

Correction of Crossover Toe Deformity by Plantar Plate Tenodesis and Arthroscopic Release of Lumbrical



Tun Hing Lui, M.B.B.S.(HK), F.R.C.S.(Edin), F.H.K.A.M., F.H.K.C.O.S., and Chun Kiu Ng, M.B.Ch.B.

Abstract: Plantar plate deficiency is the major cause of instability of the metatarsophalangeal joint. As the joint subluxates dorsally, the lumbrical is tethered on the medial side of the joint by the deep metatarsal ligament and becomes a deforming force for the development of crossover toe deformity. Release of the lumbrical is needed to achieve adequate medial soft-tissue release. Plantar plate tenodesis has been described to correct the deformity by suturing the plantar plate to the extensor digitorum longus tendon. The purpose of this Technical Note is to incorporate the technique of arthroscopic release of the lumbrical tendon into the technique of plantar plate tenodesis.

Crossover second toe is a common forefoot deformity. Most cases are due to plantar plate insufficiency.^{1,2} Attenuation or rupture of the plantar plate can lead to instability of the metatarsophalangeal (MTP) joint. As the joint instability deteriorates and the joint subluxates dorsally, the axis of pull of the interossei shifts dorsal to the center of rotation of the MTP joint and becomes an ineffective joint flexor. The lumbrical is tethered on the medial side of the joint by the deep metatarsal ligament and becomes a deforming force for the development of crossover toe deformity.^{3,4}

Conservative treatment including toe splints can rarely delay the progression, and surgical treatment is needed in symptomatic cases.⁵ Surgical treatment of this deformity includes soft-tissue balancing procedures to stabilize the

MTP joint (plantar plate repair, tendon release or transfer, and periarticular soft-tissue release) and/or bony procedures (metatarsal and/or phalangeal osteotomy, arthrodesis, and excisional arthroplasty) and even toe amputation.⁶ The Girdlestone-Taylor flexor-to-extensor tendon transfer is an effective method to stabilize the sagittal alignment of the MTP joint, but it may not be able to restore the normal coronal alignment of the MTP joint in crossover toe deformity.⁷⁻⁹ Postoperative toe stiffness is also common after the transfer.^{2,8,10}

Because the primary pathology is plantar plate deficiency, plantar plate repair is a logical treatment option. It has been shown that plantar plate repair is as effective as tendon transfer in stabilization of the MTP joint, with less postoperative stiffness and discomfort.⁸ Tears of the plantar plate can be repaired primarily with or without the use of suture anchors or repaired by distal advancement of the plate to the base of the proximal phalanx through bone tunnels via the plantar or dorsal approach.^{2,3,6,10-19} Open approaches need extensive soft-tissue dissection and periarticular fibrosis. Plantar plate tenodesis, an arthroscopically assisted dynamic repair of the plantar plate, has been described to correct the claw toe deformity by stabilizing the attenuated plantar plate through suturing of the plantar plate with the extensor tendon.^{4,5,16-18} This arthroscopically assisted procedure allows adequate visualization of the operative field without the need for extensive soft-tissue dissection. Because tethering of the lumbrical contributes to development of crossover toe deformity, in this Technical Note, we report a modification of the

From the Department of Orthopaedics and Traumatology, North District Hospital, Sheung Shui, Hong Kong (T.H.L.); and Department of Orthopaedics and Traumatology, Yan Chai Hospital, Tsuen Wan, Hong Kong (C.K.N.).

The authors report 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 February 15, 2021; accepted March 1, 2021.

Address correspondence to Tun Hing Lui, M.B.B.S.(HK), 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 Road, Sheung Shui, NT, Hong Kong SAR, China. E-mail: luithderek@yahoo.co.uk

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2212-6287/21281

<https://doi.org/10.1016/j.eats.2021.03.004>

Table 1. Indications and Contraindications of Correction of Crossover Toe Deformity by Plantar Plate Tenodesis and Arthroscopic Release of Lumbrical

Indications	Symptomatic crossover toe deformity recalcitrant to conservative treatment
Contraindications	Degeneration or destruction of metatarsophalangeal joint Presence of Morton neuroma on lateral side of deformed toe Deformity caused by bony deformities of metatarsal or proximal phalanx

plantar plate tenodesis and incorporate endoscopic lumbrical release into the technique. This technique is indicated for symptomatic crossover toe deformity that is recalcitrant to conservative treatment.²⁰ It is

contraindicated if degeneration or destruction of the MTP joint is present, Morton neuroma is present on the lateral side of the deformed toe, or the deformity is caused by bony deformities of the metatarsal or proximal phalanx (Table 1).

