



Research Paper

Radiation-Independent Distal Locking Screw Insertion Using Dual Nail Insertion Handle: Is it a Reliable Method?



標題:使用雙釘插入手柄而無需使用造影來插入脛骨遠端鎖定螺釘:它是一個可靠的方法?

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ABSTRACT

Background: There are continuous trials to get radiation-independent distal locking to avoid the hazards of radiation exposure.

Patients and methods: Thirty cases of diaphyseal tibial fractures were fixed with locked intramedullary nail. A new dual nail insertion handle was used for insertion of the locking screws from distal to proximal position.

Results: Success rate was much improved with extra reaming. Failure rate was 20%.

Conclusion: This technique is not reliable enough to replace the classic radiation-dependent free-hand technique. Further development of this idea is needed to get a perfect radiation-independent distal locking technique.

中文摘要

背景: 有不少研究,試驗不用X光造影來插入遠端鎖定螺釘,以避免暴露於輻射的危險。

患者和方法: 30個骨幹脛骨骨折病人,接受髓內釘固定手術。手術中我們使用一個新設計的雙釘插入手柄,用來插入脛骨鎖定螺釘,從遠端到近端方向。

結果: 進行髓腔擴孔後,插入鎖定螺釘的成功率便提高很多。失敗率為20%。

結論: 現時這種技術還是不夠可靠,未能取代傳統的X光造影徒手插入技術。我們需要進一步研究,來發展不用X光造影的完美插入遠端鎖定螺釘的技術。

Introduction

Because of the increased use of fluoroscopic guidance in many orthopaedic procedures, attention has been growing for associated radiation hazards. The standard protective aprons that are commonly used during the use of fluoroscopy provide adequate protection to most of the body. However, the surgeon is exposed to significant levels of scattered radiation to the head, neck, and hands.¹ Current methods for distal interlocking continue to be dependent on image intensification.² To limit the amount of radiation used during distal interlocking screw insertion, several techniques have been described to insert the distal locking screws without fluoroscopic guidance. However, the most popular method

of insertion is still the radiation-dependent free-hand technique.³ This article describes a technique of radiation-independent distal locking screw insertion using dual nail insertion handle, technical details and the limitations are reported.

Patients and methods

All patients gave informed consent prior to being included into the study. All procedures involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments.

In the period July 2014 to August 2015, 30 patients with diaphyseal tibial fractures were fixed with locked intramedullary nail. Twenty-five cases were males and five cases were females. The mean age was 33 years (ranges 18–56 years). All cases were closed; open fractures were excluded. In all cases, insertion of locking

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screws was tried with the new dual nail insertion handle without the aid of image intensifier. All cases were done by the author. This technique was based on connecting two identical nails from the same manufacturer to the nail insertion handle. This will cause the holes of the locking screws to be exactly opposite each other (Figures 1 and 2).

Surgical technique

Operations were done with patients in a supine position, under spinal anaesthesia with a tourniquet applied to the upper thigh. A radiolucent table was used but without limb traction. The tibial nail was inserted using the classic technique.⁴ Reaming was done 1 mm more than the nail diameter to be inserted. Locking screws were inserted sequentially from distal to proximal. Great care was taken before insertion of the locking screws for rotational alignment of the limb; any rotational malalignment should be corrected before insertion of any locking screws.

Toggling of the drill bit in the holes of the locking screws in the outside nail can lead to false passage of the drill bit and subsequently the distal locking screw will be outside the distal locking holes of the inside nail. To overcome this problem, a specially



Figure 1. The new insertion handle.

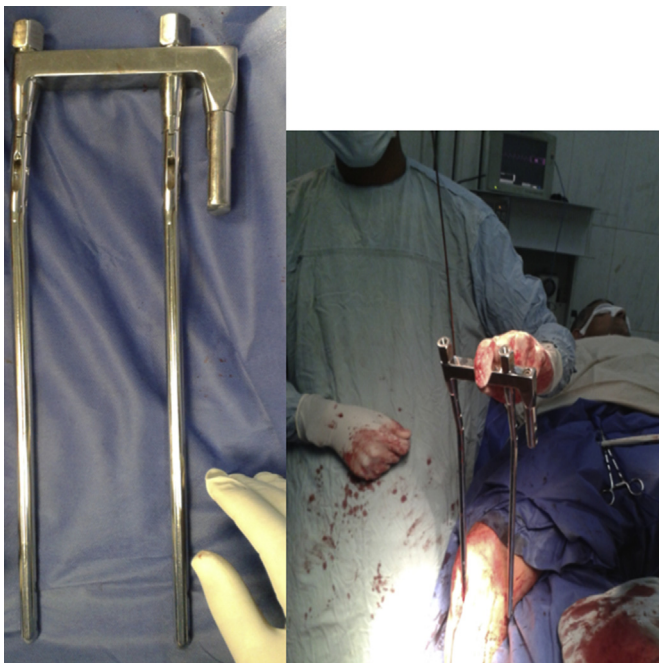


Figure 2. The insertion handle connecting the two nails.

