

## PLANTAR SKIN INCISIONS: AN OVERVIEW

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There are many indications and applications for plantar skin incisions. Depending on the location of the pathology, a plantar approach may often be the most efficient and least traumatic approach. With proper placement, surgical technique, and postoperative management, a plantar approach can be safely used.

The four main criteria used for the design of dorsal, medial, and lateral foot incisions should also be followed when designing plantar foot incisions. These criteria are: 1. the incision should be parallel to relaxed skin tension lines, 2. the incision should have adequate length for exposure, 3. neurovascular structures should be avoided, and 4. in plantar incisions, weight-bearing areas of the foot should be avoided if possible.

### RELAXED SKIN TENSION LINES

A discussion on skin incisions would be incomplete without a review of relaxed skin tension lines (RSTLs), as described by Borges and Alexander.<sup>1</sup> The RSTLs are conceptual or imaginary lines which lie perpendicular to the long axis of the underlying muscle, tendon, or bone. Courtiss et al. discussed the fact that dermal collagen is oriented perpendicular to the long axis of the muscles, and that the collagen in a scar is parallel to the direction of the scar.<sup>2</sup> Using these known facts, one can ensure that the best resultant scar is produced when the collagen of a scar forms parallel to the adjacent dermal collagen. This suggests that incisions placed in the RSTLs gap less, and result in finer scars.<sup>3</sup>

RSTLs on the plantar aspect of the foot are transversely oriented (Fig. 1). Often longitudinal exposure is needed on the plantar aspect of the foot, as in the case of plantar fibromatosis. Numerous incisions have been proposed for these cases, including linear, curved, and S- or Z-shaped. Each of these may be regarded as an anti-tension incision and, therefore has the tendency toward hypertrophy and contracture.<sup>4</sup> In some plantar surgery cases, such as plantar fasciotomy or intermetatarsal neurectomy, transverse incisions or

incisions parallel to RSTLs are possible. These incisions result in better approximation and less gapping.

### PLANTAR ANATOMY

The plantar skin is thicker than that on the remainder of the foot. It is particularly thick at the ball of the foot and at the heel. The plantar skin has a well-developed stratum corneum with many sweat glands. The superficial fascia has abundant fibrous-fatty tissue and is firmly attached to the underlying deep fascia by connective tissue septa. The cutaneous nerves and vessels lie within the superficial fascia and include the medial and lateral calcaneal vessels and nerves, branches of the medial and lateral plantar nerves, and the plantar proper digital nerves and vessels. The plantar aspect of the foot is well-vascularized, much like that of the scalp. The deep fascia of the plantar foot is a specialized band of tissue, the plantar aponeurosis of plantar fascia.<sup>5</sup>



Figure 1. Relaxed skin tension lines on the plantar aspect of the foot.

The plantar fascia is divided into three bands (medial, central, lateral) which overlie the plantar musculature. The plantar fascia sends fibrous bands between the plantar muscles, known as the medial and lateral intermuscular septa, dividing the plantar musculature into three compartments. A fourth, deeper, interosseous compartment includes the three plantar and four dorsal interossei muscles. The plantar musculature is divided into four layers and includes the majority of the intrinsic muscles of the foot. The medial and lateral plantar arteries and nerves supply the plantar skin, muscles, and bones. They begin by coursing between the first and second layers of the plantar muscles, with deep branches coursing between the third and fourth layers of plantar muscles.<sup>6</sup>

### INDICATIONS

Plantar incisions may be used for a multitude of surgical procedures. The primary excision of an intermetatarsal neuroma has been advocated through both longitudinal and transverse incisions. The more common dorsal approach to a neuroma may be difficult, due to poor exposure secondary to a tight transverse intermetatarsal ligament or narrow intermetatarsal space. The transverse plantar incision is made just distal to the sulcus, avoiding the weight-bearing area of the foot (Fig. 2). Exposure is stated to be excellent, and all branches of the intermetatarsal nerve may be resected. The transverse intermetatarsal ligament may be severed with this approach if deemed necessary. This incision provides exposure for resection of adjacent intermetatarsal neuromas, if present, through the same incision.<sup>7</sup>

A longitudinal plantar incision also offers excellent exposure to an intermetatarsal neuroma (Fig. 3). The incision is placed between the metatarsal heads, avoiding weight-bearing areas. Adequate exposure is afforded to allow for identification of the proper digital branches of the nerve. This approach offers the advantage of resecting the nerve trunk to a more proximal position. The longitudinal plantar incision, between adjacent metatarsal heads, is an ideal choice for recurrent intermetatarsal or stump neuromas.<sup>8</sup> The longitudinal approach may be modified slightly from a straight incision to one that attempts to incorporate RSTLs by curving the incision at the metatarsal heads and into the arch.

