—**Original**—

Zig-Zag Skin Incision for Treatment of Tarsal Tunnel Syndrome

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Background: Tarsal tunnel syndrome (TTS) is a common entrapment neuropathy of the posterior tibial nerve. Surgery can be performed less invasively under local anesthesia. We adopted zig-zag skin incision to prevent postoperative wound complications.
Methods: Between July 2022 and June 2023, we operated on 19 legs of 14 consecutive TTS patients (5 males, 11 females; average age 73.3 years). We made a 2- to 3-cm zig-zag skin incision on the tarsal tunnel. After posterior tibial nerve decompression by posterior tibial artery (PTA) transposition, the subcutaneous layer was tightly sutured with 4-0 PDS and the skin was closed with Dermabond Advanced. We investigated adverse events that developed during the first 30 postoperative days and recorded surgical outcomes at the final visit.
Results: In all patients the nerves were successfully decompressed with PTA transposition. There were no intraoperative complications. During the 30 postoperative days there were no adverse events, including wound complications, and patients' symptoms improved significantly.
Conclusion: Zig-zag skin incision was easy and convenient for surgical TTS treatment and may be useful for preventing postoperative wound complications. (J Nippon Med Sch 2024; 91: 357–361)

Key words: adverse events, decompression, skin incision, surgery, tarsal tunnel syndrome

Introduction

Tarsal tunnel syndrome (TTS) is an entrapment neuropathy of the posterior tibial nerve at the tarsal tunnel. It can elicit plantar symptoms such as numbness, pain, foreign-body sensation, and coldness[1–4]. Space-occupying lesions in the tarsal tunnel can cause TTS, but idiopathic TTS is more common[1,2,5,6]. When patients fail to respond to conservative treatments, surgery is indicated.

The operation is less invasive when performed under local anesthesia, and good surgical results have been reported[1,7,8]. However, because postoperative complications are a concern[1,9,10], we adopted zig-zag skin incision to reduce the wound load. We describe our surgical procedure and report the postoperative results.

Patients and Methods

This retrospective study was approved by the ethics committee of Chiba Hokusoh Hospital (approval number: H-2023-073); patients could opt-out on our hospital homepage.

Between July 2022 and June 2023, we used zig-zag incision to treat 14 consecutive TTS patients (19 legs). Patient information is presented in the **Table 1**. All patients reported numbness, pain, coldness, or foreign-body sensation in the sole. No patient had suffered trauma to the affected area. The Tinel sign at the tarsal tunnel was positive in all patients.

Surgery was indicated because TTS treatment with mirogabalin, pregabalin, and nonsteroidal anti-inflammatory drugs had failed. All patients underwent preoperative MRI of the tarsal tunnel to identify nerve

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Table 1 Characteristics of patients

Patients (surgical sites)	14 (19 legs)
	unilateral 9, bilateral 5
Gender	4 males, 10 females
Average age (range)	73.3 ± 6.5 years (63–85 years)
Affected side	right n=11, left n=8
Comorbidities	
Hypertension	9/14 (64.3%)
Diabetes mellitus	7/14 (50.0%)
Hyperlipidemia	5/14 (35.7%)
Mean interval between symptom onset and surgery (range)	42.8 ± 28.9 months (6–96 months)

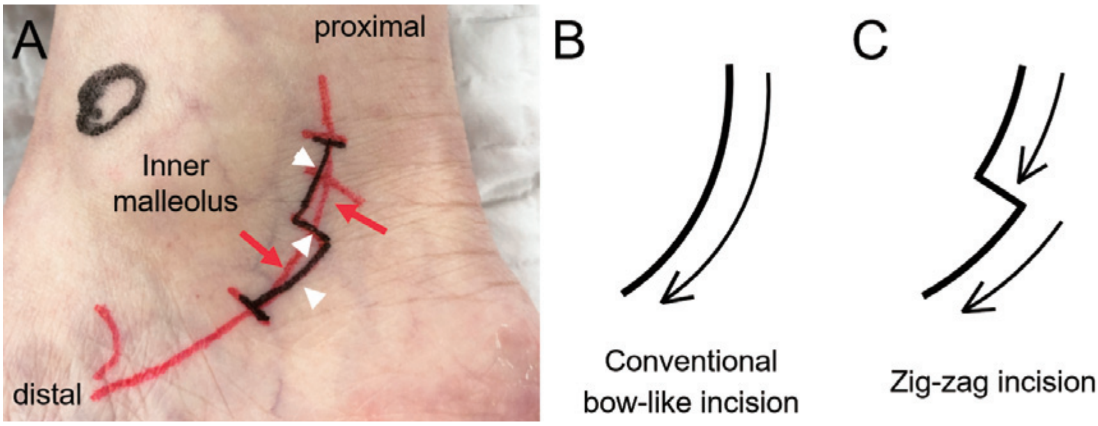

Fig. 1 A Right-sided surgery for tarsal tunnel syndrome. The red line (red arrows) shows the conventional bow-like incision, and the black line (white arrowheads) shows the zig-zag incision.
B & C Both types of incision, and the tension applied to the wound by ankle dorsiflexion (arrows). The tension length is longer for the conventional bow-like incision (B) than for the zig-zag incision (C).

compression[5,11].

