



# Arthroscopically Assisted Reduction and Fixation of Deltoid Ligament Avulsion Fracture From Medial Malleolus

Charles Churk Hang Li, M.B.Ch.B., M.R.C.S. (H.K.), F.R.C.S.Ed. (Ortho.), F.H.K.C.O.S., F.H.K.A.M. (Ortho.), and  
Tun Hing Lui, M.B.B.S. (H.K.), F.R.C.S. (Edin.), F.H.K.A.M., F.H.K.C.O.S.

**Abstract:** Ankle fractures are one of the most common orthopaedic injuries. The surgical principle is to restore anatomy and stability of the ankle mortise. Repositioning of the talus under the tibia with normalization of the medial clear space is mandatory for a good outcome. Deltoid ligament injuries can present as an avulsion fracture of the medial malleolus. The purpose of this Technical Note is to describe the details of arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus. This can restore the medial stability of the ankle.

Ankle fractures are one of the most common orthopaedic injuries.<sup>1</sup> The surgical principle is to restore anatomy and stability of the ankle mortise. Repositioning of the talus under the tibia with normalization of the medial clear space (MCS) is mandatory for a good outcome.<sup>2</sup>

The deltoid ligament is frequently ruptured in ankle fractures.<sup>1,3-5</sup> The ligament plays an important role in maintaining concentric talus reduction within the ankle mortise and stabilizes the ankle joint against eversion, external rotation, and plantar flexion forces.<sup>1,6-8</sup> However, there is no consensus on the optimal treatment of ruptured deltoid ligament in bimalleolar equivalent ankle fractures, and there is no evidence proving superiority of suturing the deltoid

ligament in all ruptures.<sup>1,2,4-7,9</sup> Deltoid ligament repair may be indicated in bimalleolar equivalent fractures with extensive capsuloligamentous damage, combined syndesmotic and deltoid insufficiency, or multi-ligamentous/multidirectional instability, especially in heavier patients with greater mechanical requirements.<sup>6,7</sup> This can be manifested as persistent external rotation or valgus instability after anatomic fibula fixation.<sup>10</sup> In this case, deltoid ligament repair enhances ankle stability and improves the quality of MCS and ankle reduction.<sup>1,2,5,8</sup> If the deltoid ligament rupture is not repaired, retraction of the ligament with subsequent healing in a nonanatomic position may cause ankle instability, persistent medial gutter pain, and risk of early traumatic arthritis of the ankle joint.<sup>4,7,11,12</sup> Persistent widened MCS after anatomical fibula and syndesmosis fixation can be indicative of interposition either of the deltoid ligament, posterior tibial tendon or loose bodies, and medial exploration and deltoid ligament repair also is indicated.<sup>2,6-8</sup>

Deltoid ligament injury can present as an avulsion fracture. It is most often seen as an avulsion off of the medial malleolus, especially for the superficial deltoid ligament. Although less common, a ligamentous avulsion off of the medial talus can occur, especially for the deep deltoid ligament.<sup>7</sup> A small avulsion fracture of the medial malleolus presents in 10% cases of ligamentous supination-external-rotation ankle injuries and may be associated with extensive deltoid incompetence.<sup>3,13,14</sup> Moreover, this small avulsion fragment

From the North District Hospital (C.C.H.L.), Department of Orthopaedics and Traumatology (T.H.L.), Hong Kong SAR, China.

The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received April 23, 2022; accepted June 1, 2022.