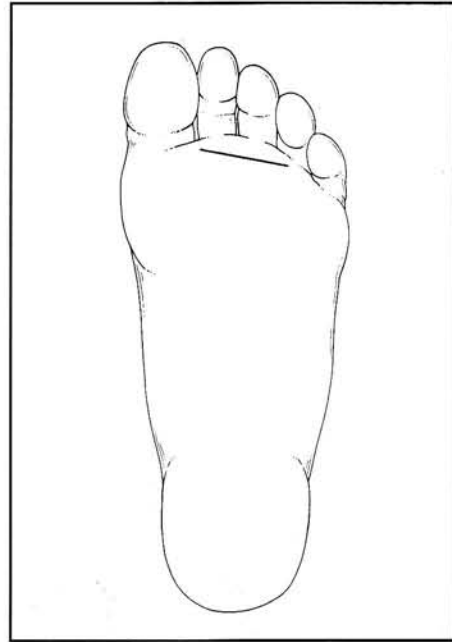


Figure 2. Transverse incision placed distal to the sulcus for intermetatarsal neurectomy.

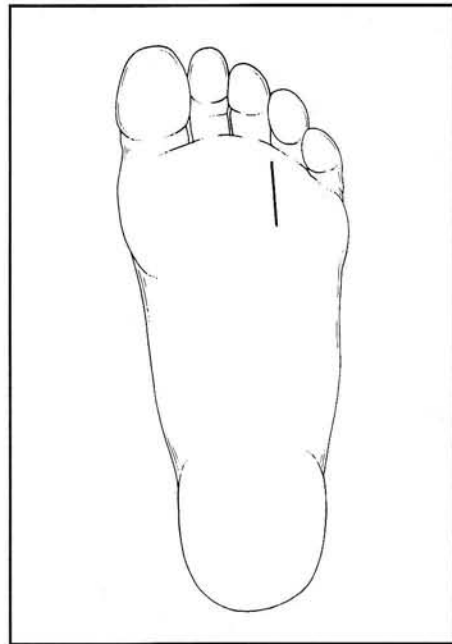


Figure 3. Longitudinal incision placed on the non-weight-bearing areas for intermetatarsal neurectomy.

A plantar incision may be used for an intractable plantar keratosis that has not adequately responded to conservative measures. A double-arm, semi-elliptical plantar excision, following the 3:1 rule (length three times the width of the incision), easily excises the lesion (Fig. 4). This same incision may be utilized for porokeratoses and small pigmented lesions. This is traditionally performed in a longitudinal fashion, but works as well in a transverse orientation.

Resection of plantar fibromatosis requires longitudinal exposure. To gain this exposure, the incision must cross perpendicular to RSTL. The linear incision offers the best exposure for plantar fibromatosis resection. Unfortunately, these are likely to contract and become hypertrophic and painful postoperatively. Transverse incisions, while paralleling the RSTLs, do not provide adequate exposure. Gently curving, S-shaped incisions provide the necessary exposure, but still tend to hypertrophy and develop contractures.

Curtin suggested a zig-zag incision with a long linear central arm, and proximal and distal arms that parallel RSTL.<sup>9</sup> Later, Burns and Harvey modified Curtin's plantar incision so that the proximal and distal arms of the incision were more oblique, and the central arm of the incision was

also oblique in design.<sup>10</sup> An incision combining these plantar approaches is the Z-shaped incision. The proximal and distal arms of the incision are parallel to RSTL, as Curtin originally described, but the central arm of the incision is oblique like Burns and Harvey's modified description<sup>4</sup> (Fig. 5). This incision comes very close to meeting the four main criteria for incisions. The sharp corners of this Z-shaped incision may be gently rounded to preserve the tenuous blood supply to the corners. This Z-shaped incision is ideal for surgery in the non-weight-bearing longitudinal arch of the foot. It has been useful in the excision of soft tissue tumors within the plantar vault, excision of congenital abnormalities such as neurofibromatosis and arterial-venous malformations, as well as exposure to prominent bone secondary to neuropathic arthropathy.<sup>11</sup>

Isolated plantar fibromas may be resected through a simple transverse incision placed within RSTLs (Fig. 6). This will allow adequate exposure of the solitary nodule and sufficient surrounding plantar fascia.<sup>12</sup> This incision meets all four criteria, including avoiding weight-bearing areas, if the lesion is located within the longitudinal arch.