Technique

Preoperative Assessment and Patient Positioning

A preoperative standing radiograph of the foot is essential for studying the deformity and excluding degeneration or destruction of the involved MTP joint or the presence of any bone deformity of the metatarsal or proximal phalanx. There should not be any clinical evidence of Morton neuroma of the second toe web.

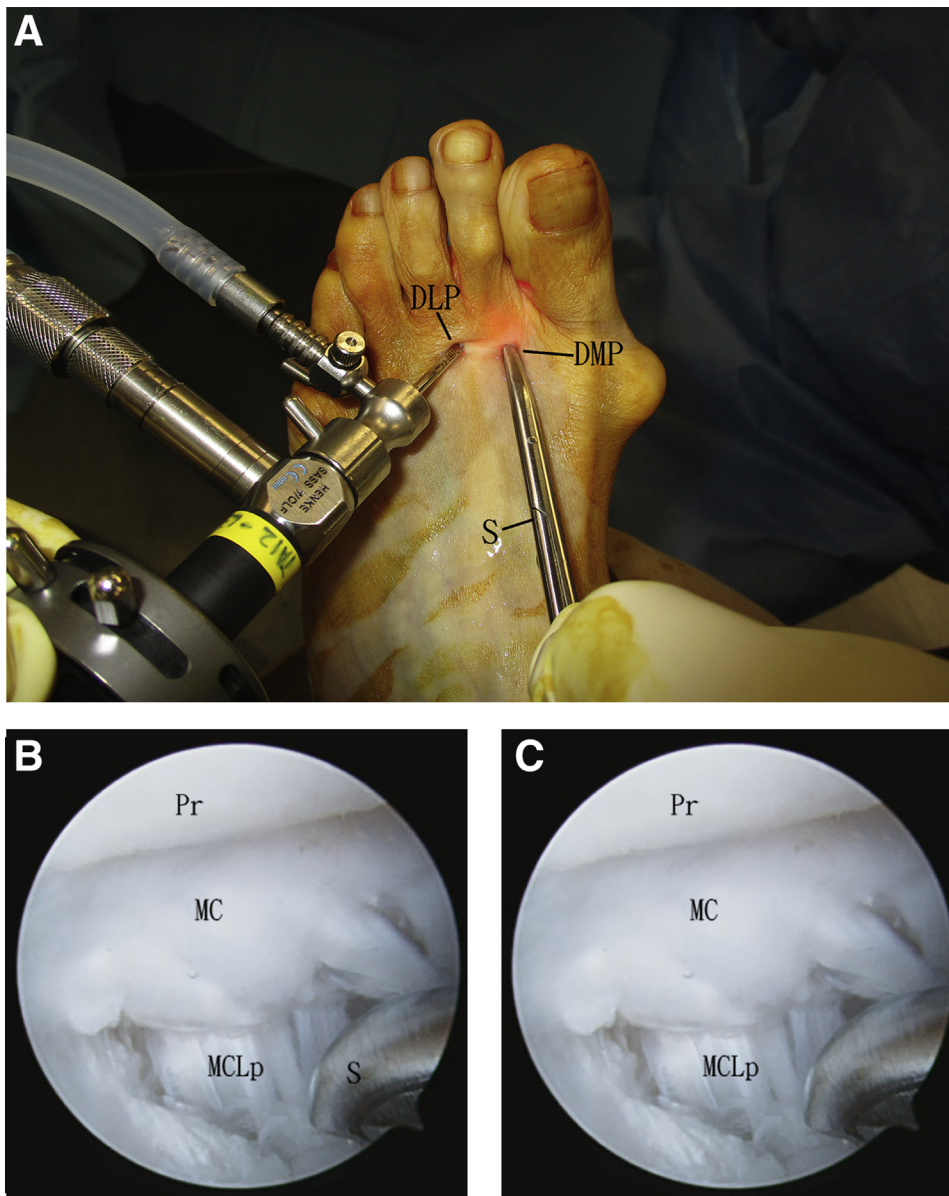


Fig 1. Correction of crossover toe deformity of left second toe by plantar plate tenodesis and arthroscopic release of lumbrical. The patient is in the supine position. (A) The dorsolateral portal (DLP) is the viewing portal, and the dorsomedial portal (DMP) is the working portal. (B) The medial capsulotomy is performed down to the plantar plate by means of SuperCut scissars. (C) The medial proper collateral ligament (MCLp) can be identified and released via the capsulotomy site. (MC, medial capsule; Pr, proximal phalanx; S, scissars.)

