



A Technique for the Reduction of Complications Associated With Anterior Portal Placement During Ankle Arthroscopy Using a Peripheral Vein Illumination Device

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Abstract: Ankle arthroscopy is a minimally invasive technique for ankle joint treatment. However, injury to the intermediate dorsal cutaneous nerve (IDCN) and the medial dorsal cutaneous nerve (MDCN) is a common complication during anterior portal placement. To prevent injuries, methods such as palpating the nerves topographically and marking the nerves by transilluminating the skin with an arthroscope have been proposed. Easier and more definitive methods of identifying the IDCN and MDCN should result in a reduction of complications. Recently, a vein imaging system was developed that projects images of subcutaneous vasculature directly onto the skin with the use of near-infrared (NIR) light. Because anatomic studies have shown that superficial veins accompany the IDCN and MDCN, protecting the subcutaneous veins could lower the risk of nerve injury. We introduce our technique for the creation of an ankle arthroscopic portal using an NIR imaging system, which displays the vein image on the skin, to prevent injury to the superficial veins and, consequently, reduce IDCN and MDCN injuries. This is the first technical report on the prevention of vein and nerve injuries using an NIR imaging system. Our technique for avoiding vein injury using a peripheral vein illumination device during anterior portal placement in ankle arthroscopy could lower the risk of complications.

Ankle arthroscopy is a minimally invasive technique for ankle joint treatment. However, several studies have shown that injury to the intermediate dorsal cutaneous nerve (IDCN) and the medial dorsal cutaneous nerve (MDCN), which are the branches of the superficial peroneal nerve (SPN), is a common complication during portal placement in ankle

arthroscopy.¹⁻⁴ The SPN arises from the common peroneal nerve, divides into the MDCN and IDCN, and further subdivides its terminal branches. The SPN or IDCN is positioned on the lateral border of the anterior tibialis tendon in 27% of patients.⁵ According to these anatomic features, the SPN including its branches is often injured during anteromedial portal placement. Several methods to prevent nerve injuries have been reported. Suzangar and Rosenfeld⁴ proposed a less invasive method in which the IDCN could be identified topographically by palpating its course with the ankle held in plantar flexion and inversion. However, it is difficult to palpate the nerve under the skin in several cases such as in an obese patient. Ferkel et al.² reported that the course of the IDCN could be marked by transilluminating the skin with an arthroscope through the anteromedial portal. Although these techniques have been reported, SPN and IDCN injury can still occur. Complications during portal placement may be minimized if the courses of the SPN and IDCN are more easily and definitively identified.

Recently, a vein imaging system with near-infrared (NIR) light was developed to view the subcutaneous

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vasculature and to project images directly onto the surface of the skin in real time. The Vein Viewer Flex (Christie Medical Holdings, Memphis, TN) uses NIR light and displays the vein image on the skin, with the depth of vein visualization ranging from 10 to 15 mm. This light penetrates the skin and subcutaneous fat effectively because of the low absorption of the NIR-wavelength range by these tissues. NIR light is absorbed or scattered in the forward direction by blood but is scattered in all directions in the skin and subcutaneous fat. Hence, blood appears as a dark image, whereas skin and fat appear brighter. The image reflected from the subject is detected with a video camera. An infrared filter prevents visible light from reaching the video camera. The resulting NIR image is then projected back onto the subject's skin with a projector using a green light.⁶ Moreover, this machine has an inverse mode that projects the veins with a green light, and there are some reports that this device improves the visibility of peripheral veins.⁷⁻⁹

Among the anatomic studies on the IDCN and MDCN, the study of Ferkel et al.¹ reported that superficial veins accompany the IDCN and MDCN in the subcutaneous layer. Identification of superficial veins around the site of portal placement for ankle arthroscopy should predict the course of the IDCN and MDCN. The Vein Viewer enables the display of the superficial veins that accompany the IDCN and MDCN and should aid the preclusion of IDCN and MDCN injuries during anteromedial and anterolateral portal placement. We introduce our technique for the placement of an ankle arthroscopic portal using the Vein Viewer Flex to prevent injury to the superficial veins and, consequently, reduce IDCN and MDCN injuries.

