NERVE INJURY AND PAIN AFTER OPERATIVE REPAIR OF CALCANEAL FRACTURES: A LITERATURE REVIEW

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ABSTRACT

Peripheral nerve injury is a common problem in foot and ankle surgery. We look at evidence of nerve injury as it relates to different operative approaches to the fractured calcaneus. The direct lateral, extended lateral, smile, sinus tarsi, and percutaneous approaches are discussed and the reported incidence of nerve injury in each is identified. We expect to identify divergent rates of injury between approaches and stimulate further investigation into prevention and treatment.

INTRODUCTION

Peripheral nerve injury is a common clinical problem associated with foot and ankle surgery that may lead to severe pain, serious disability, and poor outcomes[1,2]. This condition is especially concerning following operative repair of calcaneal fractures. The calcaneus is a subcutaneous bone that sustains repetitive and maximum impact loads from ground reaction forces as well as irritation from shoe wear[3,4]. Thus, heel pain and hypersensitivity following surgery can be unrelenting and difficult to manage. The literature has not adequately focused on nerve injuries related to the surgical treatment of calcaneus fractures despite the large impact of this unfortunate complication. While wound complications have greatly improved with modification of incisions and concern for vascular injury, nerve injury remains a prominent clinical problem[5]. The goal of this review is to highlight the current literature on nerve injury-related pain after repair of calcaneal fractures to prompt future research in the topic.

Although it is suspected that this condition has been underreported, studies have nonetheless revealed multiple different types of nerve injury following various surgical approaches to repair calcaneal fractures[6-11]. Whether resulting from direct injury, traction injury, or idiopathic mechanisms such as reflex sympathetic dystrophy/complex regional pain syndrome, nerve pain results in significant morbidity and distress for affected patients. As there is no uniform definition or diagnosis to describe postsurgical nerve pain, such conditions may appear in the literature as neuropraxia, post-surgical neuroma, unexplained heel pain, hypersensitive scar, or complex regional pain syndrome (CRPS). Neuromas can result from traumatic mechanisms including direct injury (transection or unintentional suturing), excessive retraction, or entrapment within scar tissue[12]. They typically cause pain, burning, paresthesias, dysesthesias, and hyperesthesia[1,12]. CRPS can be caused by any type of surgery or trauma and results in unremitting and prolonged pain that is out of proportion to injury[8]. CRPS type I is similar to idiopathic reflex sympathetic dystrophy and not related to a specific nerve. CRPS type II is defined as causalgia from direct injury to a named nerve[8]. Neuropraxia, defined as irritation to a nerve resulting in a transient loss of function through conduction block without axonal degeneration, is most commonly caused by traction[13,14]. It is typically diagnosed by pain at the site of lesion with radiation in the anatomic path of the nerve and carries a relatively good prognosis[13,14].

INCIDENCE OF NERVE INJURY RELATED TO VARIOUS SURGICAL APPROACHES

Direct lateral approach

Palmer[15] originally described the direct lateral approach in 1948 for treatment of displaced intra-articular calcaneal fractures. The incision is initiated proximal and posterior to the tip of the fibula, curves around the lateral malleolus at the level of the sinus tarsi, and extends to the calcaneocuboid joint (Figure 1, A)[15-17]. Depth of the incision is made down to the sheath of the peroneal tendons, which can then be retracted anteriorly[15,17]. In addition, the sural nerve is dissected posteriorly and retracted[17]. Early studies by Stephenson[17] and Leung et al[18]. reported 1 out of 22 (5%) and 5 out of 64 (8%) calcaneal fractures developed post-operative paresthesias and painful incisions along the sural nerve distribution. All the cases spontaneously resolved without treatment[17,18]. In 1992, Buckley and Meek[19] reported 5 of 17 feet that had post-operative sural nerve lesions following the

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Table 1. Summary of nerve injury complications reported in the literature by various approaches for operative repair of calcaneal fractures