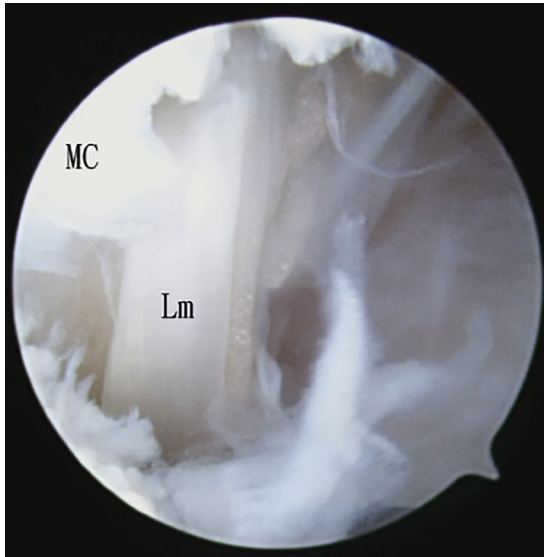


Fig 2. Correction of crossover toe deformity of left second toe by plantar plate tenodesis and arthroscopic release of lumbrical. The patient is in the supine position. The dorsolateral portal is the viewing portal, and the dorsomedial portal is the working portal. After release of the medial capsuloligamentous complex, the arthroscopic view can be extended outside the boundary of the metatarsophalangeal joint. The lumbrical tendon (Lm) can then be identified and released with the scissors. (MC, medial capsule.)

The patient is placed in the supine position with a thigh tourniquet to provide a bloodless operative field. A 1.9-mm 30° arthroscope (Henke Sass Wolf, Tuttlingen, Germany) is used for this procedure. Fluid inflow is driven by gravity, and no arthro-pump is used. Continuous toe traction is not needed.

Portal Placement

The procedure is performed via the standard dorso-medial and dorsolateral portals for second MTP arthroscopy, which are located at the MTP joint level and are on the medial and lateral sides of the long extensor tendon, respectively. Three- to four-millimeter skin incisions are made at the portal sites. The subcutaneous tissue is bluntly dissected down to the joint capsule by a hemostat, and the capsule is perforated by the hemostat tip. The MTP joint is examined arthroscopically to assess the integrity of the plantar plate, the status of the articular cartilage, and the presence of synovitis. Arthroscopic synovectomy is performed with an arthroscopic shaver (Smith & Nephew, Andover, MA) if synovitis is present. The dorsal capsule is stripped from the metatarsal neck by a small periosteal elevator via the portals.

Release of Medial Capsule and Medial Proper Collateral Ligament

The dorsolateral portal is the viewing portal, and the dorsomedial portal is the working portal. The medial

capsulotomy is performed down to the plantar plate by means of SuperCut scissors (Stille, Lombard, IL). The medial proper collateral ligament can be identified and released via the capsulotomy site (Fig 1).

Release of Lumbrical

The dorsolateral portal is the viewing portal, and the dorsomedial portal is the working portal. After release of the medial capsuloligamentous complex, the arthroscopic view can be extended outside the boundary of the MTP joint. The lumbrical tendon can then be identified and released with the scissors (Fig 2).

