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A New Distal Locking Technique in Intramedullary Nailing

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Abstract

Objective: This study aimed to describe a new fluoroscopy-assisted freehand distal locking technique in intramedullary nailing.

Methods: The efficiency of this technique was defined by comparing the results of patients with tibial shaft fractures. A total of 114 patients with closed tibial shaft fractures treated by intramedullary nailing were included in this study. The patients were evaluated in 2 groups. Group I included the patients operated with the classical fluoroscopy-assisted freehand technique (n=46), whereas group II included patients operated with the fluoroscopy-assisted freehand technique that we described (n=68). In group II, the technique we described included locking with the help of a grooved awl with removable handgrips.

Results: The rate of distal locking time to total operation time and the rate of radiation time for distal locking to total radiation time were compared. The total operation time and total radiation time were similar in both the groups ($p>0.05$). Distal locking time (Group I: 21.5±5.8 min and group II: 19.3±4.8 min) and radiation time for distal locking (Group I: 24.4±5.8 s and group II: 20.9±5.2 s) were shortened with the described technique ($p<0.05$). The rates of distal locking time to total operation time and those of radiation time for distal locking to total radiation time were also shorter in Group II ($p<0.05$).

Conclusion: We believe that the freehand technique, using the fluoroscopy-assisted grooved awl with removable handgrips, is efficient and can be easily applied with a reasonable distal locking time and radiation exposure.

Keywords: Distal locking, freehand technique, intramedullary nailing

Kanal İçi Çivilerin Distalden Kilitlenmesinde Yeni Bir Yöntem

Öz

Amaç: İntramedüller çivilemede yeni, floroskopi destekli, serbest distal kilitleme tekniği tanımlanmıştır.

Yöntemler: Bu tekniğin etkinliğini değerlendirmek için, tibial şaft kırığı olan hastaların sonuçları karşılaştırıldı. İntramedüller çivileme ile tedavi edilen kapalı tibial şaft kırığı olan toplam 114 hasta çalışmaya dahil edildi. Hastalar iki grupta değerlendirildi. Grup I, klasik floroskopi destekli serbest el tekniği (n=46); Grup II ise tarif ettiğimiz skopi destekli serbest el tekniği ile kullanıldı (n=68). Grup II'de tarif ettiğimiz teknik, çıkarılabilir tutma yerleri olan yivli bir bız yardımıyla kilitlenmeyi içeriyordu.

Bulgular: Distal kilitleme süresinin toplam çalışma süresine oranı ile distal kilitleme süresinin toplam radyasyon süresine oranı da karşılaştırıldı. Toplam operasyon süresi ve toplam radyasyon süresi de her iki grupta benzerdi ($p>0,05$). Distal kilitleme süresi (Grup I: 21,5±5,8 ve Grup II: 19,3±4,8 dk) ve distal kilitleme için radyasyon süresi (Grup I: 24,4±5,8 ve Grup II: 20,9±5,2 sn) tarif edilen teknikle kısaltıldı ($p<0,05$). Distal kilitlenme süresinin toplam çalışma süresine oranı ve distal kilitlemenin toplam radyasyon süresine göre radyasyon süresi de Grup II'de daha kısa idi ($p<0,05$).

Sonuç: Floroskopi destekli ve çıkarılabilir saplara sahip yivli bız kullanımı ile serbest el tekniğinin etkili ve makul bir distal kilitleme süresi ve radyasyon maruziyeti ile kolayca uygulanabileceğine inanıyoruz.

Anahtar Kelimeler: Distal kilitleme, serbest el tekniği, kanal içi çivileme

One of the most critical steps in intramedullary nailing of long bones is distal locking. This difficult, time-consuming step is complicated by any inability to place the distal locking screws in the right place, causing serious amounts of radiation exposure [1-7]. Many different techniques are described for distal locking. Easy application, efficiency, low radiation exposure, less need for additional equipment, and low cost can be some of the criteria applied choose the preferred technique [1, 4, 7-12]. Although new, radiation-free, and computer-assisted systems or complicated designs are now being used more commonly, fluoroscopy-assisted freehand technique is still the most commonly used technique [5, 9, 13-16].