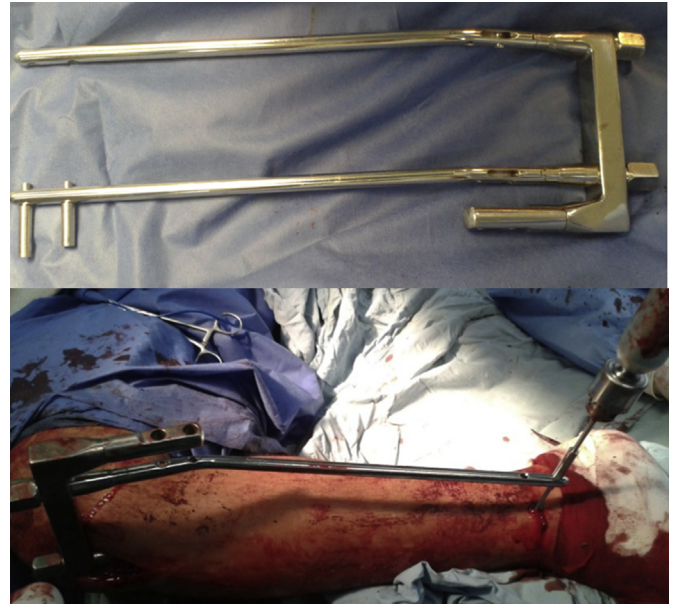


Figure 3. Aiming sleeves introduced in the distal locking holes.

designed aiming sleeve is inserted in the holes of the distal locking of the outside nail to prevent toggling of the drill bit (Figure 3).

To make sure that the drill bit was in the correct trajectory, a sound or a guide wire was introduced into the medulla of the inside nail, first after insertion of the drill bit through the two nails and again after insertion of the distal locking screws. The length of the sound between the proximal end of the nail and the site of the block inside the nail should be exactly equal for both the inside and the outside nails (Figure 4). This method ascertained that the drill bit and the distal locking screws were inserted correctly inside the distal locking holes of the inside nail.

If the previous trial failed, the nail was removed and extra reaming by 1 mm more was done and insertion of locking screws was tried again. If this second trial failed, insertion of the locking screws by the classic free-hand radiation-dependent method was done.

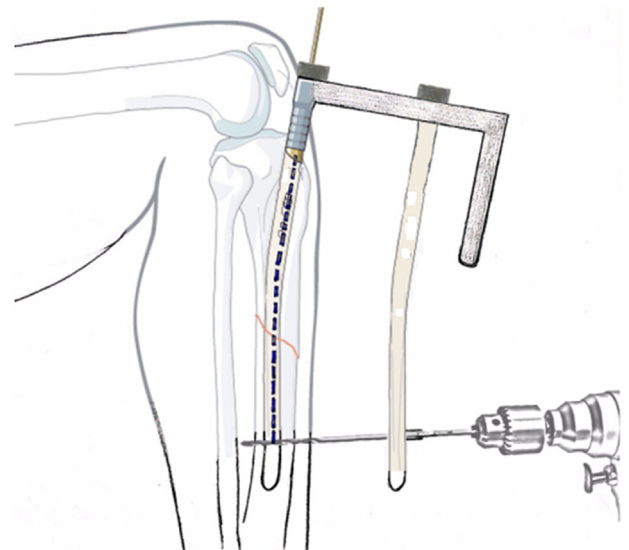


Figure 4. A guide wire inserted inside nail, hitting against the drill bit to make sure that the latter is introduced in the correct trajectory.

Results

Success rate from the first trial was limited. In the first trial, where reaming was done 1 mm more than the nail diameter to be inserted, the procedure of distal locking succeeded in only six cases out of 30 cases (20%). In the second trial, where extra reaming by 1 mm more was done, succeeded in 18 cases out of the remaining 24 cases (75%) (Figure 5). The procedure failed in both trials in six cases out of a total of 30 cases (20%). Extra reaming improved the success rate on the second trial than classic reaming on the first trial. During the second trial, the procedure was successful in 18 cases of a total of 24 cases (75%) (Table 1).

Discussion

The hazards of exposure to radiation encouraged many orthopaedic surgeons to search for radiation-independent methods for insertion of distal locking screws. Mehlman and Dipasquale reported that unprotected individuals working at 24 inches (60 cm) or less from a fluoroscopic beam received significant amounts of radiation.⁵ The highest radiation doses were received by the surgeons' hands.⁶ Furthermore, the doses received by less experienced surgeons were higher and may be higher than those reported in the literature.⁷ Also, ionizing radiation has no safe threshold of exposure below which it ceases to have adverse effects.⁶ Moreover, the long-term effects of this radiation exposure are unknown.⁸ Therefore, every effort must be made to keep radiation exposure to a minimum.