Plantar fasciotomy/fasciectomy, with or without resection of a plantar calcaneal spur, has traditionally

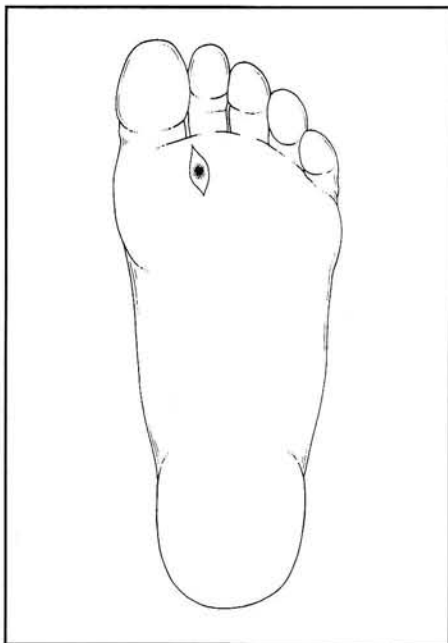


Figure 4. Longitudinal, double semi-elliptical incision for excision of intractable plantar keratoma or other similar lesion.

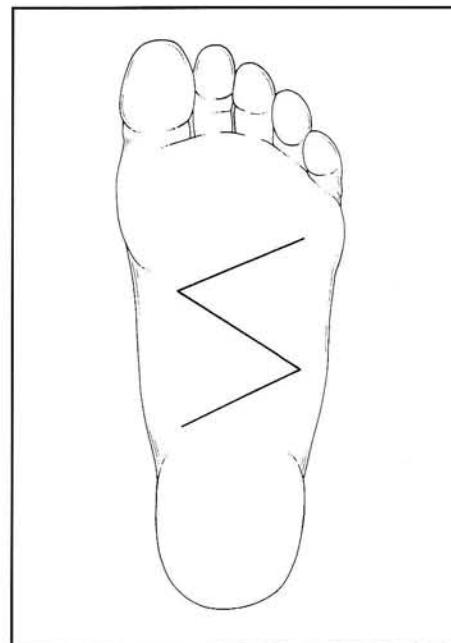


Figure 5. Z incision for plantar fasciectomy or excision of other soft tissue tumors within the longitudinal arch.

been performed through a medial calcaneal incision. Common problems with this traditional incision approach include pain at the incision site, limited visualization, and entrapment of the medial calcaneal nerve within the scar. Heel spur surgery may be performed through a transverse plantar incision or through a longitudinal plantar incision. Lewis et al. advocated a six centimeter longitudinal plantar incision centered over the calcaneal tuberosity (Fig. 7). They stated that this incision gave full visualization of the bursa (if present) the plantar fascia insertion, and the heel spur. The risk of hematoma and nerve entrapment was diminished.<sup>13</sup>

Transverse plantar incisions for plantar fascial release, with or without heel spur resection, have also been described.<sup>7</sup> These are placed distal to the fascial insertion, and traverse most of the heel area (Fig. 8). More recently, a smaller transverse plantar incision has been described which is situated over the medial band of the plantar fascia. This 1.5 to 2 centimeter incision is placed just distal to the calcaneal fat pad (Fig. 9). The plantar calcaneal spur is not addressed with this incision. This technique has been termed the in-step fasciotomy.<sup>14</sup>

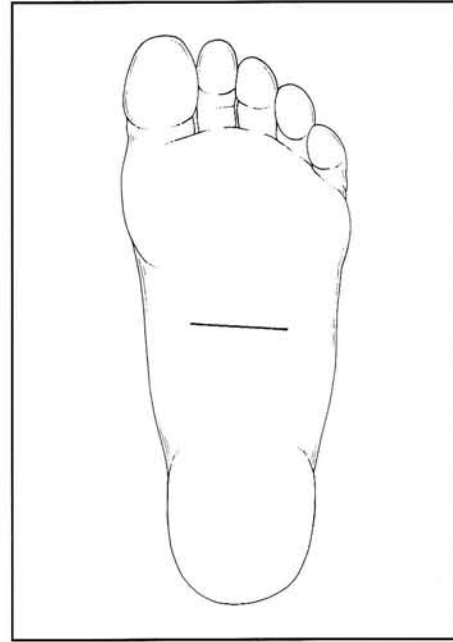


Figure 6. Transverse incision within the longitudinal arch for excision of a solitary plantar fibroma.

