International Journal of Surgery 16 (2015) 19–22

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original research

# Influence of the bending of the tip of elastic stable intramedullary nails on removal and associated complications in pediatric both bone forearm fractures: A pilot study

Emmanuel Gibon [a], Jean-Sébastien Béranger [a], Manon Bachy [a, b], Marion Delpont [a, b], Reda Kabbaj [a, b], Raphaël Vialle [a, b, *]

[a] Université Pierre et Marie Curie-Paris6, Armand Trousseau Hospital, Department of Paediatric Orthopaedics, 26, avenue du Docteur Arnold Netter, F-75571 Paris Cedex 12, France
[b] The MAMUTH Hospital-University Department for Innovative Therapies in Musculoskeletal Diseases - Armand Trousseau Hospital, 26, avenue du Docteur Arnold Netter, F-75571 Paris Cedex 12, France

## HIGHLIGHTS

- Forearm fractures are efficiently treated by intramedullary nail with few complications.
- Skin irritation is commonly reported and may lead to early surgery to shorten the tip of the nail.
- Bending the tip of the nail at 180° avoid skin irritation and additional procedures.

## ARTICLE INFO

*Article history:*
Received 31 October 2014
Received in revised form
31 January 2015
Accepted 8 February 2015
Available online 18 February 2015

*Keywords:*
Forearm fracture
ESIN
Skin impingement
Hardware removal

## ABSTRACT

*Objectives:* Both bone forearm fractures are efficiently treated by elastic stable intramedullary nail (ESIN). According to the original technique, the tip of the nail must be bent at 90° and buried under the skin. However, skin irritation is commonly reported and may lead to early surgery to shorten the tip or remove the hardware. The purpose of this study was to investigate the influence of the bending of the tip of the nail in this procedure.
*Methods:* We retrospectively reviewed 72 children operated on using this technique with the tip bent either at 90° or at 180°. In both groups we recorded complication rates after the procedure and at the removal.
*Results:* Time until removal and duration of the removal were similar in both groups. Three complications (6.7%) that required additional surgery were recorded when the tip was bent at 90° whereas no complications were found with the tip bent at 180°.
*Conclusion:* We advocate bending the tip of the nail at 180° before burying it in order to avoid skin irritation and additional procedures.
*Level of evidence:* Level III—retrospective comparative study.


## 1. Introduction

Irreducible, unstable or open both bone forearm fractures are typical candidates for elastic stable intramedullary nail (ESIN) fixation. The technique has been originally described for femoral shaft fractures [1]. The procedure was then extended to other locations such as the forearm [2,3] due to good outcomes for femoral shaft fractures [4]. After that Lascombes et al. [5] reported good results, the technique spread out throughout the world and is now widely performed in orthopaedic pediatric wards worldwide. The efficiency of this technique has been validated by many studies showing that the procedure is straightforward, reproducible, has good outcomes and few complications [6–8]. The most common reported complications after ESIN are by order of frequency refractures, lesion of the superficial radial nerve and delayed union

* Corresponding author. Université Pierre et Marie Curie-Paris6, Armand Trousseau Hospital, Department of Paediatric Orthopaedics, 26, avenue du Docteur Arnold Netter, F-75571 Paris Cedex 12, France.
*E-mail address:* raphael.vialle@trs.aphp.fr (R. Vialle).