Article	Number of calcaneal fractures repaired operatively	Number of nerve injury symptoms (% of total)	Number of CRPS cases (% of total)	Incidence of spontaneous recovery (% of nerve injuries)
Direct Lateral Approach				
Eastwood and Atkins (1992)	20	11 (55%)		7 (63%)
Buckley and Meek (1992)	17	5 (29%)		4 (80%)
Stephenson (1987)	22	1 (5%)		1 (100%)
Leung et al. (1989)	64	5 (8%)		5 (100%)
Fernandez and Koella (1993)	41	1 (2%)		0 (0%)
Chan (1995)	40	3 (8%)	3 (8%)	0 (0%)
Extended Lateral Approach				
Eastwood and Atkins (1992)	20	2 (10%)		2 (100%)
Sanders et al. (1993)	132	12 (9%)		8 (66%)
Harvey et al. (2001)	218	6 (3%)		5 (83%)
Weber et al. (2008)	26	2 (8%)	4 (15%)	2 (100%)
Freeman et al. (1998)	150	4 (3%)		4 (100%)
Smile Approach				
Wiley et al. (2005)	73	6 (8%)	3 (4%)	0 (0%)
Sinus Tarsi Approach				
Ebraheim et al. (2000)	106	3 (3%) (2T; 1S)		1 (33%)
Geel and Flemister (2001)	32	0 (0%)		
Weber et al. (2008)	24	1 (4%) (1T)		1 (100%)
Mostafa et al. (2010)	18	0 (0%)		
Spagnolo et al. (2011)	39	0 (0%)		
Nosewicz et al. (2012)	21	1 (5%) (1T)		0 (0%)
Percutaneous Approach				
Tomesen et al (2011)	39	4 (10%)	1 (3%)	4 (100%)
Wang et al (2010)	210	12 (6%) (6T; 6S)		0 (0%)

T: Tibial nerve injury; S: Sural nerve injury; All reported injuries are based on sural nerve unless specified.

direct lateral approach. Four resolved spontaneously, but one resulted in an unsuccessful neuroma resection[19]. Eastwood and Atkins[16] found 11 sural nerve problems out of 20 cases, of which four continued to have permanent pain and dysfunction. Fernandez and Koella[20] reported one case of a painful sural nerve neuroma out of 41 patients (2%). Chan[21] in 1995, described 3 of 40 patients (7.5%) with sural nerve damage while another three patients (7.5%) were diagnosed with reflex sympathetic dystrophy.

Extended lateral approach

This approach is described as a full thickness 'L-shaped' incision on the lateral heel raised without direct exposure of sural nerve unless it is encountered at the proximal or distal end of the incision (Figure 1, B)[22]. In comparison to the direct lateral approach, the extended lateral approach has been shown to reduce damage to the sural nerve and preserve blood supply to the flap from minimizing the dissection[2,22,23]. Sanders et al.[24] reported four cases (3.3%) of permanent paresthesias

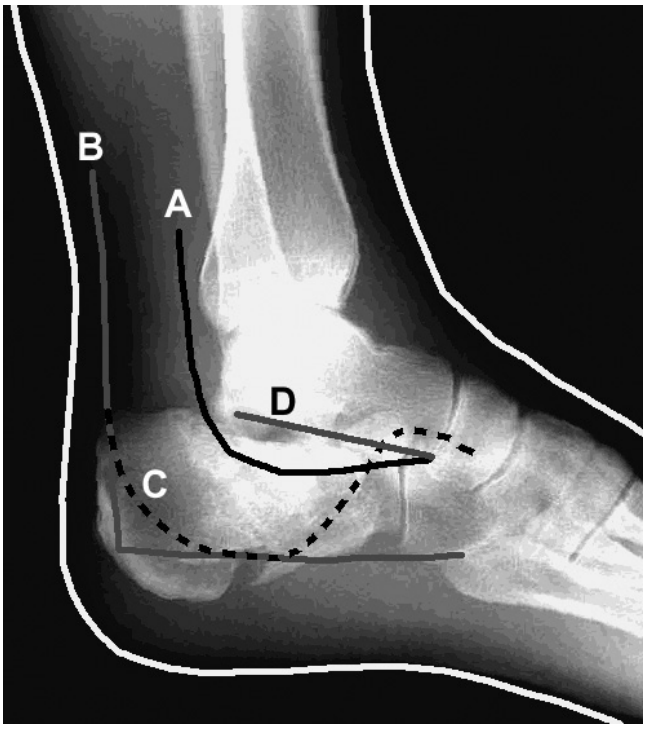

Figure 1. Radiograph of hindfoot demonstrating placement of incisions on the lateral foot for operative repair of calcaneal fractures. (A) Direct lateral approach. (B) Extended lateral approach. (C) Smile approach. (D) Sinus tarsi approach.