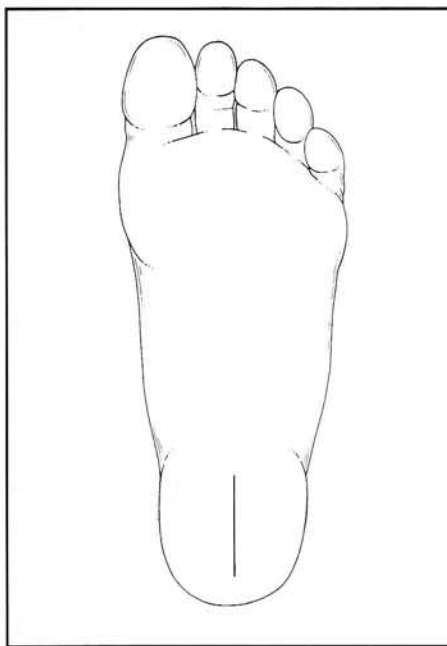


Figure 7. Longitudinal incision over the calcaneal tuberosity for release of the plantar fascia, excision of a bursa, and resection of a calcaneal spur.

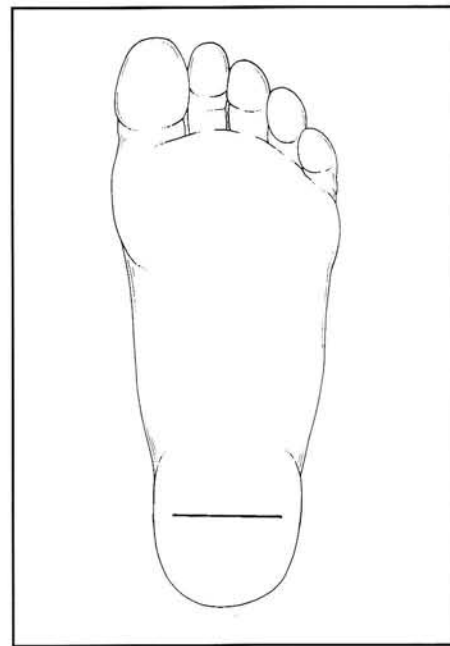


Figure 8. Transverse incision distal to the plantar fascial insertion for release of the plantar fascia and resection of the calcaneal spur.

## POSTOPERATIVE MANAGEMENT

The complications of plantar incisions are the same as an incision placed elsewhere on the foot. Potential complications include infection, superficial or deep dehiscence, hematoma, nerve entrapment, and hypertrophic scar. A hypertrophic and painful scar has been the main reason why plantar incisions have been avoided. If the patient can be non-weight bearing for three weeks or more, plantar incisions can be used with good cosmetic and functional results. Often with a plantar approach to foot surgery, a dead space is created through excision of space-occupying tissue, or through blunt dissection. The use of a closed-suction drain in these instances will decrease the likelihood of developing a hematoma or wound dehiscence. A compressive dressing with a posterior splint will also aid in hematoma prevention.

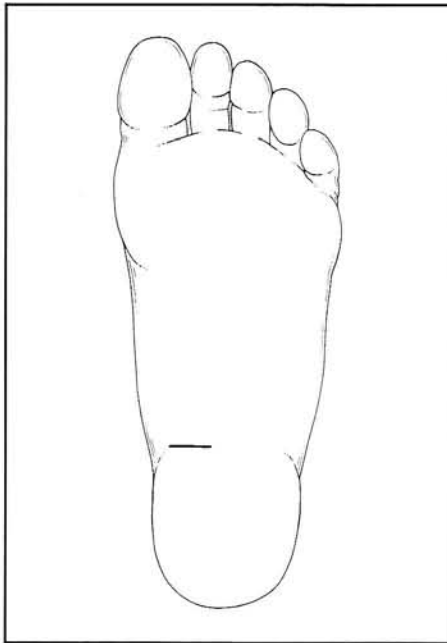


Figure 9. Short transverse incision placed just distal to the calcaneal fat pad for release of the medial band of the plantar fascia.

## CONCLUSION

The plantar incision has many applications in foot surgery and, therefore, should be added to the armamentarium of surgical approaches for every foot surgeon. While it is not the incision of choice for many patients, often it is the best choice for the pathology presented. A plantar incision is also a viable alternative over the more traditional dorsal or medial incisions for procedures such as intermetatarsal neuroma resection, and plantar fasciotomy. The properly used plantar approach can give satisfying results for both the patient and surgeon if strict atraumatic technique is used, and the four criteria for plantar skin incisions are met.

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