A Single-Incision Fasciotomy for Compartment Syndrome of the Lower Leg

Nabil A. Ebraheim, MD, Saaid Siddiqui, MD, and Craig Raberding, MD

Summary: Lower leg fasciotomy may be performed with a single lateral incision with or without fibulectomy, or by a double incision technique, with most surgeons preferring the later. The aim of this article is to describe a variation of an existing single-incision technique that will allow for the release of all four compartments with 1 incision. Our approach uses a paratibial route to release the deep posterior compartment (DPC) rather than a transfibular or parafibular route that has already been discussed in the literature. We approach the DPC from the anterior compartment, whereas the parafibular approach uses the posterior aspect of the fibula to reach the DPC. This affords a faster fasciotomy with a smaller flap, avoids potential damage to neurovascular bundle and among other advantages, makes its especially pragmatic for bedside fasciotomy, without the risk of injury to the peroneal nerves, which is common with dissection at the posterior aspect of the fibula.

Key Words: compartment syndrome, fasciotomy, single incision, paratibial, parafibular, fibulectomy, pressure measurements, leg compartments

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INTRODUCTION

We illustrate a fasciotomy approach that uses a single incision to release all 4 compartments. This technique uses a paratibial approach, and in so doing, affords specific advantages. First, because the deep posterior compartment (DPC) is accessed through the anterior compartment, the neurovascular bundle is not intruded on. Second, a single incision reduces the surgery time. And last, most surgeons' familiarity with the anterior compartment rather than posterolateral compartment means a faster surgery and from a surgeon's standpoint an intuitive and more direct approach. The more common approach of accessing the DPC through the peroneal muscles surrounding the fibula is more complicated because the fibula, unlike the tibia, is surrounded by muscles and neurovascular bundles. This means a steeper learning curve for the surgeon and potential for mistakes because this requires the surgeon to wade through more structures to access the DPC (Fig. 1).

The double incision release of the compartments is preferred by most surgeons, principally due to the notion that a double incision affords a more complete release of the compartments with most surgeons willing to fail on the side of safety. However, there have not been any studies performed to date that compare the extent of compartment release with a single versus a double-incision approach. In fact, the preferred surgical approach to release the compartments has varied over time. A brief survey of historical and prevalent techniques is in order.

DeBakey[1] initially described a 2-incision approach in 1946, whereas dealing with injuries in World War II. In the era of Vietnam, Kelly et al[2] introduced a single-incision fasciotomy through fibulectomy. This method began as a means to more completely decompress the DPC because it was believed that this compartment had inadequate decompression with the 2-incision approach. However, the 2-incision approach came back into favor with Mubarak and Owen[3] demonstrating in 1977 that it is indeed efficacious without the added morbidity of removal of the fibula. Nghiem and Boland[4] in 1980 described a single-incision technique that did not require fibulectomy. They performed an anterolateral incision and incised the deep fascia on either side of the anterior intermuscular septum to release the anterior and lateral compartments. The superficial posterior compartment was reached through the intermuscular septum along the posterior aspect of the lateral compartment, whereas the peroneals were retracted anteriorly. The DPC was reached anteriorly by retracting the extensor hallucis longus laterally and incising the interosseous membrane. Cooper[5] in 1992 described his single-incision technique in which the only deep fascia incision was over the lateral compartment. The remaining compartments were addressed through the intermuscular septae around the lateral compartment. Maheshwari et al[6] separately described a single-incision approach using a similar anterolateral incision to Nghiem and Boland[4] and incising the deep fascia over the anterior, lateral, and superficial posterior compartments (see **Figure**, **Supplemental Digital Content 1**, http://links.lww.com/BOT/A617).

OPERATIVE TECHNIQUE

The initial skin incision is made on the lateral skin halfway between the anterior crest of the tibia and fibula, starting in the middle third of the leg and extending distally. The length of the incision is variable and depends on the

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From the Department of Orthopedic Surgery, University of Toledo Medical Center, Toledo, OH.

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Reprints: Nabil A. Ebraheim, MD, Department of Orthopedic Surgery, University of Toledo Medical Center, 3000 Arlington Avenue, Toledo, OH 43614 (e-mail: nabil.ebraheim@utoledo.edu).

