocel DL. Ankle Arthrodesis for Talar Avascular Necrosis and Arthrodesis Nonunion. Foot Ankle Clin. 2019;24(1):131–42.
2. Kolodziej L, et al. Results of Arthroscopic Ankle Arthrodesis with Fixation Using Two Parallel Headless Compression Screws in a Heterogenic Group of Patients. Open Orthop J. 2017;11:37–44.
3. Kamijo S, et al. Comparison of compressive forces caused by various cannulated cancellous screws used in arthroscopic ankle arthrodesis. J Orthop Surg Res. 2017;12(1):7.

4. Courville XF, Hecht PJ, Tosteson AN. Is total ankle arthroplasty a cost-effective alternative to ankle fusion? Clin Orthop Relat Res. 2011;469(6):1721-7.

5. Norvell DC, et al. Effectiveness and Safety of Ankle Arthrodesis Versus Arthroplasty: A Prospective Multicenter Study. J Bone Joint Surg Am. 2019;101(16):1485-94.

6. Wasik J, et al. Effect of Total Ankle Arthroplasty and Ankle Arthrodesis for Ankle Osteoarthritis: A Comparative Study. Med Sci Monit. 2019;25:6797-804.

7. Gross CE, et al. Technique of Arthroscopic Treatment of Impingement After Total Ankle Arthroplasty. Arthrosc Tech. 2016;5(2):e235-9.

8. Richardson AB, Deorio JK, Parekh SG. Arthroscopic debridement: effective treatment for impingement after total ankle arthroplasty. Curr Rev Musculoskelet Med. 2012;5(2):171-5.

9. Buda R, et al. Treatment of Hemophilic Ankle Arthropathy with One-Step Arthroscopic Bone Marrow-Derived Cells Transplantation. Cartilage. 2015;6(3):150-5.

10. Oboirien M. Ankle arthrodesis following trauma, a useful salvage procedure - a report on three cases. J Surg Tech Case Rep. 2011;3(2):102-5.

11. Mendicino SS, Kreplick AL, Walters JL. Open Ankle Arthrodesis Clin Podiatr Med Surg. 2017;34(4):489-502.

12. Vila YRJ, Ojeda Thies C, Sanchez GP. Arthroscopic Posterior Subtalar Arthrodesis: Surgical Technique Arthrosc Tech. 2016;5(1):e85-8.

13. Lui TH. Arthroscopic Tarsometatarsal Arthrodesis. Arthrosc Tech. 2016;5(6):e1311-6.

14. Beimers L, de Leeuw PA, van Dijk CN. A 3-portal approach for arthroscopic subtalar arthrodesis. Knee Surg Sports Traumatol Arthrosc. 2009;17(7):830-4.
15. Park JH, et al. Arthroscopic Versus Open Ankle Arthrodesis: A Systematic Review. Arthroscopy. 2018;34(3):988–97.

16. Townshend D, et al. Arthroscopic versus open ankle arthrodesis: a multicenter comparative case series. J Bone Joint Surg Am. 2013;95(2):98–102.

17. Nielsen KK, Linde F, Jensen NC. The outcome of arthroscopic and open surgery ankle arthrodesis: a comparative retrospective study on 107 patients. Foot Ankle Surg. 2008;14(3):153–7.

18. Yasui Y, et al. Open Versus Arthroscopic Ankle Arthrodesis: A Comparison of Subsequent Procedures in a Large Database. J Foot Ankle Surg. 2016;55(4):777–81.

19. O’Brien TS, et al. Open versus arthroscopic ankle arthrodesis: a comparative study. Foot Ankle Int. 1999;20(6):368–74.

20. Honnenahalli Chandrappa M, Hajibandeh S, Hajibandeh S. Ankle arthrodesis-Open versus arthroscopic: A systematic review and meta-analysis. J Clin Orthop Trauma. 2017;8(Suppl 2):S71–7.

21. Duan X, Yang L, Yin L. Arthroscopic arthrodesis for ankle arthritis without bone graft. J Orthop Surg Res. 2016;11(1):154.

22. de Leeuw PA, et al. Midterm results of posterior arthroscopic ankle fusion. Knee Surg Sports Traumatol Arthrosc. 2016;24(4):1326–31.

23. Woo BJ, et al., Clinical outcomes comparing arthroscopic vs open ankle arthrodesis. Foot Ankle Surg, 2019.

24. Cottino U, et al. Arthroscopic ankle arthrodesis: a review. Curr Rev Musculoskelet Med. 2012;5(2):151–5.

25. Iwasa K, et al. Arthroscopic ankle arthrodesis for treating osteoarthritis in a patient with kashin-beck disease. Case Rep Med. 2014;2014:931278.

Tables
Tab.1 Comparison of baseline demographic and clinical information of patients

| group                  | cases | age     | gender [cases] | VAS score    | AOFAS       |
|------------------------|-------|---------|----------------|-------------|-------------|
|                        |       | X±s     | male           | female      |             |
| Arthroscopy group      | 30    | 49.6 ± 7.05 | 19          | 11          | 7.63±0.44   | 35.5         |
| Mini-open group        | 26    | 48.3± 6.53 | 18          | 8           | 7.76±0.53   | 36.7         |
| Test value             | -     | t=0.712  |                |             |             |
| P value                | -     | 0.479    | 0.054          | 0.320       | 0.335       |

Tab.2 Comparison of postoperative effect of patients with ankle joint arthrodesis

| Groups                  | Pre-operation | Last follow-up |
|-------------------------|---------------|----------------|
|                         | VAS           | AOFAS          | VAS          | AOFAS       |
| Arthroscopy group       | 7.63±0.44     | 35.53±4.07     | 1.55±0.57▼  | 85.32±2     |
| Mini-open group         | 7.76±0.53     | 36.73±5.15     | 1.43±0.73◆  | 86.72±3     |
| T value                 | t=1.003       | t=0.973        | t=0.690      | t=1.7       |
| P value                 | 0.320         | 0.335          | 0.493        | 0.08        |

* The VAS score between the two groups pre- and post-operation have statistically significant differences. ▼t=46.248 P<0.05 ◆t=54.190 P<0.05
The AOFAS score between the two groups pre- and post-operation have statistically significant differences. ▼t=35.779 P<0.05 ◆t=42.587 P<0.05

Tab.3 Comparison of clinical operation data of two groups
| Groups                   | Tourniquet time (min) | Operation time (min) | VAS score 3 days post-operation | Length of hospital stay (day) |
|-------------------------|----------------------|----------------------|---------------------------------|-------------------------------|
| Arthroscopy group       | 78.42±6.21           | 147.52±13.82         | 6.37±0.78                       | 5.38±0.72                     |
| Mini-open group         | 95.83±8.54           | 153.81±15.27         | 7.61±0.93                       | 7.23±0.84                     |
| T value                 | t=8.419              | t=1.543              | t=5.180                         | t=8.470                       |
| P value                 | 0.000                | 0.129                | 0.000                           | 0.000                         |