Address correspondence to Dr. Tun Hing Lui, M.B.B.S. (H.K.), F.R.C.S. (Edin.), F.H.K.A.M., F.H.K.C.O.S., Department of Orthopaedics and Traumatology, North District Hospital, 9 Po Kin Rd., Sheung Shui, NT, Hong Kong SAR, China. E-mail: [luithderek@yahoo.co.uk](mailto:luithderek@yahoo.co.uk)

© 2022 THE AUTHORS. Published by Elsevier Inc. on behalf of the Arthroscopy Association of North America. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/22567

<https://doi.org/10.1016/j.eats.2022.06.001>

may incarcerate in the MCS and thus prevents a symmetrical mortise reduction, necessitating surgical exploration of the medial ankle gutter.<sup>2,7,13</sup>

Intra-articular pathology has been shown to occur in up to 79% of ankle fractures.<sup>10</sup> Ankle arthroscopy is useful for assuring appropriate reduction of the fractures, assessment of the integrity of the deltoid ligament and syndesmosis, detection and treatment of subtle residual instability, guidance of anatomical reduction of the syndesmosis, determining interposition when the MCS remains wide after proper reduction, removal of loose bodies and treatment of osteochondral lesions.<sup>2,6,10,15-17</sup>

Recently, arthroscopic and endoscopic techniques for repairing the superficial deltoid ligament and reconstruction of the superficial and deep deltoid ligaments have been described in the context of chronic medial insufficiency.<sup>18-20</sup> The purpose of this Technical Note is to describe the details of arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus, which is a form of deltoid insufficiency. It is indicated in deltoid insufficiency presented as an avulsion fracture of the medial malleolus and associated with syndesmosis disruption or the fracture fragment incarcerates in the MCS. It is contraindicated if the fragment has enough size for stable screw fixation, the avulsion fracture is from talar side of the ligament, or there is no ankle external rotation or valgus instability after anatomic fibula fixation (Table 1).

## Surgical Technique (With Video Illustration)

### Preoperative Assessment and Patient Positioning

The fracture pattern, widening of the MCS, degree of displacement of the avulsed fragment, and syndesmosis disruption should be studied carefully with the ankle radiographs. Computed tomography is useful to study the size and origin of the fragment and pattern of syndesmosis disruption.

The patient is placed in the supine position with the legs spread. A thigh tourniquet is applied to provide a bloodless operative field. A 2.7-mm, 30° arthroscope (Henke Sass Wolf GmbH, Tuttlingen, Germany) is used for this procedure. Fluid inflow is by gravity, and an arthropump is not used.



**Fig 1.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. This procedure is performed with the standard anteromedial and anterolateral ankle arthroscopy portals, which are at the medial side of the tibialis anterior tendon and lateral side of the peroneus tertius tendon, respectively. (AMP, anteromedial portal; ALP, anterolateral portal.)

### Portal Placement

This procedure is performed with the standard anteromedial and anterolateral ankle arthroscopy portals, which are at the medial side of the tibialis anterior tendon and lateral side of the peroneus tertius tendon, respectively (Fig 1). Open reduction and internal fixation of the fibular fracture is performed. Ankle arthroscopy is performed with the anteromedial portal as the viewing portal. If syndesmosis disruption is present, it is reduced anatomically under arthroscopic guidance and a syndesmotic screw is inserted. Medial laxity of the ankle is then confirmed under fluoroscopy by applying eversion or external rotation stress to the ankle.

### Exposure of the Avulsed Fragment

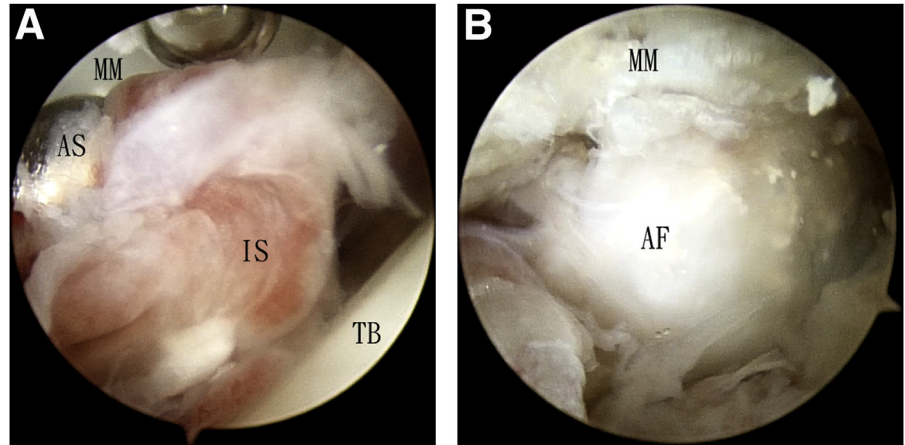
Anterolateral portal is the viewing portal and anteromedial portal is the working portal. The inflamed synovium of the medial ankle gutter is resected with an arthroscopic shaver (DYONICS; Smith & Nephew, Andover, MA). The shaver blade should face cranially and away from the cartilage of the medial malleolus and the medial talar facet and the deltoid ligament. After synovectomy, the avulsed fragment and the deltoid ligament are exposed (Fig 2).