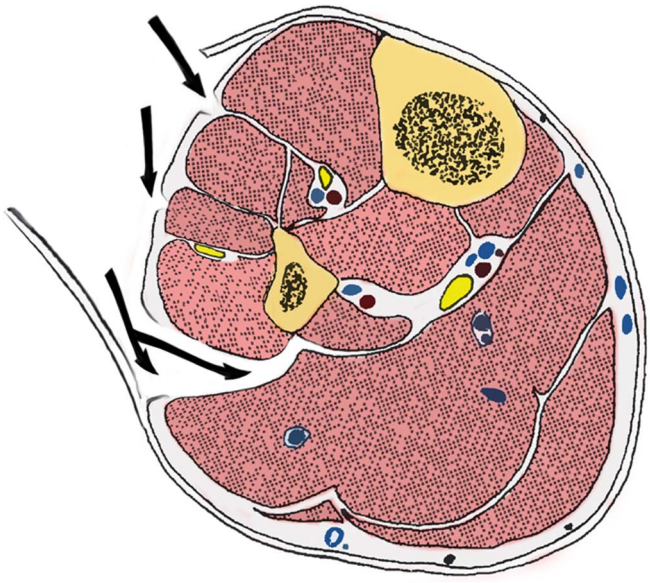

FIGURE 1. A schematic of the single incision fasciotomy as described by previous authors which approaches and releases the deep posterior compartment by going posterior to the fibula.

extent of swelling, but a typical incision runs approximately two-thirds the length of the lower leg (Fig. 2). The deep fascia and anterior intermuscular septum are visualized and are identified by palpation. An incision is made in the deep fascia anterior and posterior to the septum to open the anterior and lateral compartments (Fig. 3A, B).

These incisions in the deep fascia were extended bluntly with fingers both proximally and distally. The posterior intermuscular septum is visualized from inside the lateral compartment as the peroneals are retracted anteriorly. This is incised and extended proximally and distally to release the superficial posterior compartment (Fig. 3C).

The DPC is accessed through the anterior compartment. The tibialis anterior is retracted laterally. An incision is made along the lateral tibia posteriorly to encounter the DPC through the interosseous membrane. The membrane is incised and the incision is extended using a Cobb to fully release the DPC (Fig. 3D).

FIGURE 2. A clinical photo of a single incision fasciotomy wound.

Typically, two-thirds the length of the interosseous membrane is incised, and therefore, this is not significant enough to affect the stability and biomechanics of the leg. Also, the incision starts in the proximal to middle third of the leg and proceeds distally. The neurovascular bundle comprising of the anterior tibial artery and vein along with the deep peroneal nerve are located more laterally in this segment and are therefore not encroached on.

RESULTS

This retrospective study was authorized by the Institutional Review Board and conducted at our level 1 trauma center. We reviewed data of 184 consecutive lower leg fasciotomies from 2010 to 2014. Of these 184 patients, 30 underwent single-incision fasciotomy to release all 4 compartments performed by a single trauma surgeon. There were no specific exclusion criterion applied in selecting patients for the single incision, except when the surgeon believed it necessary to explore the DPCs, this was usually required when soft tissue injuries were extensive. We thereafter clinically reviewed these patients and collected retrospective data: Of the 30 cases, 27 patients had associated fractures (24 closed, 3 open), 3 had no associated fracture—2 of these had soft tissue injuries and 1 patient developed compartment syndrome spontaneously. There were 11 female and 19 male patients with a mean age of 42 years (range, 18–74 years) (see **Table**, **Supplemental Digital Content 2**, http://links.lww.com/BOT/A618).

Mechanisms of injury included 18 motor vehicle accidents (60%), 6 were falls from a height (20%), 3 falls on ice, and 2 had a fall from the stairs. All fasciotomies were performed within 24 hours of presentation to our institution. Table 1 shows the underlying injury that was sustained.

To establish the efficacy of the single-incision technique, we looked at outcomes that are a result of the fasciotomy procedure itself rather than the reduction and fixation procedure so as not to confound the fasciotomy outcomes with those of the fracture treatment. In the immediate postoperative period, we looked at the rate of infection and altered sensation in wound margins.