Standard freehand technique is applied by a radiolucent handle attached to a power drill. Manipulation of

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this system is not easy. When the radiolucent handle is not present, another freehand method must be used. In this situation, most surgeons try to use another familiar technique that they have improvised to perform distal locking. In this study, we aimed to present a new distal locking technique, which is easy and can be used even in the absence of a radiolucent handle or a newly designed system, with reasonable radiation exposure.

Material and Methods

A total of 131 patients who were treated with closed tibial intramedullary nailing in our institution during a 5-year period were evaluated. Furthermore, 114 patients with 2 distal and 2 proximal locking screws were followed for at least 1 year and were included in our prospective study. All patients gave their informed consent in accordance with Declaration of Helsinki before their inclusion in the study. A total of 68 (59.6%) of the patients were men and 46 (40.4%) were women. Their mean age was 38.4 (17–69) years. The patients were positioned as described by Seyhan et al. [17] with the non-operated leg placed away in a leg holder. The broken leg was positioned freely from the table with the fluoroscope placed below the table. All the intramedullary nails used were from the Expert Tibial Nails (DePuy Synthes, Paoli, USA). All patients were operated on by the same surgeon (M.S.).

A total of 114 patients included in the study were divided into 2 groups. In the first group of 46 patients, distal locking was performed using the classical fluoroscopy-assisted freehand technique with radiolucent arm. For the second group of 68 patients, distal locking was performed using our new technique with a grooved awl and removable handgrips with fluoroscopy assistance. The novel design hand-tool (awl) used in this technique was produced by Alpinendo Medical Instruments (Turkey). The tibial nails were locked with a freehand technique before the production of this device (group I). The nails were locked with the new technique after the production of this device (group II). The newly designed instrument was an awl with a removable handgrip, a metallic longitudinally grooved body that was 4 mm in diameter, and a sharp tip (Figure 1). This awl was used in all operations for distal locking. Operation time was recorded in minutes from the beginning of the first incision to the total closure of all layers. Total fluoroscopy time and time needed for distal screw locking was recorded in seconds. Technical distal locking problems with the awl and inability to find the distal locking holes were also recorded.

The method used for the new technique was as follows: a fluoroscope was fixed at the final hole position of the distal locking holes (Figure 2). A longitudinal 1-cm skin incision was made over the hole. The skin,

Figure 1. An awl, 4 mm in diameter, with a removable handgrip is longitudinally grooved

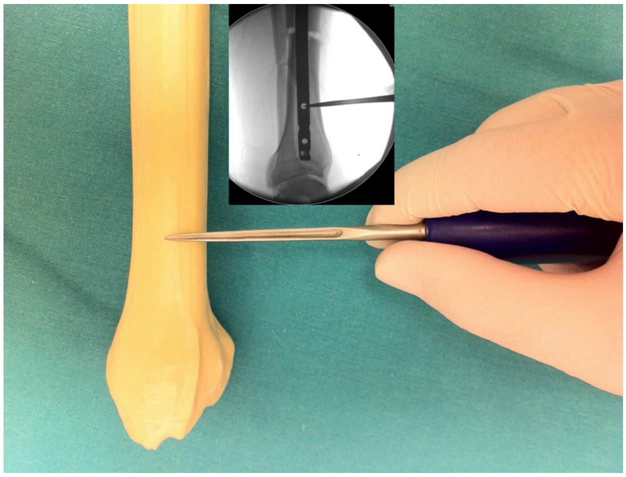

Figure 2. While the grooved awl with removable handgrips is held in the same plane with the tibia, the sharp tip of the awl is placed over the bone under fluoroscopic control

subcutaneous tissue, fascia, and muscle layers were split away with a blunt dissection until the bone was reached. While the grooved awl with removable handgrips was held in the same plane with the tibia, the sharp tip of the awl was placed over the bone under fluoroscopic control (Figure 2). The awl was rotated 90° until it was perpendicular to the locking hole without moving the tip (Figure 3). With gentle rotational movements, a small groove was created over the bone (Figure 4, 5). When the awl was able to get a grip on the bone, the handle was removed and a fluoroscopic image was obtained (Figure 6, 7). When the locking hole was perfectly centered, the groove was deepened even more. If the groove strayed away from the center of the hole, the tip of the awl was directed to the opposite side and a stabilized center was obtained. The next step was replacing the awl with the drill. To do this when connected to a power drill, a drill bit was placed on the groove of the awl and slid onto the bone (Figure 8, 9). When the awl was removed without any rotational movements, the drill bit replaced the awl on the hole over the bone (Figure 10). During this replacement, a small snapping sound was heard. After a