**Table 1.** Indications and Contraindications of Arthroscopically Assisted Reduction and Fixation of Deltoid Ligament Avulsion Fracture From Medial Malleolus

Indications	Contraindications
1. Deltoid insufficiency presented as an avulsion fracture of the medial malleolus. and associated with syndesmosis disruption. 2. The fracture fragment incarcerates in the MCS.	1. The fragment has enough size for stable screw fixation. 2. The avulsion fracture is from the talar side of the ligament. 3. There is no ankle external rotation or valgus instability after anatomic fibula fixation.

MCS, medial clear space.

**Fig 2.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. Anterolateral portal is the viewing portal and anteromedial portal is the working portal. (A) The inflamed synovium of the medial ankle gutter is resected with an arthroscopic shaver. (B) After synovectomy, the avulsed fragment and the deltoid ligament are exposed. (AF, avulsed fragment; AS, arthroscopic shaver; IS, inflamed synovium; MM, medial malleolus; TB, talar body.)

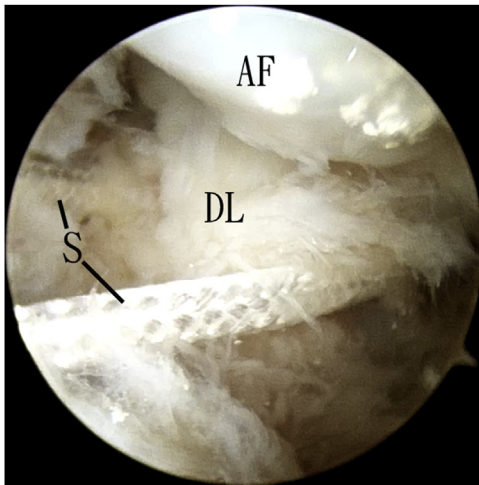


### Suturing the Deltoid Ligament

The anterolateral portal is the viewing portal and the anteromedial portal is the working portal. A No. 2 FiberWire loop (Arthrex, Naples, FL) is passed through the deltoid ligament by means of FIRSTPASS MINI Suture Passer (Smith & Nephew, Austin, TX) (Fig 3).

### Deltoid Ligament Locking Suture

The anterolateral portal is the viewing portal and the anteromedial portal is the working portal. The suture limbs are passed through the suture loop and the suture is tightened to create a locking suture on the deltoid ligament (Fig 4).



**Fig 3.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. Anterolateral portal is the viewing portal and anteromedial portal is the working portal. A No. 2 FiberWire loop (Arthrex, Naples, FL) is passed through the deltoid ligament by means of FIRSTPASS MINI Suture Passer (Smith & Nephew, Austin, TX). (AF, avulsed fragment; DL, deltoid ligament; S, suture.)

### Passing the Suction Tube

Anterolateral portal is the viewing portal and anteromedial portal is the working portal. A distal medial skin incision is made at the medial malleolar fracture site and a small-caliber suction tube is passed from the distal medial incision to the anteromedial portal (Fig 5).