http://dx.doi.org/10.1016/j.ijsu.2015.02.003
1743-9191/

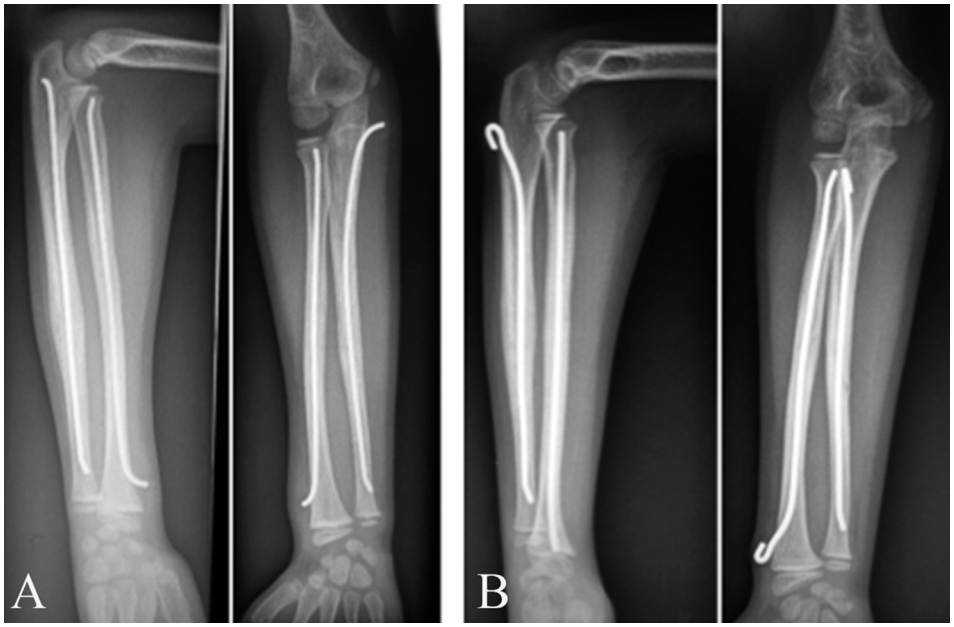


**Fig. 1.** AP and lateral view X-Rays of forearms after ESIN in the control group (A) and in the study group (B). In both group the tip of the nail is buried under the skin. In the control group, the tip is bent at 90° whereas it is bent at 180° in the study group.

[9]. With regards to the material used for ESIN, results are similar whether stainless steel Kirschner wires (K-wires) or titanium nails are used [10,11]. The only difference between these two is the price. Moreover, this procedure is less invasive than plating which requires an open reduction. Although outcomes are comparable between ESIN and plating [12,13], the advantages of ESIN over plating are smaller scars and the rapidity to remove the hardware. Removal of ESIN is controversial and little is known about this topic. However, leaving the nails in situ after the consolidation is obtained seems to be associated with an increased risk of refracture [14]. Therefore it is generally accepted to remove the nails after consolidation. The most common reported time until removal falls between 4 and 10 months [10–13,15,16] after the index surgery albeit Lascombes et al. [5] recommended to remove the nails between 10 months and 1 year after the initial procedure. Among reported complications after ESIN, skin irritation is frequent [14,17] and often leads to iterative surgical procedures either to shorten the nail or to perform hardware removal earlier than expected. The technique described by Lascombes et al. [5] recommends bending the tip of the nail at 90° and cutting it 5 mm from the bone. However, patients frequently report skin irritation and the influence of the bending of the tip over this specific complication is unknown. Furthermore, the intraoperative time for hardware removal procedure depending of the way the tip is bent is also unknown. In our daily practice, two different techniques were used to bend the tip of the nail at 90° or at 180°. Because of the limited number of cases and the non-randomized design of the study we decided to conduct a pilot study to investigate the influence of these two techniques on surgical outcome. We hypothesized that the duration of removal and the incidence of skin irritation can be influenced by the bending of the tip of the nail.

**Table 1**
Patients characteristics and surgical data in the study and control groups.

| Study outcomes | Study group n = 27 | Control group n = 45 | p value |
|---|---|---|---|
| Age (years, mean ± SD) | 9 ± 3.1 | 10.1 ± 3.1 | NS |
| Gender (M/F) ratio | 1.7 | 2.4 | NS |
| Time until removal (mo, mean ± SD) | 6.2 ± 1.9 | 6.9 ± 1.9 | NS |
| Duration of the removal (min, mean ± SD) | 22.3 ± 11.7 | 24.1 ± 12.6 | NS |
| Complication type | none | Skin irritation (n = 3) | |
| Additional procedure (type, number) | none | Tip shortened (n = 3) | |

## 2. Material and methods

The experimental design was prior approved by our Institutional Review Board. From a computer database, we retrospectively identified children with displaced forearm fractures that were treated with ESIN. All procedures were carried out under general anesthesia and without tourniquet. After closed reduction, we used the surgical technique described by Lascombes et al. [5] Blunt-ended steel or titanium nails were used equally. All nails were precurved prior to introducing them and we used nails with a diameter of 2 mm–2.5 mm. At the end of the procedure, the nails were cut and bent. The wounds were closed with absorbable sutures and all the children received an above elbow plaster splint applied postoperatively for 15 days. Two groups were created depending on the degree of the bend of the nail tip. One group had the tip bent at 180° (study group) and the other group had the tip bent at 90° (control group) (Fig. 1). In both groups, we reviewed patient demographics, complications, time until removal, and intraoperative time to perform hardware removal. The removal procedure was performed under general anesthesia without tourniquet and after radiographic confirmation of bone healing achievement. No prophylactic antibiotics were used during hardware removal procedure. Statistical analysis was performed with a Mann–Whitney U non-parametric test, as the distribution was not normal in both groups according to the Kurtosis and asymmetry indexes. A p-value <0.05 was used to indicate statistical significance.

Seventy-two children were identified through our database. 27 children were included in the study group and 45 in the control group. Patient characteristics are summarized in Table 1. Average