Operative Procedure

The operation is performed according to the method of Barg et al.¹⁰ The patient is placed supine on the operating table and receives either general or spinal anesthesia with sedation to allow lower-extremity muscle relaxation. The patient also receives intravenous prophylactic antibiotics before the operation commences. A thigh tourniquet is placed, and a well-padded genitourinary-type limb holder is placed under the thigh that is to be operated on, with care taken to ensure that the popliteal fossa is free from compression. After preparation and draping, an Acufex noninvasive ankle distracter (Smith & Nephew, Andover, MA) is attached to the operating table, and a foot strap is placed. Tension is then applied to the ankle, with care taken to avoid skin injury. Gross and fine tension is adjusted until adequate visualization is achieved while allowing ankle dorsiflexion and plantar flexion.

Normally, an anteromedial portal is created just medial to the anterior tibialis tendon. It has been

reported that positioning the portal just medial to the anterior tibialis tendon is safe, but this procedure does not take into account the course of the veins and nerves. Therefore, we check the course of the veins around the portal site using the Vein Viewer Flex (Video 1). The imaging focus distance of the Vein Viewer Flex is 30 cm, so the device is positioned a safe distance from the sterile surgical field. A doctor or nurse beside the operative foot preserves the sterile condition of the operation field (Fig 1), and the anterior aspect of the ankle joint is illuminated with the Vein Viewer Flex. The vein course is visualized with the green light on the skin in inverse and fine-detail mode (Figs 2 and 3). Veins around the anteromedial portal and anterolateral portal are marked with a skin marker (Fig 4). Avoiding the marked veins, the surgeon uses a 23-gauge needle to pierce into the ankle joint, and the point of the anteromedial portal is confirmed. Thereafter, a skin incision for the anteromedial portal is made with a scalpel medial to the anterior tibialis tendon, with care taken to avoid the marked veins. After the incision, the deeper layer is penetrated to the joint capsule using a mosquito clamp, and the joint is accessed with this clamp. A 2.7-mm arthroscope is then introduced into the joint. Before making the incision for the anterolateral portal, we transilluminate the veins around the point of the anterolateral portal and check the course of the veins marked on the skin with the Vein Viewer Flex. To check the point of the anterolateral portal, the surgeon introduces a needle into the joint, avoiding the marked veins (Fig 5). Similarly to the

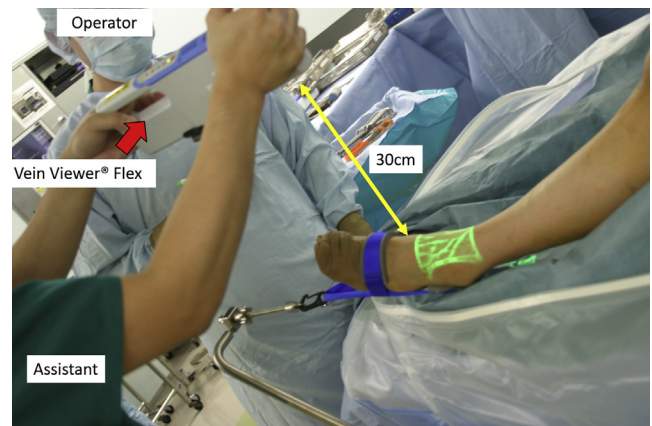


Fig 1. Left ankle, with patient lying in supine position with ankle traction. The operator is standing at the end of the operating table, and the assistant is standing on the lateral side with the Vein Viewer Flex. Assessment of the course of the veins around the portal site is made using the Vein Viewer Flex. The imaging focus distance of the Vein Viewer Flex is 30 cm, so the device is positioned a safe distance from the sterile surgical field. A doctor or nurse standing beside the operative foot ensures that the sterile condition of the surgical field is preserved.

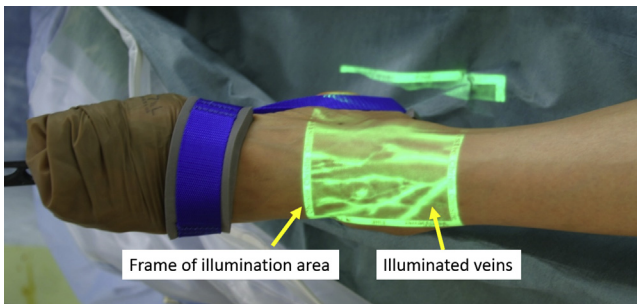


Fig 2. Left ankle, with patient lying in supine position with ankle traction. The veins are illuminated by the lateral-side assistant. The anterior aspect of the ankle joint is illuminated with the Vein Viewer Flex. The course of the veins is visualized with a green light on the skin in inverse and fine-detail mode. The veins accompanying the superficial dorsal cutaneous nerve branches, the intermediate dorsal cutaneous nerve and medial dorsal cutaneous nerve, are illuminated.

incision for the anteromedial portal, the incision for the anterolateral portal is limited to the skin alone, and blunt dissection is used to penetrate the deeper layer down to the joint capsule.