### Suture Loop From Anteromedial Portal to Distal Medial Incision

Anterolateral portal is the viewing portal and anteromedial portal is the working portal. A No. 1 polydioxanone suture loop (ETHICON, Bridgewater, NJ) is passed from the anteromedial portal to the distal medial incision via this suction tube (Fig 6). Suction is applied through the suction tube to facilitate the delivery of the suture loop.

### Deliver the Deltoid Ligament Locking Suture to Distal Medial Incision

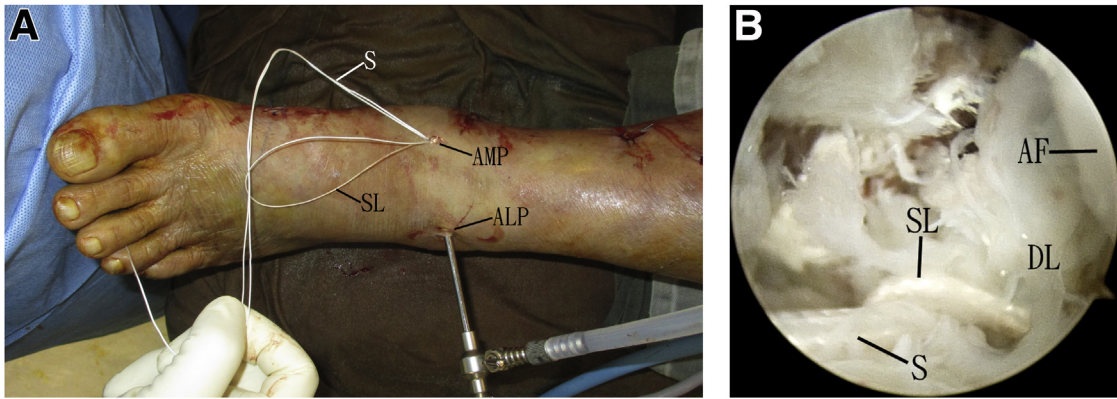
Anterolateral portal is the viewing portal and anteromedial portal is the working portal. The suction tube is removed and the FiberWire suture limbs are delivered from the anteromedial portal to the distal medial incision by means of the polydioxanone suture loop (Fig 7).

### Arthroscopically Assisted Reduction and Fixation of the Avulsed Fragment

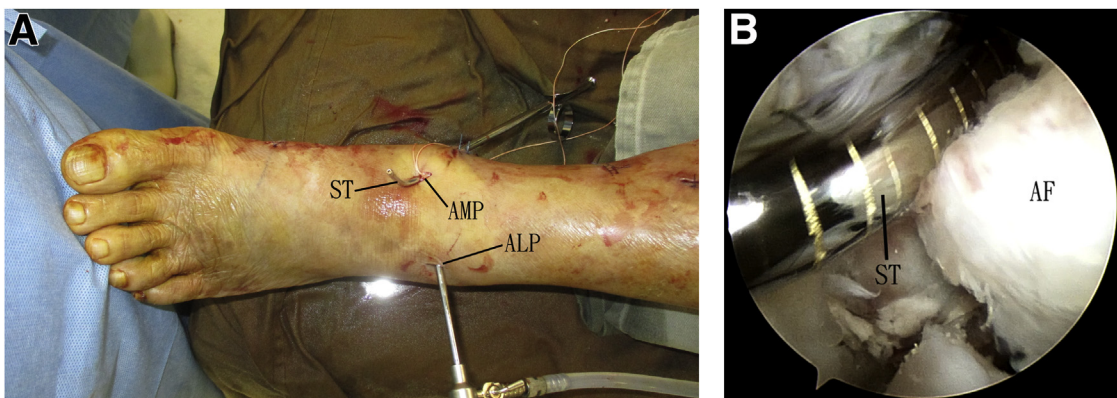
Anterolateral portal is the viewing portal and anteromedial portal is the working portal. The suture limbs are passed along the medial malleolar bone surface to a proximal medial incision which is about 4 cm from the distal medial incision. The fracture fragment is reduced by means of an arthroscopic probe and an arthroscopic probe (ACUFEX; Smith & Nephew) and tensioning of the suture limbs (Fig 8).