All patients had immediate and marked improvement in pain. Blood loss was minimal (<100 mL) There were no intraoperative complications. In the immediate postoperative period, altered sensation around the wound margins was the most common symptom and was reported in as many as 19 of the 30 patients (63.3%). This is consistent with the previous studies that have reported rates as high as 77%.[7] Superficial wound infection was reported in 1 patient and was treated with debridement and appropriate antibiotic. At the 14-week follow-up, the infection had resolved completely. Nerve damage occurred in 1 patient. He had calf pain and loss of sensation in the dorsal web spaces of the first and second toe at the 8-week follow-up. There were no reports of recurrent ulcers, amputations, or mortality. Tethered scars at the fasciotomy site were seen in 7

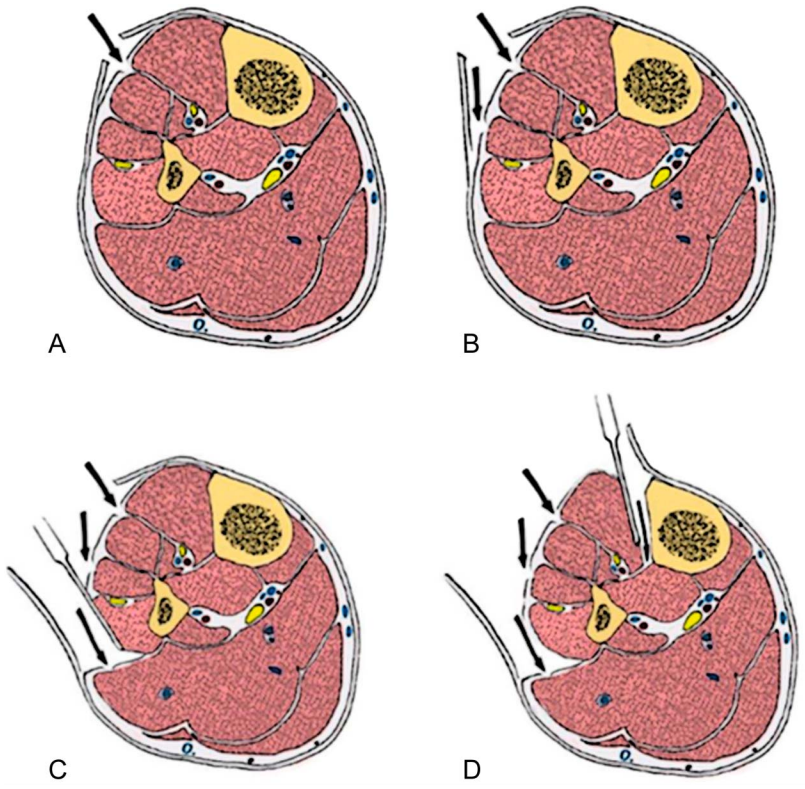

FIGURE 3. Our described approach for the single incision fasciotomy. (A) The initial skin incision is made halfway between the tibia and fibula to release the anterior compartment. (B) Release of the lateral compartment. (C) The superficial posterior compartment is released after retracting the peroneals anteriorly. A Cobb may be used for this purpose. (D) The deep posterior compartment is released by retracting the tibialis anterior laterally from the tibia and then incising the interosseous membrane.

patients, and 3 patients had tethered tendons. There were no cases of chronic infection, osteomyelitis, or amputations. Delayed primary closure was performed in 8 patients and split thickness skin grafting was performed in the remaining 22 patients. A comparison with previous studies (as reported in the literature) indicates that the outcomes, both short term and long term, are similar (Table 2).

Twenty-nine (96.7%) patients had reference range of motion of adjacent joints. Two patients had decreased range of motion; however, both these had nonunion of underlying fractures requiring revision open reduction internal fixation.

DISCUSSION

We illustrate a single-incision surgical technique and demonstrate its usage in the management of compartment syndrome. Our approach uses a paratibial route to release the DPC rather than a transfibular or parafibular route that has already been discussed in the literature. Also, we access the superficial posterior compartment from the lateral compartment. The anterior and lateral compartments are generally more familiar to the orthopaedic surgeon, and this affords an easier, straightforward, and a faster fasciotomy with a smaller flap which, among other advantages, makes its especially pragmatic for bedside fasciotomy. The single-incision technique previously described uses a fibular approach (Fig. 1), and as such presents a greater risk of injury to the deep and superficial peroneal nerve.

