

## Original Article

**ENDER NAIL: IS THE OLD IMPLANT EFFECTIVE TODAY?**

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**Background** – Tibial shaft fractures are the most common among long bone fractures. Except for the fractures with minimal displacement, treatment of these fractures is always surgical. Currently, locked medullary nailing is the preferred surgical treatment. However, use of these implants necessitates a set of instruments and specific facilities which are not currently accessible in many centers in Iran. Considering the successful results of Ender nailing in the last 20 years reported in literature and the fact that Ender nailing can be performed with simpler instruments and limited facilities in Iran, we studied the results of treatment by this method.

**Methods** – From March 1999 to June 2001, 71 patients with tibial shaft fractures (53 males and 3 females) were treated by Ender nailing at Sina Hospital, affiliated to Tehran University of Medical Sciences, Tehran, Iran. We applied 2 to 3 Ender nails 4 to 4.5 mm in diameter. These nails were inserted in the medulla after making 2 small incisions near the tibial tuberosity in lateral and medial sides. Using descriptive statistics, we showed the satisfactory results of this set of operations.

**Results** – Twenty-two (39.3%) fractures were closed and 34 (60.9%) were open. Of the 56 patients, 55 (98.2%) achieved union 8 (mean: 4.7) months after the operation. In 46 (82.1%), the fracture united in a maximum of 5 months and in 9 (16.1%), between 5 to 8 months. The most common complication was soft tissue irritation at the proximal tibia due to protruding Ender nails. Seven (12.6%) patients were affected with this problem and the nails were removed in 5 of them.

**Conclusion** – If used correctly, Ender nail can be an effective tool in treatment of tibial shaft fractures especially in centers with lower access to sophisticated and expensive facilities.

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**Keywords:** Ender nail • tibial fracture

**Introduction**

Tibial shaft fractures are important from several points of view. First, they are the most common fractures of long bones in the human body.<sup>1</sup> Second, the patient is often young and active and early return to daily activities is necessary. Third, in tibial shaft fractures with massive bone and soft tissue injury the treatment can be difficult. In fact, except for the fractures due to low energy and with minimal displacement, surgical treatment is usually indicated for the rest.

Locked intramedullary nailing is currently the

preferred method for surgical treatment of this injury.<sup>1-3</sup> The method needs specific instruments and facilities like image intensifier and a complete set of nails, screws, and insertion devices which must be checked regularly so that the damaged parts can be replaced. Such facilities are not accessible in many hospitals in our country, where as in rather well-equipped hospitals like our center, interlocking nailing is the routine procedure. What kind of implants can be used in less-equipped centers with limited facilities?

The limitation is that plates can not be usually used in open and comminuted fractures and though bridging plates can be used in a broader spectrum of fractures, an image intensifier is a must in bridging plate fixation.

External fixators are invaluable tools. In modern fracture treatment, they are currently used in temporary fixations. In less-equipped centers, external fixators are very useful in most high-

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energy fractures and we can never deny their important role.

We believe that Ender nails can be used successfully in difficult-to-manage tibial fractures such as open, comminuted, and segmental fractures.

Ender, an Austrian surgeon from the University of Vienna, first introduced Ender nails for fixation of peritrochanteric fractures in 1969.<sup>4,5</sup> Since 1980, there have been several reports of successful use of Ender nails in tibial shaft fractures.<sup>6 - 20</sup> In the classic textbooks of orthopedic surgery, Ender nails are advised in some specific conditions.<sup>3</sup> In recent years, the use of Ender nails in adult tibial shaft fractures significantly decreased in the USA and interlocking nailing has now replaced it as the preferred surgical technique.

Concerning the availability of Ender nail, its low price, and the low economic conditions of many of our patients in Iran, we aimed to demonstrate that Ender nails may yield sufficiently satisfying results to consider them as a proper choice at least when patients' access to modern and expensive alternatives is limited.

### Patients and Methods

From March 1999 to June 2001, 71 patients with tibial shaft fractures were treated by Ender nailing. Fifteen patients were excluded from the study because of incomplete follow-up. Fifty-six patients including 53 (94%) males and 3 (5.4%) females with the mean age of 29 years (age range: 13 to 73 years) were included in the study. These patients were selected from tibial shaft fracture patients referred to our center who were good candidates for Ender nailing. Our criteria were the fractures located between the proximal middle-third junction to 7 cm from ankle joint and a minimum of 25% of the intact cortical circumference. These criteria were adjusted according to Wiss.<sup>19</sup> At the time of the study, many patients who met our criteria for Ender nailing were treated with other techniques such as interlocking nails and plating.