### Screw Post Fixation

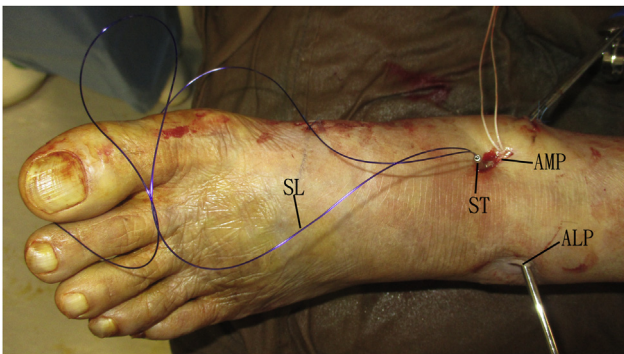
Anterolateral portal is the viewing portal and anteromedial portal is the working portal. The suture limbs are anchored to a tibial screw post (4-mm cancellous screw



**Fig 4.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. Anterolateral portal is the viewing portal and anteromedial portal is the working portal. (A) The suture limbs are passed through the suture loop and the suture is tightened to create a locking suture on the deltoid ligament. (B) Arthroscopic view shows the locking suture on the deltoid ligament. (AF, avulsed fragment; ALP, anterolateral portal; AMP, anteromedial portal; DL, deltoid ligament; S, suture limbs; SL, suture loop.)



**Fig 5.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. Anterolateral portal is the viewing portal and anteromedial portal is the working portal. (A) A distal medial skin incision is made at the medial malleolar fracture site and a small-caliber suction tube is passed from the distal medial incision to the anteromedial portal. (B) Arthroscopic view shows the suction tube passes from the distal medial incision to the anteromedial portal. (AF, avulsed fragment; ALP, anterolateral portal; AMP, anteromedial portal; ST, suction tube.)

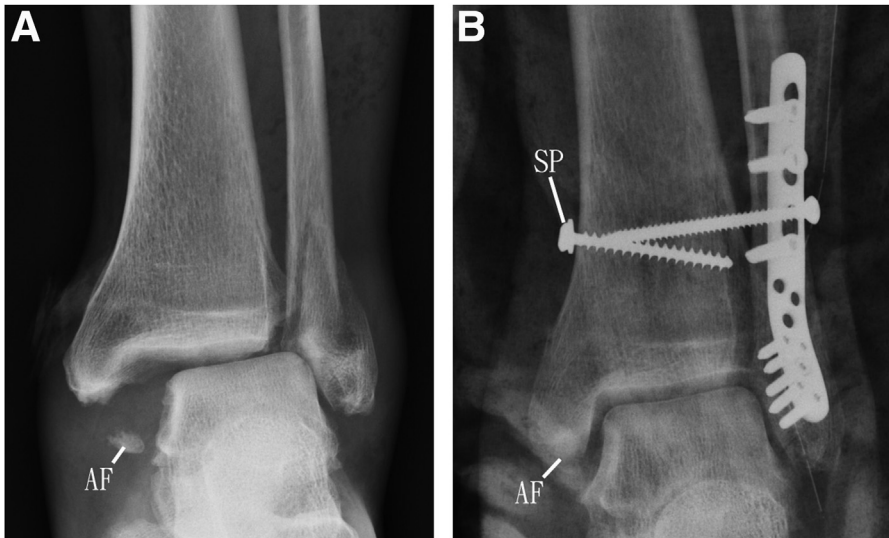
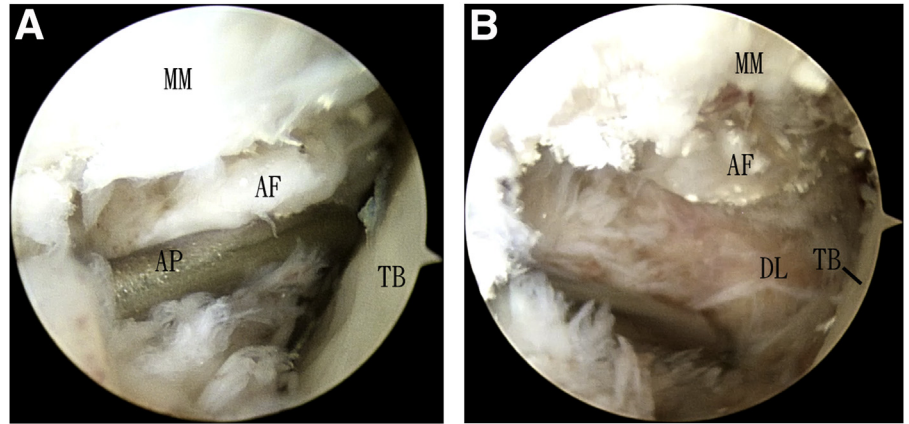