Anchorage of Lateral Part of Plantar Plate

The dorsomedial portal is the viewing portal, and the dorsolateral portal is the working portal. A No. 1 PDS suture (Ethicon—Johnson & Johnson, Cincinnati, OH) is passed through the lateral part of the plantar plate by means of a straight eyed needle (FavorMed, Ningbo, China). The needle and the suture pass through the lateral part of the plantar plate, the fibrous flexor tendon sheath, and the plantar skin. A 1-cm proximal incision is made on the dorsal side of the diaphysis of the second metatarsal. The suture is retrieved from the plantar surface of the flexor fibrous tendon sheath to the proximal incision by a curved hemostat along the lateral surface of the metatarsal. The suture is tensioned to facilitate catching of the suture by the hemostat. The other limb of the suture passes through the plantar plate, fibrous flexor tendon sheath, and plantar skin by means of the straight eyed needle via the dorsolateral portal. A suture loop is maintained at the dorsolateral portal to allow suture tensioning during retrieval of the suture limb back to the proximal incision. This helps the hemostat to catch the suture at the plantar surface of the fibrous flexor tendon sheath. Then, anchorage of the lateral part of the plantar plate is achieved (Fig 3). The procedure is repeated with another No. 1 PDS suture, and finally, a cruciate configuration of suture anchorage of the plantar plate is achieved (Fig 4).

Correction of Crossover Toe Deformity and Postoperative Protocol

The crossover toe is slightly overcorrected by 20° of plantar flexion and 20° of abduction of the MTP joint. The sutures are tied to the extensor digitorum longus (EDL) tendon to the second toe to complete the correction (Fig 5, Video 1, Table 2). Any concomitant hallux valgus deformity will be corrected under arthroscopic assistance.^{21,22} Postoperatively, bulky dressing is applied to the operated foot for 2 weeks. The operated lesser toe is allowed free mobilization. The patient is advised to follow a non-weight-bearing protocol for 2 weeks and then allowed weight-bearing walking as tolerated with a wooden-based sandal for another 4 weeks before resuming normal shoe wear.⁵