Most patients with open fractures were operated immediately or within the first 24 hours. We used 2 or 3 Ender nails, 4 to 4.5 mm in diameter. These nails were inserted in the medulla after making 2 small incisions near the tibial tuberosity in lateral and medial sides. The number of nails related to the diameter of medullary canal and fracture comminution.

Except for the first 11 months of the study, we routinely used an image intensifier during the operation and whenever possible, a closed technique without opening the fracture site was performed. After operation, considering the stability of fracture site after fixation, presence of other fractures such as ankle fractures, and the patient's compliance and cooperation, different external immobilizations or no external support were applied. Long leg cast, patellar tendon-bearing (PTB), cast brace, or none of them were used. Early mobilization was possible and the amount of weight bearing upon the involved extremity was determined by fracture stability, patient's compliance, and progress in union which was observed in the follow-up X-rays. The union was defined as the appearance of bridging callus at follow-up X-rays.

Considering the 90% success (union) rate in previous reports, the sample size was calculated as a minimum of 50.

### Results

Of the 56 patients, 55 (98.2%) achieved union in 8 months (mean: 4.7 month [20 weeks]), 46 (82.1%) united in 5 months, and 9 (16.1%) between 5 and 8 months. Twenty-two fractures (39.3%) were closed and 34 (60.9%) open. The open fractures were classified according to Gustilo (Table 1).<sup>1</sup>

Fracture configuration was classified according to Arbeitsegmeinschaft Fur Osteosythesfragen (AO) classification.<sup>19</sup> About thirty-eight percent of the fractures were of A type; 51.7% of B type; and 10.7 % of C type. There were 5 segmental fractures in C group. The most common mechanism of injury was motorcycle-related accidents. About sixty-one percent were cyclists injured in motorcycle-automobile accidents and 10.7% were pedestrians injured in pedestrian-motorcycle accidents.

Fixation was performed with 2 Ender nails in 21 (37.5%) patients and with 3 in the rest (62.5%).

Thirty-one patients (55.4%) were operated by

**Table 1.** Open fractures classified according to Gustilo.<sup>1</sup>

Fracture type	Number (%)
Closed	22 (39.3)
Open II	8 (14.3)
Open IIIa	25 (44.6)
Open IIIb	1 (1.8)
<b>Total</b>	<b>56</b>

**Table 2.** Summaries of results in treatment of tibial fracture with Ender nails.

Authors and (year of publication)	No. of fractures	Percentage of open fractures	Percentage of union	Important points
Hassenhuttel (1981) <sup>11</sup>	235	75.8	92.9	Union rate is higher in closed fractures, and open fractures had more complications
Pankovich et al (1981) <sup>16</sup>	37	21.7	91.8	
Mayer et al (1985) <sup>14</sup>	51	49	96	Two malunions, 2 infections
Merlanos et al (1985) <sup>15</sup>	143	28	95	Eight malunions
Wiss (1986) <sup>20</sup>	50	56	96	
Wiss et al (1986) <sup>19</sup>	111	50	94	
Rinaldi et al (1987) <sup>17</sup>	32	?	98	
Jannke et al (1992) <sup>13</sup>	80	17	97.5	In type IIA open fractures, nail is contraindicated
Abramovitz et al (1993) <sup>6</sup>	46	100	?	High complication rate in type IIIB and IIIC open fractures
Semenovicz et al (1996) <sup>18</sup>	46	39	100	One infection
Ando et al (2000) <sup>7</sup>	280	?	97	
Hussain et al (2001) <sup>12</sup>	39	30	87	

closed method and 25 (43.6%) with open method. In the latter group, fasciotomy was performed due to compartment syndrome in 4 patients and primary bone grafting in 6.

In 35 patients (62.5%), there was another simultaneous major injury; 3 patients suffered from major head trauma and 5 were found to have ipsilateral femoral shaft fracture (floating knee injury). Ankle fractures and ligament injuries of the knee were other accompanying problems.

