

# Elastic Stable Intramedullary Nailing versus Compression Plating in Pediatric Femoral Shaft Fractures: A Retrospective Study

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**Background:** The operative treatment of femoral shaft fractures in children of 6- to 12-year-old necessitates the controversial operative options of elastic stable intramedullary nailing (ESIN) and dynamic compression plating (DCP).

**Objective:** To compare clinical outcomes of the operative options between the ESIN and the DCP for treatment of pediatric femoral shaft fractures.

**Material and Method:** Analyses of femoral shaft fractures were conducted among the pediatric patients of the Khon Kaen Hospital, 6- to 12-year-old, treated with either ESIN or DCP techniques between January 2012 and December 2015. Medical records and radiographs were retrospectively reviewed for recorded data; regarding demographics, union time, operative time, estimated blood loss, and complications.

**Results:** Fifty-four consecutive patients with 55 femoral shaft fractures were evaluated, in which 21 femoral fractures treated with ESIN fixation, and 34 with DCP fixation with comparable demographic data. There was a statistically significant difference between the ESIN and DCP groups in estimated blood loss ( $5.4 \pm 2.1$  and  $68.8 \pm 23.1$  ml,  $p < 0.001$ ), but no statistically significant differences of union time ( $8.8 \pm 1.5$  and  $12.2 \pm 6.9$  weeks,  $p = 0.077$ ), operative time ( $101.9 \pm 9.9$  and  $52.1 \pm 7.1$  minutes,  $p = 0.141$ ), numbers of complication events (14.3 and 17.6%,  $p = 0.743$ ), and numbers of malunion (19.0 and 8.8%,  $p = 0.269$ ). The most common complication with ESIN was pin tract infection (three events), and peri-implant or mechanical related failure (six events) with DCP.

**Conclusion:** ESIN fixation for pediatric femoral shaft fractures presented significantly less intraoperative blood loss than the DCP fixation, but no significant differences in union time, operative time, and numbers of complication and malunion.

**Keywords:** Pediatric femoral shaft fracture, Elastic stable intramedullary nailing, Dynamic compression plating

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The femoral shaft fracture is a common major pediatric injury. The preferred treatment must be determined with consideration of many factors, including age, weight, associated injury, fracture pattern, and mechanism of injury. The most significant of which, is the patient's age<sup>(1-5)</sup>. The conservative treatment with casting with or without traction, has proven to be an effective treatment for children less than six years old<sup>(6)</sup>. In children over 12 years of age, the recommended operative fixation is similar to that of an adult, due to the near-maturity of the growth plate. However, children with femoral shaft fractures, ranging from six to 12 years of age, can be treated operatively with favorable outcomes, but the preferred fixation method and their associated advantages and disadvantages remain controversial<sup>(7,8)</sup>.

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Elastic stable intramedullary nailing (ESIN) and dynamic compression plating (DCP) are the predominant options for operative fixation of femoral shaft fractures in these school-age (6 to 12 years of age) children. Generally, ESIN fixation implants provides relatively stable construction, though less stable than DCP fixation, with less invasive surgical exposure<sup>(9,10)</sup>. The more controversial issues of these comparative procedures involve aspects of their respective surgical outcomes. The purpose of this retrospective study was to analyze and compare the outcomes of these two procedures.

## Material and Method

Retrospective analysis of femoral shaft fractures was conducted among the pediatric patients of the Khon Kaen Hospital, 6 to 12 years of age, treated with either ESIN or DCP fixation techniques between January 2012 and December 2015. The medical records and radiographs reviews were made for recorded data; regarding demographics, union time, operative times,

estimated blood loss, as well as any complications. The protocol of the present study was reviewed and approved by the Ethics Committee of Khon Kaen Hospital, Khon Kaen, Thailand (No. KE59061).

### Study participants

The study group consisted of pediatric patients, 6 to 12 years of age, presenting an acute femoral shaft fracture, less than one-week duration of injury, treated with either ESIN or DCP fixation techniques. Sample illustrations of the basic ESIN and DCP techniques were presented in Fig.1 and 2. Exclusion criteria were patients with associated ipsilateral lower limb injury or underlying disease, as well as having prior ipsilateral limb surgery or

malfunctions, which may have compromised the outcome.