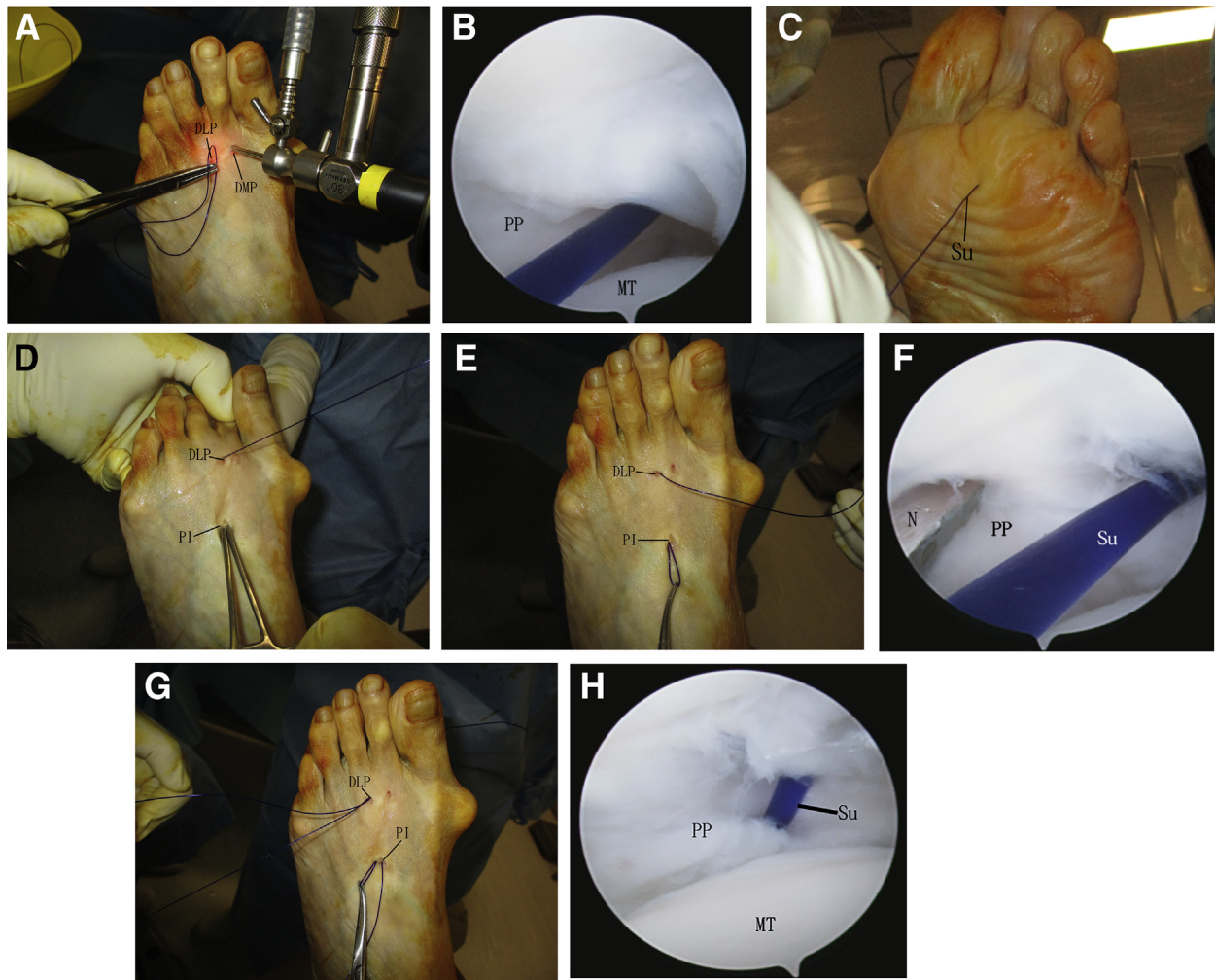


Fig 3. Correction of crossover toe deformity of left second toe by plantar plate tenodesis and arthroscopic release of lumbrical. The patient is in the supine position. (A) The dorsomedial portal (DMP) is the viewing portal, and the dorsolateral portal (DLP) is the working portal. (B) A No. 1 PDS suture is passed through the lateral part of the plantar plate (PP) by means of a straight eyed needle. (C) The needle and the suture (Su) pass through the lateral part of the PP, the fibrous flexor tendon sheath, and the plantar skin. (D, E) A 1-cm proximal incision (PI) is made on the dorsal side of the diaphysis of the second metatarsal. The suture is retrieved from the plantar surface of the flexor fibrous tendon sheath to the PI by a curved hemostat along the lateral surface of the metatarsal. The suture is tensioned to facilitate catching of the suture by the hemostat. (F) The other limb of the suture (Su) passes through the PP, fibrous flexor tendon sheath, and plantar skin by means of the straight eyed needle (N) via the DLP. (G) A suture loop is maintained at the DLP to allow tensioning of the suture during retrieval of the suture limb back to the PI. This helps the hemostat to catch the suture at the plantar surface of the fibrous flexor tendon sheath. (H) Anchorage of the lateral part of the PP is achieved. (MT, metatarsal head; Su, suture.)

Discussion

Plantar plate insufficiency is the most common cause of crossover toe deformity. With time, the plantar plate is deformed and displaced dorsomedially and the fibrous tendon sheath and flexor tendons are displaced medially.²³ With failure of the plate and medial displacement of the flexor tendons, procedures such as capsular release, direct ligament repair, or standard flexor-to-extensor tendon transfer cannot be expected to give reliable full correction of the medial deviation.²³ Plantar plate tenodesis is a form of indirect repair of the plantar plate.^{4,5} The plantar plate and the fibrous flexor tendon sheath are

anchored by the sutures and are pulled back to the normal position.^{4,5} As the plantar plate sutures are tied to the EDL tendon, the pull of the EDL is redirected plantarward to stabilize the plantar plate and the fibrous flexor tendon sheath. The tension of the EDL distal to the sutures is relieved. This, together with release of the dorsal capsule, medial capsuloligamentous complex, and lumbrical, can restore the soft-tissue balance around the MTP joint. The MTP joint can then be reduced, the interosseous tendons become plantar to the axis of rotation of the metatarsal head, and the intrinsic minus toe will be corrected.¹⁸ This technique can stabilize the plantar plate even in case of a