**Fig 6.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. Anterolateral portal is the viewing portal and anteromedial portal is the working portal. A No. 1 PDS (polydioxanone) suture loop is passed from the anteromedial portal to the distal medial incision via this suction tube. (ALP, anterolateral portal; AMP, anteromedial portal; SL, PDS (polydioxanone) suture loop; ST, suction tube.)



**Fig 7.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. Anterolateral portal is the viewing portal and anteromedial portal is the working portal. The suction tube is removed and the FiberWire suture limbs are delivered from the anteromedial portal to the distal medial incision by means of the PDS suture loop. (ALP, anterolateral portal; AMP, anteromedial portal; S, FiberWire suture; SL, PDS (polydioxanone) suture loop.)

**Fig 8.** Arthroscopically assisted reduction and fixation of deltoid ligament avulsion fracture from medial malleolus of the left ankle. The patient is in the supine position with the legs spread. Anterolateral portal is the viewing portal and anteromedial portal is the working portal. The sutures limbs are passed along the medial malleolar bone surface to a proximal medial incision which is about 4 cm from the distal medial incision. (A) The fracture fragment is reduced by means of an arthroscopic probe an arthroscopic probe (ACUFEX, Smith & Nephew) and tensioning of the suture limbs. (B) Normal tension of the deltoid ligament is confirmed arthroscopically. (AF, avulsed fragment; AP, arthroscopic probe; DL, deltoid ligament; MM, medial malleolus; TB, talar body.)



**Fig 9.** Anterolateral portal is the viewing portal and anteromedial portal is the working portal. (A) injury film of this illustrated case showed an ankle fracture with avulsion fracture of the medial malleolar tip. The medial clear space is grossly widened. (B) Post-operative radiograph showed the reduction of the avulsed fragment and medial clear space after the suture limbs are anchored to a tibial screw post at the proximal medial incision. (AF, avulsed fragment; SP, screw post.)

**Table 2.** Pearls and Pitfalls of Arthroscopically Assisted Reduction and Fixation of Deltoid Ligament Avulsion Fracture From Medial Malleolus

Pearls	Pitfalls
1) If needed, the anterolateral portal can be made at the medial side of the peroneus tertius tendon to improve the visualization of the deltoid ligament. 2) The shaver blade should face proximally to avoid injury to the deltoid ligament and the cartilage of the medial malleolus and medial talar facet. 3) The FiberWire suture loop should pass through the deltoid ligament as close to the avulsed fragment as possible. 4) The FiberWire suture limbs should pass along the medial cortex of the avulsed fragment before exit to the distal medial incision.	1) If the anterolateral portal is made at the medial side of the peroneus tertius tendon, there is a greater chance of injury to the intermediate branch of the superficial peroneal nerve. 2) Cartilage injury by the shaver may lead to degeneration of the medial ankle gutter.