### Outcome measurement

The patients' demographic and clinical characteristics, including their age, gender, complexity, number of open fractures, and associated injuries were collected. The patients were routinely followed-up and radiographic investigated every month until the fracture was union. The primary surgical outcome, at weeks of union time, was calculated through serial radiographs. The union of fracture site was defined as at least three of four cortices bone healing from radiographic findings. Operative time, duration from the initial skin incision, or manipulation to wound closure, was also gathered from medical records. Complications, which required additional treatment, as well as malunions presenting more than 10 degrees of angulation, were recorded as both number of events and percentage.

### Statistical analysis

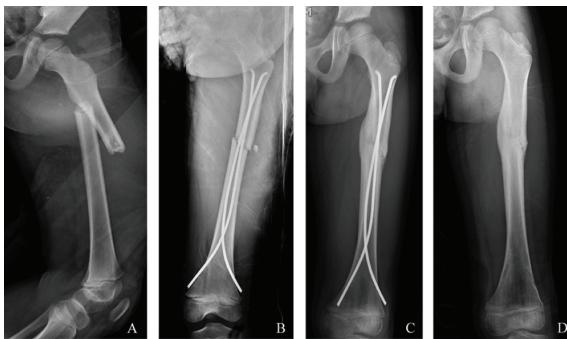
Sample size of population was determined by using a power of 0.8, assumed significance level of  $\alpha = 0.05$ , and a pooled standard deviation of 1.06 from the union time of previous study<sup>(11)</sup>. The minimum sample size calculated was a group of 18 fractures.

Comparative baseline characteristics of the patients in each group included age, gender, configuration, type of fracture, and major associated injury. Categorical data was expressed through percentages, and continuous data was represented through mean and standard deviation.

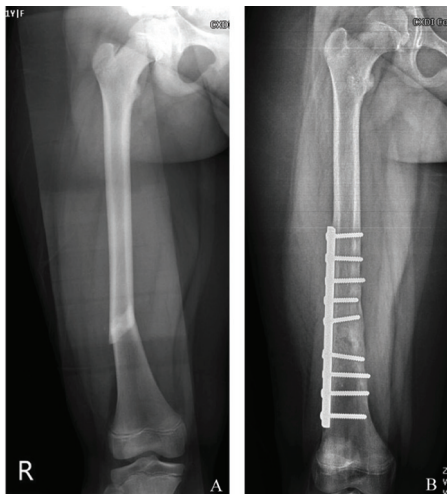
Union time (weeks), operative time (minutes) and estimated blood loss (milliliters) were analyzed and reported as a mean difference and 95% confidence interval using either an unpaired t-test or Mann-Whitney U test, depending on the normal distribution of data. The  $\alpha$  was set at 0.05, and a  $p$ -value of less than 0.05 was considered statistically significant. The Chi-square test was employed to analyze post-operative complications and malunions.

### Results

Fifty-four pediatric patients presented with 55 femoral shaft fractures, in which no patient met the exclusion criteria. According to medical records, 21 fractures were treated with ESIN fixation, and 34 were treated with DCP. Mean age of patients in the ESIN group was  $7.5 \pm 1.5$  years, and  $10.4 \pm 1.7$  years in the DCP group. There were 14 male patients (66.7%) in the ESIN group, and 18 (52.9%) in the DCP group.



**Fig. 1** Typical pediatric femoral shaft fracture (A) treated with ESIN fixation (B). The 10-week follow-up radiograph (C) details the union of the fracture. ESIN was removed post-operatively at 20-week (D).



**Fig. 2** Typical pediatric femoral shaft fracture (A) treated with DCP fixation. The 12-week post-operative radiograph details the successful union of the femoral shaft (B).