In 2003 Kanellopoulos et al⁹ suggested making a cortical window to expose the distal part of the intramedullary nail to insert the distal locking screws under direct vision. Although the authors reported no complications as regards their technique, this technique would make the overall procedure of insertion of interlocking nail more invasive and complex as it would increase the operative time and bone exposure.

In another attempt to minimize radiation exposure, several types of aiming devices have been described, including proximally

mounted aiming arms. However, these aiming devices were not proved to be perfect because the implants deform secondary to insertion-related bending and torsional forces.^{10,11} In addition to the nail deformation, the lengthy distance between the mounting of the proximal jig and the distal locking screws causes minor manufacturing errors to be magnified. Further problems include deformation of the jig by its own weight or when the surgeon applies force to it.¹²

A navigational system using electromagnetic (EM) field-based tracking technology has been developed to assist in the placement of locking screws in interlocking nails without the need for fluoroscopy.¹³ These authors reported many advantages to this device as being totally radiation-independent, 100% accurate and faster than the traditional methods. However, the presence of metal objects nearby the target such as metals in the orthopaedic table or metal instruments can disturb the electromagnetic signal and hence the accuracy of the device. They recommended keeping surgical instruments such as reduction clamps or hammers away from the field by at least 6 inches. In addition, this device represents additional equipment which increases the complexity of the procedure.

Other authors¹⁴ introduced the concept of the nail-over-nail technique. The idea of this technique depends on the assumption that if two nails of the same length are used, one inserted inside the tibial medullary canal and the other outside the canal and adjusted to be exactly parallel and in the same position as the inside nail, the holes of the distal locking will be opposite each other. In their technique, the medullary canal had to be reamed 1.5 mm more than the diameter of the nail to prevent nail deformation which can distort parallelism between the inside and the outside nail. They considered that over-reaming was the key to the success of this technique but they also considered that over-reaming could predispose to fixation failure. These authors depended on placement of an outside nail parallel to the inside nail; the outside nail was not well connected to the inside nail and minor motions can result in failure to make the distal holes of the inside and outside nails perfectly opposite each other with subsequent failure of the procedure.

Our device used the same principles as the nail-over-nail technique but it provided a constrained construct in which the outside and the inside nails were connected to the proximal insertion handle and so long as the outside nail was well fixed to the device and connected to it in a sound direction, it would be perfectly parallel to the inside nail without any motions disturbing the nails' parallelism and leading to wrong trajectory of the distal locking screws.

Until now, the results of this technique are not promising enough because higher success rate was achieved with extra reaming to prevent or minimize nail deformation inside the medulla. On the other hand, extra reaming will jeopardize fracture stability, a very important precipitating factor for delayed union and nonunion. A balance should be made between benefits of radiation-independent distal locking versus extra reaming that threatens union.

With failure of the first trial, there will be a hole of the first false trajectory. The presence of this hole will make the next trial more difficult. In addition, repeated trials to insert the distal locking screws with that technique will increase the operative time. This has a negative impact, adding to the drawbacks of that technique.

Other problems with this technique are that it is mandatory to insert the distal locking screws first before the proximal locking ones, and there is a need to have a fully equipped set with two nails of each length which may not be available in all situations.

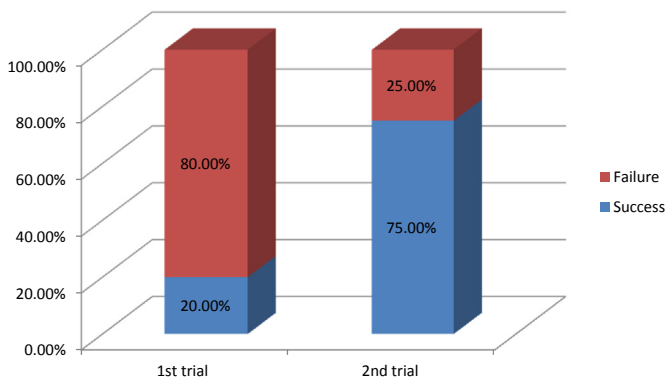


Figure 5. Success rate of second trial compared with the first trial after extra reaming.

Table 1
The effect of extra reaming on the success of the procedure

	First trial: classic reaming (30 cases)		Second trial: extra reaming (24 cases)		P
	n	%	n	%	
Success	6	20.0	18	75.0	0.00005
Failure	24	80.0	6	25.0	

Conclusion

This technique is a continuation of the active attempts to minimize radiation exposure in the practice of orthopaedic surgery. Based on the aforementioned results and drawbacks, this technique is not reliable enough to replace the classic free-hand radiation-dependent distal locking technique at this moment. In the future, further development of this technique may afford a more precise device that can achieve perfect radiation-independent distal locking.

Conflict of interest

The author did not receive any outside funding or grants in support of his research for or preparation of this work. Neither he nor a member of his immediate family received payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, division, center, clinical practice, or other charitable or nonprofit organization with which the author or a member of his immediate family are affiliated or associated.

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