A positive electrophysiological finding was recorded when the terminal latency of the abductor hallucis muscle exceeded 5.8 ms and the difference in the side-to-side amplitude was more than 50% of the sensory nerve conduction velocity at the tarsal tunnel[5,7].

Surgery was performed using a surgical microscope and local anesthesia. Patients were placed in the lateral position with the affected side down. A 2- to 3-cm zig-zag skin incision was placed at the tarsal tunnel (**Fig. 1A**). After opening the flexor retinaculum and identifying the posterior tibial artery (PTA), it was trans-positioned to the medial malleolus or the Achilles tendon side for decompressing the posterior tibial nerve ventral to the PTA[5,7]. When necessary, small branches from the PTA and posterior tibial vein were coagulated and excised. The trans-positioned PTA was fixed with 5-0 nylon stitches to prevent re-compression of the nerve. Sufficient blood flow in the PTA was confirmed by the Doppler method before and after transposition. After placing a subcutaneous drain the subcutaneous layer was sutured perpendicularly with 4-0 PDS and the skin was closed with Dermabond Advanced (Johnson & Johnson Inc.). Immediately after the operation the patients were allowed to walk without external fixation. The drain was removed the day after surgery, and the patient was discharged. The patients were in hospital for 3 days, i.e., on the day of admission, the day of surgery, and the day after surgery, when they were discharged. Patients with bilateral TTS usually underwent two 3-day hospitalizations using the same pre-, intra-, and postoperative procedures that were used for unilateral operations.

The incidence of adverse surgical events was evaluated during the first 30 postoperative days[9,12,13]. The surgical outcome, assessed at the final follow-up visit (mean 5.5 ± 0.9 months, range 3-6 months), was determined by comparing preoperative and postoperative numerical rating scale (NRS) scores, where 0 is no pain and 10 is severe pain. Symptom improvement was statistically analyzed with the Wilcoxon signed-rank test using IBM SPSS for Windows ver. 25.0 (IBM Corp., Armonk, NY, USA). Differences of $p < 0.05$ were considered statistically signifi-

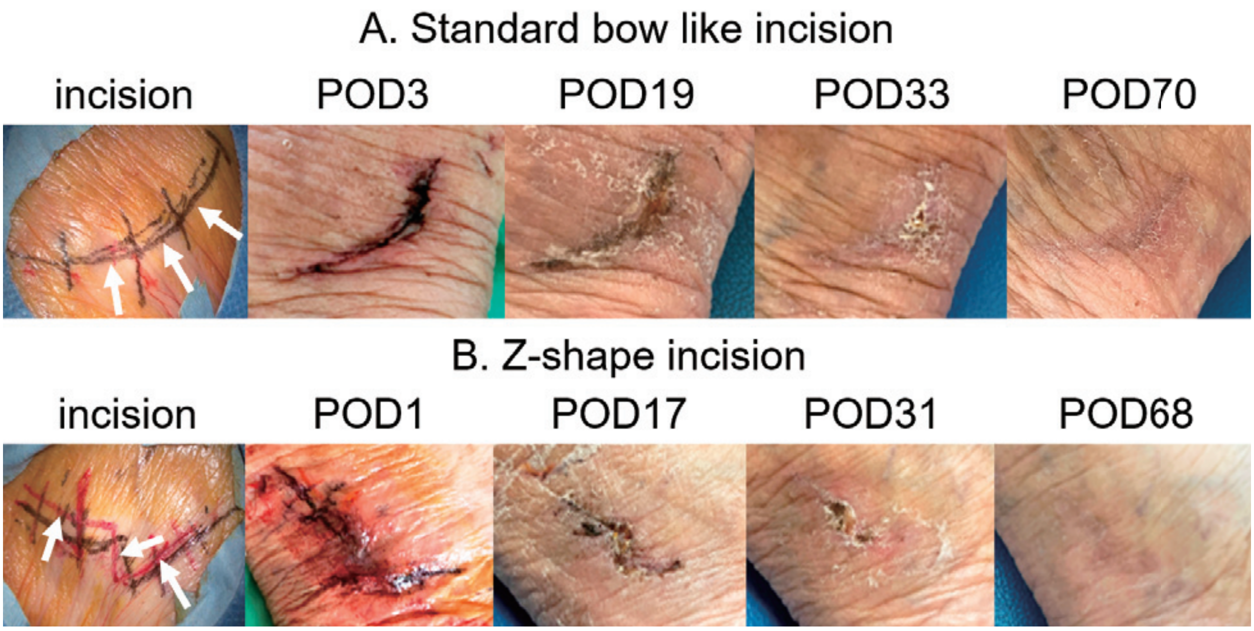

Fig. 2 An 84-year-old woman with bilateral TTS underwent different skin incisions on the left (A) and right side (B). The zig-zag incision (B) yielded a shorter crust-attachment period, and she reported less tightness than after the bow-like incision.
POD: postoperative day

cant. All values are expressed as mean ± SD.