Discussion

Ankle arthroscopy is a minimally invasive and important diagnostic and therapeutic tool, but nerve injury while creating an anteromedial or anterolateral portal is still a major problem. Ferkel et al.² reported that the anteromedial portal is established just medial to the anterior tibial tendon at the joint line and care must be taken not to injure the saphenous vein and nerve as

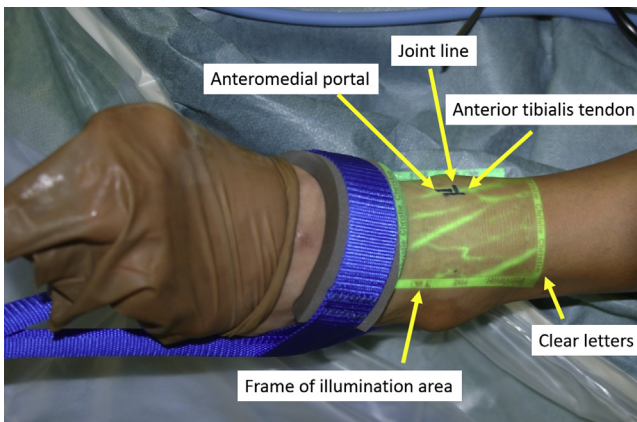


Fig 3. Left ankle, with patient lying in supine position with ankle traction. The medial edge of the anterior tibialis tendon and joint line is marked with a skin marker. The anteromedial portal is marked at the joint line and just medial to the anterior tibialis tendon. After the portals are marked, the anterior aspect of the foot is illuminated by the Vein Viewer Flex. The letters in the frame of the illuminated area are clearly detected. Clear letters mean that the Vein Viewer Flex is in focus. The marked anteromedial portal is checked to determine whether the illuminated veins are overlapping.

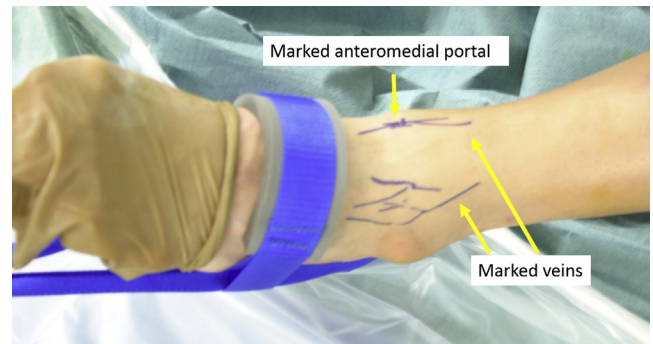


Fig 4. Left ankle, with patient lying in supine position with ankle traction. The veins accompanying the medial dorsal cutaneous nerve and intermediate dorsal cutaneous nerve are marked with a skin marker. Superficial veins are located just below the marked anteromedial portal, so the anteromedial portal placement is changed to just medial to the marked veins. Avoiding the marked veins, the surgeon uses a 23-gauge needle to pierce the ankle joint, and the point of the anteromedial portal is confirmed. Thereafter, a skin incision for the anteromedial portal is made with a scalpel, with care taken to avoid the marked veins. After the incision, the deeper layer is penetrated to the joint capsule using a mosquito clamp, and the joint is accessed with this clamp. A 2.7-mm arthroscope is then introduced into the joint.

they traverse the anterior joint line. Moreover, the anterolateral portal is placed just lateral to the peroneus tertius tendon and slightly proximal to the joint line. The structure at highest risk of injury is the IDCN, and