The ESIN group presented five complex fractures (23.8%), with two (9.5%) having associated injuries; whereas the DCP group presented 10 complex fractures (29.4%), with six (17.6%) presenting associated injuries. There were no significant differences in age, gender, or type of fracture between the two groups, as shown in Table 1. The significant statistical difference of associated injuries was demonstrated (ESIN 9.5%, DCP 17.6%;  $p = 0.006$ ).

The union times of the ESIN and DCP groups were  $8.8 \pm 1.5$  and  $12.2 \pm 6.9$  weeks, respectively; with no statistically significant difference ( $p = 0.077$ ). The operative time of the ESIN group proved longer than the DCP group, at  $101.9 \pm 9.9$  and  $52.1 \pm 7.1$  minutes, respectively; with no statistically significant difference ( $p = 0.141$ ). Patients within the ESIN group demonstrated less estimated blood loss ( $5.4 \pm 2.1$  ml) than the DCP group ( $52.1 \pm 7.1$  ml), with a statistically significant difference of  $p < 0.001$ . Recorded incidents of complication and malunion showed no statistically significant difference ( $p = 0.743$  and  $0.269$ , respectively), as shown in Table 2. Complications within the ESIN group were pin tract related, including a prominent nail tip and sinus tract infection, which was completely resolved upon removal of the nail (Fig. 3). Peri-implant or mechanical-related implant failure was the most common complication within DCP group, which required revision surgery (Fig. 4, 5).

**Table 1.** Demographic characteristics of the eligible patients

Characteristics	ESIN (n = 21)	DCP (n = 34)	p-value
Age (years), mean $\pm$ SD	7.5 $\pm$ 1.5	10.4 $\pm$ 1.7	0.587
Male gender, n (%)	14 (66.7)	18 (52.9)	0.062
Type of fracture, n (%)			
Complex	5 (23.8)	10 (29.4)	0.063
Open fracture	0	0	N/A
Associated injury, n (%)	2 (9.5)	6 (17.6)	0.006

ESIN = elastic stable intramedullary nailing; DCP = dynamic compression plating

**Table 2.** Comparative outcomes of the operative treatments (two groups)

Outcomes	ESIN (n = 21)	DCP (n = 34)	Mean difference $\pm$ SE	95% CI	p-value
Union time (weeks)	8.8 $\pm$ 1.5	12.2 $\pm$ 6.9	-3.3 $\pm$ 1.5	-6.4, -0.3	0.077
Operative time (minutes)	101.9 $\pm$ 9.9	52.1 $\pm$ 7.1	49.8 $\pm$ 2.3	45.2, 54.5	0.141
Estimated blood loss (milliliters)	5.4 $\pm$ 2.1	68.8 $\pm$ 23.1	-63.4 $\pm$ 5.1	-73.6, -71.5	<0.001
Complication, No. of events (%)	3 (14.3)	6 (17.6)	-	-	0.743
Malunion, No. of events (%)	4 (19.0)	3 (8.8)	-	-	0.269

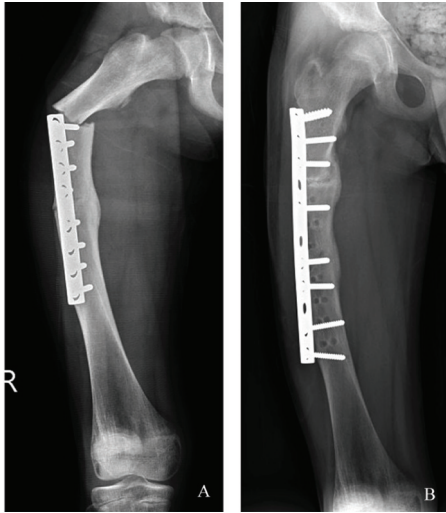


**Fig. 3** Representing the most common complication post ESIN fixation: prominent nail tip with pin tract infection at the entry site of the distal femur.