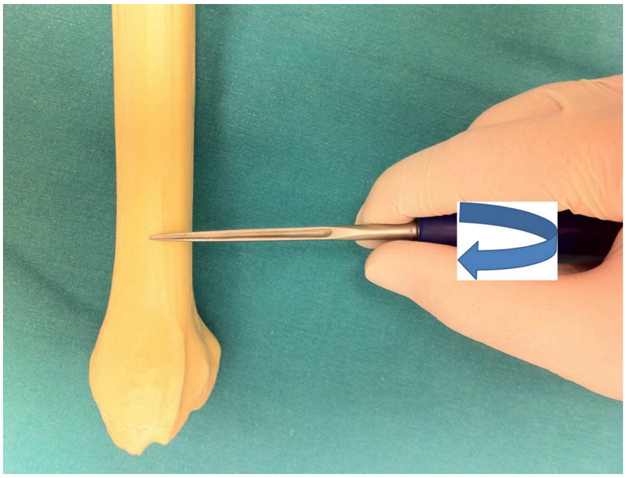

Figure 3. The awl is rotated 90° until it is perpendicular to the locking hole without moving the tip

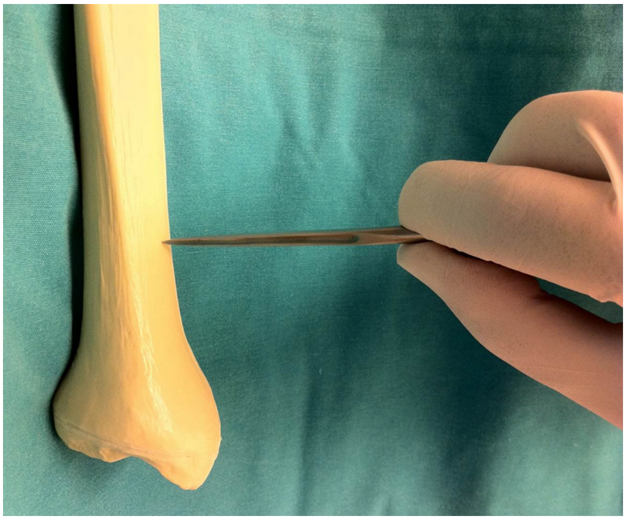

Figure 4. The awl is rotated gently

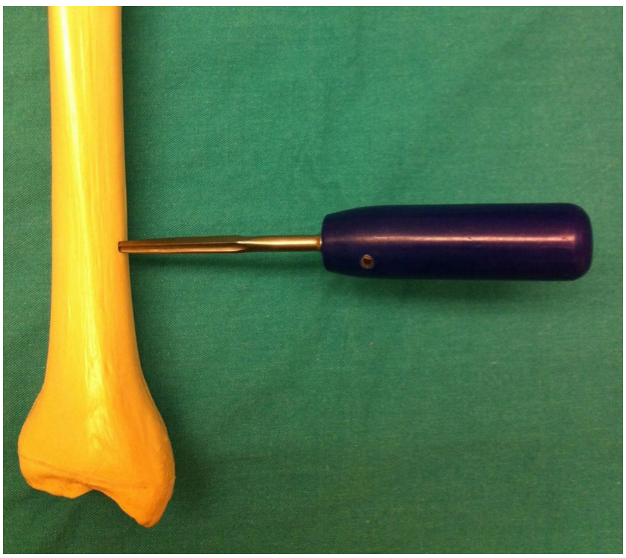

Figure 5. With gentle rotational movements, a small groove is created over the bone