**Table 3.** Advantages and Risks of Arthroscopically Assisted Reduction and Fixation of Deltoid Ligament Avulsion Fracture From Medial Malleolus

Advantages	Risks
1) Small incisions and better cosmetic outcome	1) Cutaneous nerve injury
2) Minimal soft-tissue trauma	2) Persistent medial ankle instability
3) Anatomical fracture reduction under arthroscopic guidance	3) Malunion
4) Assessment and treatment of concomitant intra-articular pathology	4) Nonunion
	5) Persistent medial ankle gutter pain

with washer) at the proximal medial incision.<sup>21</sup> Normal tension of the deltoid ligament can be confirmed arthroscopically. Free ankle dorsiflexion–plantarflexion motion is allowed immediately after the operation. Inversion–eversion motion can be started four weeks later (Fig 9, Table 2, Video 1).

### Discussion

Restoration of the lateral column is important in surgical management of ankle fractures. In contrast, restoration of the medial column is also important because the deltoid ligament is the medial restraint holding the talus under the tibia firmly, allowing less than 1 mm of lateralization.<sup>2</sup> The deltoid ligament has a close relationship with the syndesmotoc ligaments. In cases of combined deltoid ligament and syndesmotoc rupture and where the syndesmotoc stabilization is insufficient, additional deltoid ligament repair can strengthen the construct and stabilize the mortise.<sup>2,9</sup>

Frequently, the avulsed fragment only involves the anterior colliculus of the medial malleolus which is the insertion point of the superficial deltoid ligament. In this case, the deep deltoid ligament may have substance tear or avulsion fracture at the talar side.<sup>10</sup> Fixation of this small avulsed fragment may not be sufficient to restore medial stability.<sup>2</sup> However, we believe that reduction and fixation of the medial malleolar avulsion fracture is still worthwhile as bone-to-bone healing in case of avulsion fracture is more guaranteed for restoration of normal anatomy of the superficial deltoid ligament as compared with soft-tissue healing in case of substance tear of the ligament. In contrast to previous belief that the deep deltoid ligament is a more important static stabilizer of the ankle than the superficial deltoid ligament, recent biomechanical study demonstrates that isolated rupture of either superficial or deep deltoid is enough to cause instability.<sup>22</sup> Moreover, restoration of normal anatomy and tension of the superficial deltoid ligament may facilitate healing of the deep deltoid ligament in anatomical position.

The deltoid ligament is sutured and the suture limbs are passed over the medial surface of the avulsed fragment. The pull vector of the suture can neutralize

the plantarly directed pull of the superficial deltoid ligament and the laterally directed pull of the deep deltoid ligament. However, to allow healing of the deep deltoid ligament in physiological tension, eversion stress to the ankle should be avoided in the initial postoperative period.

The advantages of this technique include small incisions and better cosmetic outcome, minimal soft-tissue trauma, anatomical fracture reduction under arthroscopic guidance, and assessment and treatment of concomitant intra-articular pathology. The potential risks of this technique include cutaneous nerve injury, persistent medial ankle instability, malunion, nonunion, and persistent medial ankle gutter pain (Table 3).<sup>12</sup> This procedure is not technically difficult and can be managed by foot and ankle arthroscopists of average experience.