Although our approach requires retraction of the tibialis anterior, the anterior tibial artery and the anterior tibial vein along with the deep peroneal nerve are located laterally from tibialis anterior in the middle portion of the lower leg and as such are not encroached on at all. Also, restricting our incision to the distal two-thirds of the leg affords a smaller incision of the interosseous membrane rather than the entire length of the lower leg as required in other single-incision

TABLE 1. Underlying Injury

Underlying Injury	No. Cases (%)
Tibial diaphyseal fracture	13 (48)
Tibial plateau fracture	9 (30)
Tibial pilon fracture	3 (10)
Talar fracture	1 (3.33)
No fracture	3 (10)

TABLE 2. Outcomes After Fasciotomy

Outcomes	This Study (%)	Previous Studies (%)
Wound infection	1 (3.33)	4–7[8,9]
Altered sensation in wound margins	19 (62)	77[7]
Nerve damage	1 (3.33)	6[7–10]
Tethered scars	7 (23.3)	26[7]
Tethered tendons	3 (10)	7[7]
Persistent wound pain	1 (3.33)	17[7]
Recurrent ulceration	None	13[7]
Amputation	None	5–21[8–12]
Death	None	11–25[9,11–13]

Comparison with previous studies in the literature.

techniques,[6] this may be important to avoid any biomechanical instability that may result from a longer incision of the interosseous membrane. Incision of the interosseous membrane to achieve release of the DPC has been successfully performed in the past by Nghiem and Boland.[4] Their approach involves retraction of the extensor hallucis longus to access the interosseous membrane, which is then incised to release the DPC.

Retracting the tibialis anterior away from the tibia may seem disadvantageous as muscle attachment to the bone promotes healing, but this is not borne out from the authors experience with the patients undergoing this procedure. Also, retracting peroneals from the fibula is used by Maheshwari et al[6] (see **Figure**, **Supplemental Digital Content 1**, http://links.lww.com/BOT/A617), and their patient series do not seem to have developed a specific comorbidity arising from retracting muscle away from the bone either. Moreover, stripping muscle from bone is common in orthopaedic surgery, for example, the pronator quadratus is stripped from the distal radius in the volar approach to all types of distal radius fractures.

This single-incision fasciotomy may be used for compartment syndrome of the lower leg arising from a variety of conditions and fractures. The only exclusion criteria would be when the tibial shaft is severely comminuted, in which case retracting the tibialis anterior to access the interosseous membrane may not be feasible, and there is a danger of devitalizing a fracture fragment. Otherwise, the surgeon may choose to judiciously incise away from the sight of the tibial fracture. Also, if the surgeon wishes to explore the DPC, then it may be better to use the double-incision approach.

A concern that has been expressed in the past is that of increased operative time for a single-incision fasciotomy. Initial comparisons in the literature performed by Mubarak and Owen[3] compared the dual-incision approach to that of the single-incision approach with fibulectomy. Undoubtedly, adding an osseous component to the surgical technique would likely require more time. However, current single-incision techniques like the one described here rely solely on fascial release without fibulectomy. To our knowledge, there has not been any demonstration in the literature of a single-incision technique without fibulectomy requiring longer operative times. The other concern raised with respect to time is that it requires longer to reliably identify the DPC. Using the tibia as a landmark, our experience has been that this is a task that is quickly and accurately performed. Traversing the lateral border of the tibia takes the surgeon directly to the interosseous membrane with minimal risk to neurovascular structures.

This article has inherent limitations, including being a retrospective study, having a small study group, and lacking a control. For obvious reasons, it would be unethical to compare fasciotomy to no treatment because the sequelae of failure to timely treat compartment syndrome have been well defined. However, comparison of this described technique to other techniques would likely prove beneficial to the orthopaedic community. Further prospective studies comparing this described technique to other single-incision approaches and the dual-incision approach are warranted. In addition, there is a lack of objective strength assessment to demonstrate full decompression of all 4 compartments. In the setting of acute trauma, however, muscle injury from the direct trauma would be likely to cause decreased strength just as injury secondary to ischemia making this a difficult objective measure. Assessing the functional status of the limb after procedure is confounded by the functional deficits inherent in the patients' limb trauma.

In conclusion, there are multiple proposed techniques to treat compartment syndrome of the leg. We present a technique to release all 4 compartments that may be thought of as a variation of an existing technique. In our institution, this technique has been established to be fast and reliable to decompress all compartments with adequate surgical exposure and minimal soft tissue morbidity. For these reasons, this single-incision technique may prove beneficial to the surgical repertoire in the orthopaedic community.

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