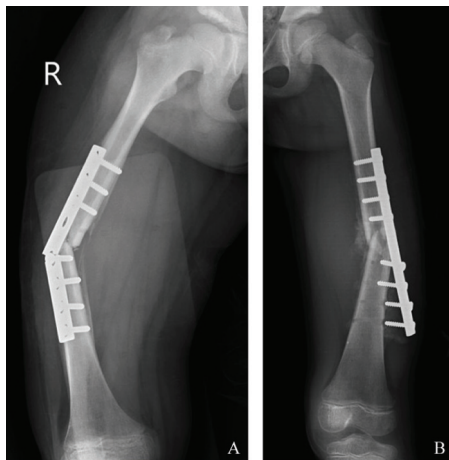
## Discussion

In the present study, ESIN fixation provided more favorable union times, less number of complications, and less estimated blood loss when compared to DCP fixation in the represented pediatric femoral shaft fractures. Malunions within the ESIN group compared to those of the DCP group, represented higher percentage. The statistically significant difference was demonstrated only in estimated blood loss. Moreover, the operative time of the ESIN group was double that of the DCP fixation group. This uncontented result may be the result of each individual surgeon's familiarity with this more recently introduced implant technique.

The previous literature of Sun et al (2014)<sup>(12)</sup>, Wall et al (2008)<sup>(13)</sup>, and Till et al (2000)<sup>(14)</sup> demonstrated similar satisfactory results, as well as a high union rate of elastic nailing; however, there was no account of intraoperative blood loss<sup>(12-14)</sup>. Caglar et al (2006) also presented a retrospective study of 40 adolescent femoral fractures, patients 6 to 12 years of age, treated with either ESIN or DCP fixation<sup>(11)</sup>. The nail group had significantly shorter operative times ( $p = 0.039$ ) and only a single case of non-union. Conversely,



**Fig. 4** Peri-implant fracture (A), a post DCP fixation complication which unrelated to the initial injury, treated with plate revision (B).



**Fig. 5** Plate breakage (A) and loosening (B) were the most common complications post DCP fixation.

four implant failures were reported in the plating group. The intraoperative blood loss was also not recorded.

Salem et al (2006)<sup>(15)</sup> studied the outcomes of titanium elastic nail fixation in 73 children with closed fracture of long bone. The results demonstrated satisfactory outcomes with all unions, with minimal, insignificant malalignment<sup>(15)</sup>. However, Luhmann et al (2003) reported the occurrence of major complications post ESIN fixation, including septic arthritis and hypertrophic nonunion<sup>(16)</sup>. Minor complications, such as skin irritation, implant prominence, and instability, were also reported, at low rates<sup>(17-20)</sup>.

Retrospective study of DCP fixation, Caird et al (2003) examined 60 cases of femoral shaft fracture, treated with compression plate fixation<sup>(21)</sup>. All cases presented successful union, with few complications, including limb discrepancy, re-fracture, and hardware failure. More recently, May et al (2013) retrospective study of 85 young patients presented complications, including surgical site infection, deformity, limb discrepancy, and subsequent reoperation<sup>(22)</sup>. The results of the current study demonstrated similar complications in hardware failure, which required a revision procedure.

### Limitation

This retrospective study did not collect the other clinical outcome data e.g., pain score, functional outcome, and cost-effectiveness, which were probably recorded in the medical record. Further study should conduct a prospective or randomized controlled trial for comparing the both groups in the mentioned aspects.

### Conclusion

The ESIN fixation for pediatric femoral shaft fractures had significantly less intraoperative blood loss than the DCP fixation, without significant differences of union time, operative time, and numbers of complication and malunion. The most common complication in ESIN group was the pin tract infection, and in DCP group was the peri-implant or mechanical related failure.

### What is already known on this topic?

A singular, prior study comparing ESIN and DCP fixation of the pediatric femoral shaft fracture reported similar results, including union time, operative time, and complications; however, failed to account for any intraoperative blood loss.

### What this study adds?

This present study demonstrated the less intraoperative blood loss within the ESIN group and elaborated upon the common complications found in both groups.

### Acknowledgement

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### Potential conflicts of interest

None.