The most common complication was soft tissue irritation at the proximal part of tibia due to protruding Ender nail. This complication was found in 7 patients (12.6%) and the nails were removed in 4 after the union and in one before it.

Malunion was detected in 3 cases (5.4%); 2 with more than 10 degrees of external rotation at the fracture site and one with 6 degrees of posterior angulation after union. A reoperation was conducted in one case due to malalignment 2 days after the first operation. There was no infection.

## Discussion

A union rate of 98.2% in a mean period of 20 weeks is acceptable and comparable with previous reports summarized in Table 2. This rate of union was achieved in spite of a significant number of high-energy trauma cases (i.e. 60.7% of the cases had open fractures and 62.4%, had C type fractures).

The union rate and time in our study compares to the results of interlocking nailing.<sup>2</sup> We never argue against the superiority of interlocking nails to Ender nails; however, available facilities must be considered too. In 1996, Chiu compared the results of interlocking nails and Ender nails.<sup>8</sup> Of 116 patients, 60 patients were randomly treated with interlocking nails and 56 with Ender nails. In the fractures with cortical comminution more than 50% of the diaphyseal diameter, the results of interlocking nails were significantly superior to those of Ender nails. Nevertheless, in the fractures with cortical comminution below 50%, interlocking and Ender nails did not significantly differ.

In fact, the fractures with severe comminution are not good candidates for Ender nailing. Wiss in his comprehensive study on 111 cases stated that a minimum of 25% intact cortical circumference at the fracture site is required for a low complication rate.<sup>19</sup>

In 62.5% of the patients, concomitant injuries were present, some of which needed surgical treatment. In such patients, even when interlocking nails are available, Ender nailing may be more helpful because of swiftness and simplicity of the technique.

Eight patients (12.5%) were younger than 18 years old. Ender nails can be used without growth plate damage and is an ideal option in children. Titanium elastic nails (TEN) that have been

recently introduced for fixation of pediatric fractures are in many aspects similar to Ender nails.

One of the most important disadvantages of Ender nailing is the necessity for postoperative external support in a significant number of patients. This is considered a major disadvantage in modern fracture surgery. This immobilization may be more important in highly comminuted fractures. With more experience in Ender nailing, the surgeon can achieve more stable fixations, less dependence on external immobilizations, and even with no external support in some cases.

The most common complication in our study was soft tissue irritation of the proximal tibia in 7 patients. We believe that this is a technical problem and the nail must be inserted deep enough in the medulla to prevent soft tissue irritation. However, inserting the nails too deep may make extraction of the pins difficult.

The role of an image intensifier (C-arm) in Ender nailing is another noteworthy point. This apparatus is not accessible in many hospitals in our country. Ender nailing by closed method, using an image intensifier, is ideal but when it is not available, as in the first 11 months of our study, minimal incision at fracture site makes reduction and nail insertion easy. In open fractures with major wounds, the problem is smaller. Another major point is that Ender nails, like interlocking nails<sup>2, 3</sup> are not effective tools for fixation of the fractures of the proximal third of tibia. Nail tends to exit from posterior cortex. There have been some reports of retrograde use of Ender nails (entrance near the ankle).<sup>3, 7</sup>

The dynamic property of Ender nails is very helpful in fracture union. In response to axial loading when patients start weight bearing, compression of fracture fragments occurs which is beneficial to bone union.

Excessive bending of a nail may angulate the fracture site. The surgeon must allow enough bending for each fracture especially in highly comminuted fractures. However, complete straightening of nail can eliminate their 3 point fixation properties.

Consideration of the more comminuted cortex is another significant point to put the third nail in such a manner that the nail comes in contact with the more comminuted cortex.

External fixators are the routinely available implants in most less-equipped centers and their usefulness must never be underestimated. There

have been two reports comparing the results of external fixator versus Ender nails.<sup>21, 22</sup> In both studies which were performed on 2 groups of patients (one treated with external fixators and the other with Ender nails), there was no major superiority of external fixator to Ender nails. The complications of Ender nails were fewer in many aspects while the union rates were similar. We think that there were some problems in the matching of the 2 groups in these studies. Each of these implants if used correctly are beneficial.

We believe that Ender nailing, if performed correctly in properly selected patient, can be a very helpful and effective method in fixation of tibial shaft fractures especially in less-equipped centers without access to interlocking nails, though we never deny the usefulness and good results of interlocking nails.

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