Figure 6. When the awl is able to get a grip on the bone, the handle is removed

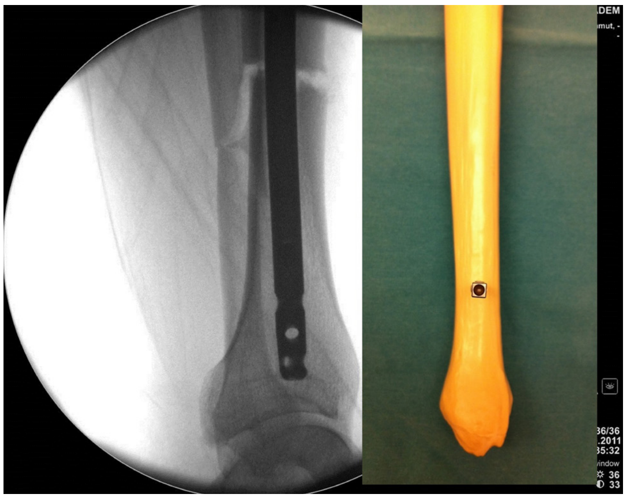

Figure 7. The handle is removed and a fluoroscopic image is obtained

fluoroscopy check (Figure 11), the drill was advanced and passed through the opposite cortex, completing the process. When the drill was inside the bone, a lateral fluoroscopic final check was performed (Figure 12), and the screw was locked (Figure 13). The same process was repeated for the second screw.

In our study, fluoroscopic images for all 114 patients were recorded. Postoperative 1 day and 1 year, tibial anteroposterior and lateral images were obtained.

Figure 8. To replace the awl with drill, the drill bit is placed on the groove of the awl

Figure 9. The drill bit is slid onto the bone

Figure 10. When the awl is removed without any rotational movements, the drill bit replaces the awl on the hole over the bone

Problems with the screw placement, loosening, or breakage were also recorded.

Statistical analysis

Statistical analysis was performed using the IBM Statistical Package for the Social Sciences version 24.0 software (IBM SPSS Corp., Armonk, NY, USA).

Results

There was no difference in age and gender distribution in the 2 groups. No statistically significant differences were found between the fracture healing time in the 2 groups ($p>0.05$) (Table 1).

Postoperative and intraoperative complications were similar ($p>0.05$). In 5 patients from group I, operated on using the classical technique without the awl, the locking screws could not be placed in the correct position in the first trial compared with only 3 patients from group II, in whom the new awl technique was used (Table 2). After fluoroscopy, control procedures were repeated and the screws were placed in the correct positions. In 1 patient in whom the awl was used, the awl tip was bent and deformed. Without interruption in the procedure, another awl was used in its place. Postoperative radiographies, both on first day and in the first year, revealed that all the screws were in the

Table 1. Age and sex distribution in both the groups

	Without grooved awl (n=46)		With grooved awl (n=68)		
Variables	**Mean±SD**	**Min–max**	**Mean±SD**	**Min–max**	**p**
Age (years)	41.36±13.56	19–73	38.37±12.85	17–69	0.234*
Sex, n (%)					
Women	16 (34.8)		25(36.8)		0.829**
Men	30 (65.2)		43 (63.2)		

*Student t test. **Chi-square test
max: maximum; min: minimum; SD: standard deviation

Figure 11. Fluoroscopic control to confirm that the drill bit is inside the hole

Figure 12. The drill is advanced and passed through the opposite cortex

Figure 13. Locking screw is placed

correct position and remained in the correct position. For both the groups, the operating time and total radiation time were similar (p>0.05). Distal locking time and distal locking fluoroscopy time were significantly shorter with the new technique (p< 0.05). The ratio of distal locking time to total operation time and that of distal locking fluoroscopy time to total operation fluoroscopy time was significantly shorter with the new technique (p<0.05) (Table 3).

Discussion

One of the most critical steps in long bone intramedullary nailing is distal locking of the nail. During distal locking, technical problems such as the inability to place the screws in the locking holes, deformation or breakage of the screws, or drill bit, can occur. Most of the radiation exposure during the operations occurs owing to the distal locking stage, which is where most of the operation time is spent [5, 7, 9, 13-15]. There are numerous techniques for distal locking. The most commonly used ones are the freehand technique and hand-help guides, image intensifier mounted targeting devices, nail mounted guides, computer navigation systems, and self-locking nailing systems [5]. All of these techniques have their own advantages and disadvantages. Factors, such as efficiency, cost, radiation exposure, and user-friendliness, are part of the decision process.

Image intensifier mounted targeting devices can fail in micro-movements. This inconsistency is generally accepted as the main disadvantage of the system, preventing its general acceptance. Nail mounted guides are only produced for certain brands [5, 8]. Targeting problems with this system occur from time to time (5). In cadaver studies, Krettek et al. [15, 16, 18, 19] have shown a decrease in radiation exposure using external guides. Computer navigation systems are relatively new and continue to develop [2, 3, 5, 20]. Their main advantage is being radiation free. Their disadvantage is the need for additional equipment and cost. Self-locking nailing systems work by swelling the nail instead of locking screws. This user-friendly advantage is often considered inefficient, and removal of screws is sometimes problematic [5].