Results

There were no intraoperative complications. All PTAs were trans-positioned, and all addressed nerves were successfully decompressed. There were no adverse postoperative events and no wound complications (**Fig. 2**).

The mean duration of hospitalization was 5.7 ± 2.8 days (range 3-11 days). Four patients requested and underwent bilateral operations during a single hospitalization; the average interval between decompression procedures was 4.5 days, and the mean duration of hospitalization was 9.8 days (range 7-11 days). The increase in the duration of hospitalization was in accordance with the wishes of the patients and was not due to surgery-related adverse events.

Postoperatively the patients' TTS symptoms significantly improved; NRS scores fell from a preoperative mean of 7.5 ± 0.8 to a postoperative mean of 1.7 ± 0.9 ($p < 0.05$).

Discussion

Although TTS surgery can be performed less invasively under local anesthesia, postoperative wound complications have been reported[1,9,10]. Our earlier studies indicated that the rate of adverse events within 30 days of TTS surgery was 6.2% (16/257 cases)[9]. In another report, 12% of patients who had undergone TTS surgery developed surgical complications. Wound complications after TTS surgery can require additional hospital visits, medications, re-suturing, and skin grafts. Expensive preventive negative-pressure wound therapy may be useful for high-risk patients.

Patients with postoperative lower limb wounds must be instructed to keep the area clean. The operated tarsal tunnel is located near the ankle, and walking applies a dynamic load. Because wounds near or at the joint may not heal or heal slowly, the stretching force around wounds, especially those near the joint, must be reduced[14-18]. Although uncomfortable, postoperative external fixation of the ankle is an option. Because high-tension force on the wound reduces perfusion at the wound margins and affects wound healing[19-21], optimal tension distribution is important[22,23]. Because a zig-zag incision can reduce tension along the incision, it may aid in wound healing; it is also cosmetically preferable[14,18,22-24]. A study comparing scars after zig-zag and linear incisions reported that zig-zag incisions yielded superior results[14]. Using a porcine skin model, Wachtel et al.[22] studied the biomechanical stability of 3 different types of incision (conventional straight, lazy-S, and zig-zag incisions). They preferred the biomechanical stability obtained with the lazy-S and especially the zig-zag incision, followed by perpendicular suture placement. Others[14,23] also preferred the zig-zag incision for routine operations.

For TTS surgery we placed a zig-zag skin incision to reduce stretching force on the skin and the dynamic load on the wound. In the 19 TTS operations we performed over the course of 1 year we encountered no adverse events involving the wounds, and all 14 patients were satisfied with the treatment results.

A simple modification of the linear incision is straightforward but requires more time. The tension length of the zig-zag incision is shorter than that of linear incisions, and the resulting scar can be compared to ropes of collagen fibers. Short scars (**Fig. 1C**) are exposed to less load than long scars (**Fig. 1B**), and tension on the scar along the zig-zag incision is dispersed, thereby promoting wound healing[22,23]. The zig-zag scar is also less visible[22,23]. When placing a zig-zag incision, the surgeon must consider the blood supply at the edge of the flap, especially when it is a long and/or narrow-angle skin flap. Zide and Epker[18] recommended an incision angle of around 80°, although a range from 45° to 80° may be acceptable. Ours was an angle of approximately 90°, and the distance of the middle line of the zig-zag incision was short, to reduce flap length. To make the wound less susceptible to ankle movement, the proximal part of the incision was placed on the side closer to the axis (the medial malleolus side), because wound load tends to be higher on sites that are highly mobile and those with greater tension[16,19].

Our study is limited because the number of patients was small and follow-up was short. Future studies should further compare the zig-zag method with other types of skin incision. Lastly, because we used Dermabond Advanced instead of nylon or other types of suture to close the superficial wound layer, we cannot compare these methods.

Conclusion

The zig-zag skin incision is convenient and may reduce the incidence of wound complications after TTS surgery. However, further study is required in order to confirm its usefulness.

Conflict of Interest: The authors declare no conflicts of interest and no commercial relationships or financial support from pharmaceutical or other commercial entities.

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