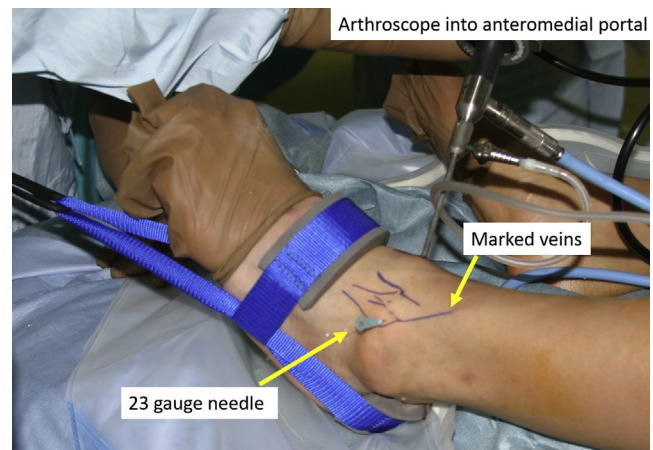


Fig 5. Left ankle, with patient lying in supine position with ankle traction. Before the incision is made for the anterolateral portal, the veins around the point of the anterolateral portal are transilluminated with the Vein Viewer Flex and the course of the veins is marked by a skin marker. To assess and select the point of the anterolateral portal, a 23-gauge needle is used to pierce the joint, with the marked veins being taken into consideration. After removal of the needle, the incision for the anterolateral portal is limited to the skin alone, and blunt dissection with a mosquito clamp is used to penetrate the deeper layer down to the joint capsule.

Table 1. Pearls of Using Peripheral Vein Illumination Device

The imaging focus of the Vein Viewer Flex is 30 cm. The focus point can be confirmed using outer frame letters. The letters are clearly displayed when the device is in focus.

The illumination device has to be kept perpendicular to the anterior aspect of the ankle. If illuminated obliquely, the veins are depicted as a distorted image.

Fine-detail and inverse mode is recommended to display the veins more clearly. The mode is easy to change by pushing a button on the Vein Viewer Flex.

clinical studies have frequently reported injury to the SPN or its branches when using the anterolateral portal.¹¹ Ferkel et al.² also reported an overall complication rate of 9% in 612 ankle arthroscopies, with the most common complication being neurologic injury, which accounted for 49% of the complications. Young et al.³ reported a 6.8% complication rate in 294 ankle arthroscopies, and neurologic injury was the most common complication, accounting for 80% of all complications. Vascular injuries, although less prevalent, have also been reported.¹²

To avoid these complications, several methods to establish portals, such as use of a mosquito clamp after skin incision, a nerve palpation technique, and a transillumination technique, have been suggested.^{1,2,11,13,14} However, to reduce the risk of iatrogenic injury to the nerve, it is expected that our method will identify neurovascular structures more easily before making arthroscopic portal incisions. Ferkel et al.¹ reported that 3 sensory nerve systems and accompanying superficial veins are located in the subcutaneous layer around the ankle—the superficial peroneal, saphenous, and sural veins—and there is a possibility that avoiding vein injury will prevent injury to the IDCN or MDCN.

The anteromedial portal is recognized as a relatively safe portal, but the placement of the anteromedial portal can only be evaluated when it is just lateral to the tibialis anterior tendon. Our method for evaluating the placement of portals with the Vein Viewer Flex can assess veins around the anteromedial portal non-invasively (Video 1).

To our knowledge, there are no reports regarding the use of an NIR light imaging system in arthroscopic portal placement. With the described method, the vasculature may be evaluated noninvasively just before the procedure, a safe distance from the sterile surgical field. Furthermore, this method is considered very low risk because the veins are depicted with safe NIR light from a safe distance. We suggest the adoption of this method using the Vein Viewer Flex to minimize complications associated with portal creation for ankle arthroscopy.

There are several limitations to this study. First, the complication rate after surgery with the described method was not prospectively evaluated. Second, the

Table 2. Advantages and Disadvantages of Using Peripheral Vein Illumination Device During Ankle Arthroscopic Portal Placement

Advantages

- The veins can be depicted on the skin using the Vein Viewer Flex.
- The device is easy to use, only illuminating the skin.
- The device is able to illuminate the veins while the operation field is kept sterile.
- The veins are detected just before the moment of portal placement with ankle traction.

Disadvantages

- The smallest vein size visible is limited to 0.22 mm in diameter.¹⁵
- Application of the technique in obese patients is difficult because the visible depth is limited to 10-15 mm.
- After the veins are marked, the course of the veins will change if the ankle position is changed.

actual relation between the superficial veins and nerves and the vein images obtained with the Vein Viewer Flex was not assessed. Further examination, including cadaveric studies, seems necessary to address these limitations. Our technique for preventing vein injury using a peripheral vein illumination device could lower the risk of complications associated with anterior portal placement in ankle arthroscopy (Tables 1 and 2).

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