Nevertheless, the most common technique in distal locking is the freehand technique with fluoroscopic control [5, 13, 14]. The standard freehand technique is performed with the help of a radiolucent handle. With the use of fluoroscopy, a notch is created in the first cortex by a sharp drill bit and the hole is completed using a power drill. When the radiolucent handle is unavailable, another technique should be used. There are some freehand techniques using the Kirschner wire, cannulated drill, or the Steinmann pins [5, 21]. Our technique is simple and does not need a radiolucent handle. The cortex is notched with a grooved thin awl, and the hole is completed with a power drill.

In the traditional freehand technique, it is not very easy to use the sharp drill bit connected to a heavy power drill and a radiolucent handle. Sometimes it is challenging to place the drill bit connected to a heavy power drill to the precise spot and hold it at the same point for long periods of time. In our technique, manipulation and usage of the awl is very simple. Unlike the classical technique, replacement of the drill bit with the awl is very simple because of the grooves.

In fluoroscopic evaluation, a hole over the nail must be seen as a complete circle and a hole over the bone must be created from the center of the circle. If this step is not executed properly, problems, such as inability to find the hole and breakage of the drill bit, can occur. Whenever the bone is drilled without centering the nail insertion point, the created hole becomes larger than necessary and causes the locking to be weak. Owing to the easy handling and high maneuver ability of the awl, this risk is lowered.

The standard freehand technique is performed by placing a radiolucent handle to a power drill (5). When the radiolucent handle is unavailable, the surgeon can use another known technique or improvise a practical technique for distal locking. In this study, we offer a simple technique for distal locking whenever the computer navigation systems or radiolucent power drills are unavailable. It is not very difficult to prepare a grooved awl with removable handle. Nearly

Table 2. Complications and screw loosening in the 2 groups

Variables	Without grooved awl (n=46)	With grooved awl (n=68)	p*
Intraoperative complications, n (%)	5 (10.9)	3 (4.4)	0.265
Distal locking screw loosening in follow-up, n (%)	4 (8.7)	1 (1.5)	0.156

*Fisher's exact test

Table 3. Data results for the 2 groups

Variables	Without grooved awl (n=46)		With grooved awl (n=68)		p*
	Mean±SD	Min–max	Mean±SD	Min–max	
Total operation time (min)	90.13±18.57	58–130	94.34±16.97	60–140	0.214
Total operation fluoroscopy time (s)	39.67±19.27	37–112	72.17±22.09	32–132	0.534
Distal locking time (min)	21.52±5.80	15–38	19.25±4.80	12–34	**0.025**
Distal locking fluoroscopy time (s)	24.39±5.80	15–38	20.91±5.24	12–34	**0.001**
Ratio of distal locking time to total operating time (%)	23.98±4.27	16.84–33.87	20.68±4.75	13.64–33.33	**0.001**
Ratio of distal locking fluoroscopy time to total operating fluoroscopy time (%)	36.22±8.21	18.82–58.54	30.71±9.22	15.79–60.00	**0.001**

*Student's t test. max: maximum; min: minimum; SD: standard deviation; Statistically significant ($p<0.05$)

all hospitals with operating facilities have an awl, even if the handle is not removable. This technique can be modified and still be performed.

In our study, distal locking time and distal locking fluoroscopy time are significantly shorter ($p<0.05$). The ratio of distal locking time to total operating time and that of distal locking fluoroscopy time to total operation fluoroscopy time is significantly shorter with the new technique ($p<0.05$). Prior cumulative experience gained during the freehand locking of the nail can be a bias for the study. This may be owing to the ease of use with a small and light awl, instead of using heavy and time-consuming medical devices.

The main disadvantage of our technique is exposure to radiation as in other freehand techniques. Manually handling the awl exposes the surgeon to high levels of radiation; therefore, we recommend using protective gloves for this step. This study was based on a single center and a single surgeon. This was the main limitation of this study.

In intramedullary tibial nailing operations, the distal locking step takes most of the operating time and intraoperative fluoroscopy time. In our study, the results show that using a grooved awl with a removable handle in the absence of a radiolucent handle is an easy and effective way of distal locking.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Acıbadem University (ATADEK/2020-04).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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