from the original 12 patients with sural nerve symptoms (10%) following 120 repaired calcaneal fractures using this approach. Harvey et al.[25] reported post-operative sural nerve dysfunction in 6 of 218 patients (2.8%), one of which was treated with transposition of a neuroma, while the others resolved spontaneously. Four of 26 patients (15%) studied by Weber et al.[10] in 2008 were diagnosed with complex regional pain syndrome following extended lateral incision with 2 additional cases (8%) having injury to the sural nerve. Eastwood and Atkins[16] described 2/20 (10%) of patients that had altered sensation in the sural nerve distribution following the extended lateral approach, both of which resolved spontaneously. Additionally, Freeman et al.[22] reviewed 150 cases of open reduction and internal fixation of calcaneal fractures using the extensile lateral approach and found four cases of paresthesias that resolved spontaneously without major sural nerve injuries. Overall, up to 23% of patients with the extended lateral approach have some sort of nerve pain following operative repair, if sural nerve injury and CRPS cases are combined[10].

Smile Approach

The "smile" approach, as described by Wiley et al.[11] in 2005, was developed to reduce wound healing issues, but sural nerve injury is still a concern as the incision and nerve cross at right angles. The three main landmarks of the incision include the posterior superior apex of the calcaneus (1), the inferior border of the calcaneus below the fibula (2), and the superior extent of the anterior process of the calcaneus (3) (Figure 1, C). From landmarks 1 and 2 the incision is taken directly down to bone, but from landmarks 2 to 3 only skin is incised initially. The sural nerve is then carefully dissected out with a blunt instrument and mobilized. Six out of the 73 patients (8%) followed by Wiley reported numbness or pain in the sural nerve distribution following the "smile" approach. In addition, three patients developed reflex sympathetic dystrophy, but there were no neuromas reported. They concluded that the "smile" approach does not cause any more nerve injuries compared to those in the extended lateral incision.

Sinus Tarsi Approach

The sinus tarsi approach is more recently described and growing in popularity as a limited incision for fractures of the os calcis. As described by Weber et al.[10] in 2008, the incision is made from the tip of the lateral malleolus to the calcaneocuboid joint in line with the 4th metatarsal (Figure 1, D). The incision continues deep between the peroneal tendons and the sinus fat pad but only to the fascia of the extensor digitorum brevis muscle located more distally. Out of 24 cases, Weber et al.[10] reported one case of plantar nerve injury but no sural nerve injuries and no cases of complex regional pain syndrome (CRPS). Nosewicz et al.[26] reported one case of tarsal tunnel syndrome (tibial nerve) out of 21 patients following the sinus tarsi approach that improved following a tarsal tunnel release without additional cases of nerve injuries. Of 106 surgically repaired calcaneal fractures using the sinus tarsi technique, Ebraheim et al.[27] described two patients with symptoms of tarsal tunnel syndrome and improvement following a tarsal tunnel release. In addition, there was one case of sural nerve injury that recovered spontaneously at four months. There were no reported cases of nerve injury, entrapment, or CRPS in studies by Geel and Flemister[28], Mostafa et al[29], and Spagnolo et al.[30] evaluating 32, 18, and 39 cases, respectively. An anatomic study done by Lawrence[6] highlighted a concern for incisions placed in the sinus tarsi area causing potential injury to the communicating branch connecting the sural and superficial peroneal nerves, but no specific injuries to this branch have been reported. The relatively more common tibial nerve symptoms related to this approach are poorly understood. Overall, there are less reported nerve injuries with the sinus tarsi incision compared to both the direct lateral and the extensile lateral incision.