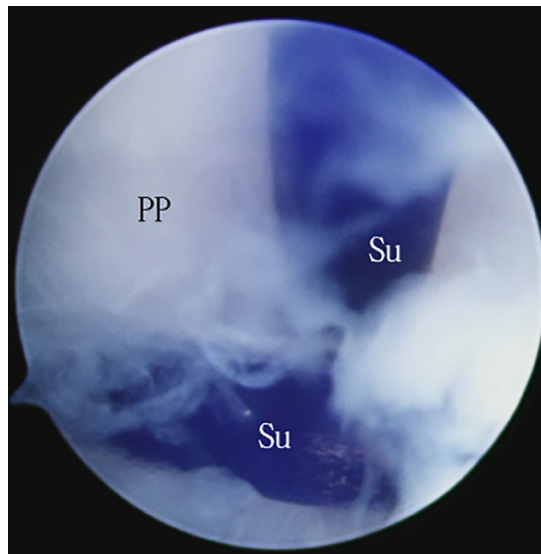


Fig 4. Correction of crossover toe deformity of left second toe by plantar plate tenodesis and arthroscopic release of lumbrical. The patient is in the supine position. The dorsomedial portal is the viewing portal. A cruciate configuration of suture (Su) anchorage of the plantar plate (PP) is achieved.

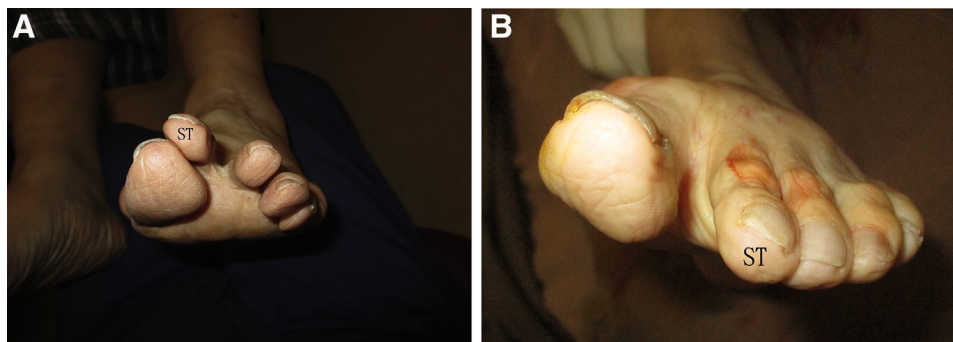


Fig 5. Correction of crossover toe deformity of left second toe by plantar plate tenodesis and arthroscopic release of lumbrical. The patient is in the supine position. (A) A preoperative clinical photograph shows the crossover deformity of the second toe (ST). (B) A postoperative clinical photograph shows that the crossover toe deformity has been corrected.

Table 2. Pearls and Pitfalls of Correction of Crossover Toe Deformity by Plantar Plate Tenodesis and Arthroscopic Release of Lumbrical

Pearls

- Release of the medial capsuloligamentous complex, lumbrical, and dorsal capsule should be completed.
- The needle should pierce the intact part of the plantar plate if possible.
- The hemostat should be inserted along the lateral side of the metatarsal, and no soft tissue should be trapped between the hemostat and the metatarsal.
- The suture is retrieved from the plantar surface of the flexor tendon sheath so that the tendon sheath and the plantar plate are incorporated into the tenodesis construct.

Pitfalls

- Forceful clamping of the suture during suture retrieval from the plantar plate to the proximal incision may weaken the suture and predispose to premature suture rupture.
- Using a large-sized eyed cutting needle to sew the sutures to the extensor tendon may predispose to a longitudinal tear of the tendon.

Table 3. Advantages and Risks of Correction of Crossover Toe Deformity by Plantar Plate Tenodesis and Arthroscopic Release of Lumbrical

Advantages

- Complete medial soft-tissue release
- Precise placement of plantar plate suture
- Minimal soft-tissue dissection
- Avoidance of plantar wound
- Preservation of toe tendons
- No need for sophisticated instruments

Risks

- Injury to articular cartilage
- Injury to interdigital nerve
- Recurrent or residual deformity
- Reduced active toe motion

massive or complicated tear or if the quality of the tissue is poor because the fibrous tendon sheath is incorporated into the construct.^{5,23}

The advantages of this technique include complete medial soft-tissue release, precise placement of the suture to the plantar plate under arthroscopic guidance, minimal soft-tissue dissection, and avoidance of plantar wounds; in addition, the tendons of the toes can be preserved, and sophisticated instruments are not needed. The potential risks of this technique include injury to the articular cartilage, injury to the interdigital nerve, recurrent or residual deformity, and reduced active toe motion (Table 3). This technique is technically demanding and should be reserved for the experienced foot and ankle arthroscopist.

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