### References

1. Wang J, Stride D, Horner NS, et al. The role of deltoid ligament repair in ankle fractures with syndesmotoc instability: A systematic review. *J Foot Ankle Surg* 2021;60:132-139.
2. Wiegerinck JJI, Stufkens SA. Deltoid rupture in ankle fractures. To repair or not to repair? *Foot Ankle Clin N Am* 2021;26:361-371.
3. Fukuyama JM, Pires RES, Labronici PJ, Hungria JOS, Decusati RL. Bimalleolar ankle fracture: A simple fracture? *Acta Ortop Bras* 2017;25:48-51.
4. Nasrallah K, Haim S, Einal B. Therapeutic approach to combined deltoid ligament disruption with lateral malleolus fracture: Current evidence and literature review. *Orthop Rev (Pavia)* 2021;13:8987.
5. Guo W, Lin W, Chen W, Pan Y, Zhuang R. Comparison of deltoid ligament repair and non-repair in acute ankle fracture: A meta-analysis of comparative studies. *PLoS One* 2021;16:e0258785.
6. Bastias GF, Filippi J. Acute deltoid ligament repair in ankle fractures. *Foot Ankle Clin* 2020;25:597-612.
7. Doty JF, Dunlap BD, Panchbhavi VK, Gardner MJ. Deltoid ligament injuries associated with ankle fractures: Arguments for and against direct repair. *J Am Acad Orthop Surg* 2021;29:e388-e395.
8. Butler BA, Hempen EC, Barbosa M, et al. Deltoid ligament repair reduces and stabilizes the talus in unstable ankle fractures. *J Orthop* 2020;17:87-90.
9. James M, Dodd A. Management of deltoid ligament injuries in acute ankle fracture: a systematic review. *Can J Surg* 2022;65:E9-E15.
10. Cooper MT. The role of deltoid repair and arthroscopy in ankle fractures. *Clin Sports Med* 2020;39:733-743.
11. Ramsey PL, Hamilton W. Changes in tibiotalar area of contact caused by lateral talar shift. *J Bone Joint Surg Am* 1976;58:356-357.
12. Choi SJ, Choi Y, Baek E, Jo S. Does repair of deltoid ligament contribute to restoring a mortise in SER type IV ankle fracture with syndesmotoc diastasis? *Arch Orthop Trauma Surg* 2022;142:535-541.

13. Nwosu K, Schneiderman BA, Shymon SJ, Harris TG. A medial malleolar "Fleck sign" may predict ankle instability in ligamentous supination external rotation ankle fractures. *Foot Ankle Spec* 2018;11:246-251.
14. Tornetta P 3rd. Competence of the deltoid ligament in bimalleolar ankle fractures after medial malleolar fixation. *J Bone Joint Surg Am* 2000;82:843-848.
15. Chiang CC, Lin CJ, Tzeng YH, Teng MH, Yang TC. Arthroscopic quantitative measurement of medial clear space for deltoid injury of the ankle: A cadaveric comparative study with stress radiography. *Am J Sports Med* 2022;50:778-787.
16. Lui TH, Ip KY, Chow HT. Comparison of radiologic and arthroscopic diagnoses of distal tibiofibular syndesmosis disruption in acute ankle fracture. *Arthroscopy* 2005;21:1370E1-1370E7.
17. Chan KB, Lui TH. Role of ankle arthroscopy in management of acute ankle fracture. *Arthroscopy* 2016;32:2373-2380.
18. Lui TH. Technical tips: reconstruction of deep and superficial deltoid ligaments by peroneus longus tendon in stage 4 posterior tibial tendon dysfunction. *Foot Ankle Surg* 2014;20:295-297.
19. Lui TH. Endoscopic repair of the superficial deltoid ligament and spring ligament. *Arthrosc Tech* 2016;5:e621-e625.
20. Acevedo JI, Kreulen C, Cedeno AA, Baumfeld D, Nery C, Mangone PG. Technique for arthroscopic deltoid ligament repair with description of safe zones. *Foot Ankle Int* 2020;41:605-611.
21. Lack W, Phisitkul P, Femino JE. Anatomic deltoid ligament repair with anchor-to-post suture reinforcement: Technique tip. *Iowa Orthop J* 2012;32:227-230.
22. Hempen EC, Butler BA, Barbosa M, Muriuki M, Havey RM, Kadakia AR. Superficial deltoid ligament and deep deltoid ligament play equally important roles in the stability of isolated lateral malleolus (OTA/AO 44-B1) fractures: A biomechanical study. *J Orthop Trauma* 2022;36:e73-e79.