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การศึกษาเปรียบเทียบการรักษาภาวะกระดูกต้นขาหักในเด็กด้วยวิธี *elastic stable intramedullary nailing* และ *compression plating*: การศึกษาย้อนหลัง

วันจักร พงษ์สมักรไทย

**ภูมิหลัง:** การรักษาโดยวิธีการผ่าตัดภาวะกระดูกต้นขาหักในเด็กช่วงอายุ 6-12 ปี ยังไม่มีข้อสรุปที่ชัดเจนของผลการรักษาระหว่างวิธี *elastic stable intramedullary nailing (ESIN)* และ วิธี *dynamic compression plating (DCP)*

**วัตถุประสงค์:** เพื่อเปรียบเทียบผลการรักษาระหว่าง *ESIN* และ *DCP* ในการรักษาภาวะกระดูกต้นขาหักในเด็ก

**วัสดุและวิธีการ:** ศึกษาทบทวนข้อมูลย้อนหลังจากระบบเวชระเบียนและผลการตรวจทางรังสีวินิจฉัยในผู้ป่วยเด็กอายุระหว่าง 6-12 ปี ที่เข้ารับการรักษาด้วยภาวะกระดูกต้นขาหัก และได้รับการผ่าตัดด้วยวิธี *ESIN* หรือ *DCP* ในช่วงระหว่าง เดือนมกราคม พ.ศ. 2555 ถึง ธันวาคม พ.ศ. 2558 โดยทำการรวบรวมข้อมูลพื้นฐานของผู้ป่วย ระยะเวลาที่กระดูกติด ระยะเวลาในการผ่าตัด การเสียเลือดโดยประมาณ และภาวะแทรกซ้อนที่เกิดขึ้น

**ผลการศึกษา:** ผู้ป่วยทั้งหมด 54 ราย มีภาวะกระดูกต้นขาหักทั้งหมด 55 ข้าง ได้รับการผ่าตัดรักษาด้วยวิธี *ESIN* และ *DCP* จำนวน 21 และ 34 ข้าง ตามลำดับ ซึ่งผู้ป่วยทั้งสองกลุ่มมีข้อมูลพื้นฐานโดยรวมใกล้เคียงกัน ผลการศึกษาแสดงให้เห็นว่ากลุ่ม *ESIN* มีการเสียเลือดน้อยกว่ากลุ่ม *DCP* อย่างมีนัยสำคัญทางสถิติ ( $5.4 \pm 2.1$  และ  $68.8 \pm 23.1$  มิลลิลิตร ตามลำดับ,  $p < 0.001$ ) และไม่มีแตกต่างอย่างมีนัยสำคัญทางสถิติของระยะเวลาที่กระดูกติด ( $8.8 \pm 1.5$  และ  $12.2 \pm 6.9$  สัปดาห์,  $p = 0.077$ ) ระยะเวลาในการผ่าตัด ( $101.9 \pm 9.9$  และ  $52.1 \pm 7.1$  นาที,  $p = 0.141$ ) จำนวนภาวะแทรกซ้อน ( $14.3$  และ  $17.6\%$ ,  $p = 0.743$ ) และจำนวนกระดูกติดผิดปกติ ( $19.0$  และ  $8.8\%$ ,  $p = 0.269$ ) ภาวะแทรกซ้อนที่พบบ่อยที่สุดในกลุ่ม *ESIN* คือ ภาวะนูนและติดเชื่อบริเวณปลายโลหะ รวมทั้งพบภาวะกระดูกหักซ้ำบริเวณใกล้เคียงกับโลหะตามเดิมและภาวะลิ่มเหลวเชิงกลศาสตร์ของโลหะเดิมเป็นภาวะแทรกซ้อนในกลุ่ม *DCP*

**สรุป:** การผ่าตัดรักษาภาวะกระดูกหักในเด็กด้วยวิธี *ESIN* มีภาวะเสียเลือดน้อยกว่ากลุ่ม *DCP* อย่างมีนัยสำคัญทางสถิติ แต่ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติในด้านระยะเวลาที่กระดูกติด ระยะเวลาในการผ่าตัด จำนวนภาวะแทรกซ้อน และกระดูกติดผิดปกติระหว่างทั้งสองกลุ่ม

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