Percutaneous Approach

Many newer approaches for operative repair of calcaneal fractures, including the percutaneous approaches, are becoming more popular in foot and ankle surgery. However, a limited number of studies report nerve injury complications following the percutaneous approaches. Percutaneous reduction of calcaneal fractures typically involves posterior superior placement of K wires or Steinmann pins to aid in reduction followed by screw placement, followed often, in various techniques, by a lateral to medial screw into the sustentaculum tali. Screw placement is ultimately variable based on fracture lines and different methods are employed for distraction and reduction between studies. Tomesen et al.[29] reported four out of 39 patients developed transient paresthesias and one patient that developed CRPS following percutaneous calcaneal fracture repair. Of the 210 fractures reported by Wang et al.[31], four patients developed medial plantar nerve injuries, two had tibial nerve injuries (calcaneal branch), and six patients had sural nerve injuries. This approach involved a small posterolateral incision for insertion of a plate. All of these patients improved following hardware removal and/or neurolysis. Schepers et al.[32] described a 10% risk of injury to the lateral dorsal cutaneous nerve, the continuation of the sural nerve, using the percutaneous approach with most cases improving spontaneously. Specific data was not reported, however, in that description. Overall, additional studies reporting the incidence of nerve injury complications are needed to accurately assess the risk using the percutaneous approach. Much of the existing literature focuses on wound complications and maintenance of reduction when comparing percutaneous approaches to more standard described approaches.

PREVENTION AND AVAILABLE TREATMENT

Nerve pain is a difficult problem to treat and the best management is prevention of nerve injury[12]. Knowledge of peripheral neuroanatomy and potential pattern variations, in addition to choosing an incision that is less likely to cross the main nerve, are the foundations to prevent nerve pain[12-14]. Minimizing the degree of nerve retraction should also be considered when choosing the best incision; but when necessary, gentle and brief retraction should be implemented[12,14]. In some cases nerve sacrifice is unavoidable and may be preferable to excessive nerve retraction. In addition, careful wound closure with awareness of stitch placement is needed to avoid entrapment[12]. It is unknown the exact mechanism and cause of complex regional pain syndrome; however some[33] have proposed potential preventative measures to reduce its likelihood postoperatively. Overall, identification and protection of the nerve throughout surgery is imperative to reduce the incidence of nerve pain.

Even if the above measures are taken to prevent nerve injury, injuries will still occur. The presence of pain post-operatively is difficult to treat, as some pain resolves spontaneously while others may only improve surgically, even with experienced clinical judgement, it may be hard to discern initially which patients will get better non-operatively. Nerve pain is first managed medically with steroid injections, local or peripheral nerve blocks, and neuropathic pain medications such as amitriptyline, gabapentin, and carbamazepine in addition to physical therapy and continued activity of the affected limb[34]. Narcotics should only be used during acute pain episodes[35]. Some patients may find pain improvement with transcutaneous electrical nerve stimulation (TENS)[35]. Patients with continued intractable pain who fail non-surgical treatments may benefit from a surgical treatment[35,36]. For neuromas, proximal resection and embedding into nearby muscle or silicone capping has been proposed[12,34]. Neuromas are difficult to treat as cut ends can form new neuromas[12]. Therefore, embedding into the nearby muscle or capping is thought to protect the nerve and, hopefully, any neuroma that may form is minimized[12]. If there is not an obvious nerve lesion intraoperatively, decompression or neurolysis may be beneficial, or occasionally nerve resection with repair or grafting may be an option[34,36]. These surgical procedures should only be reserved for those with intractable pain as they put the patient at risk of having increased pain postoperatively[34].

CONCLUSION

Nerve pain is a common complaint in foot and ankle surgery, especially following operative repair of calcaneal fractures. Current research demonstrates rates of nerve injuries in the direct and extended lateral approach, but research is lacking for the newer and more limited incisions, such as percutaneous approach. Additional research should be focused on the incidence of nerve complications using these newer incisions and other methods to reduce future nerve injuries.

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