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Original research

Comparison of hybrid fixation versus dual intramedullary nailing fixation for forearm fractures in older children: Case-control study

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HIGHLIGHTS

- The clinical outcomes and complication rates are similar between the two methods.
- Hybrid fixation is superior to intramedullary nailing fixation in some respects.
- Hybrid fixation provides an alternative treatment for forearm fractures in children.

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ABSTRACT

Objective: The aim of the present study was to compare the clinical outcomes of hybrid fixation using elastic stable intramedullary nailing (ESIN) for the radius and plate screw fixation for the ulna (Hybrid group) with dual ESIN fixation (D-ESIN group) for both-bone forearm fractures in children between 10 and 16 years of age.
Methods: Fifty patients with both-bone forearm fractures (28 patients in the Hybrid group and 22 patients in the D-ESIN group) were reviewed. Functional outcomes were evaluated according to the criteria of Price et al. Radiological results were assessed by fracture union at three and six months and bone union time. Postoperative complications were also recorded.
Results: The times of fluoroscopy intraoperatively and duration of immobilization postoperatively were significantly lower in the Hybrid group ($P < 0.05$). The union rate of the ulna at three months postoperatively in the hybrid group was significantly higher than that in the D-ESIN group ($P < 0.05$). The average time of bone union was significantly shorter in the hybrid group than that in the D-ESIN group ($P < 0.05$). There were no differences according to the satisfactory rate and degree, the major and minor complications between the groups.
Conclusion: Hybrid fixation is superior in terms of the times of fluoroscopy intraoperatively, duration of immobilization postoperatively, delayed union rate of the ulna and the average time of bone union. Therefore, hybrid fixation is an alternative treatment for both-bone forearm fractures in children between 10 and 16 years of age.

1. Introduction

Both-bone forearm fractures account for 3.4% of all pediatric fractures and 26% of pediatric upper extremity long bone fractures [1,2]. Most fractures of the forearm in children younger than 10 years can be treated effectively with closed reduction and casting because of the considerable bone remodeling potential [3–5]. Although casting remains a feasible option in children older than 10 years of age [6], the incidence of poor results after closed treatment in this group may be underestimated because of their limited bone remodeling potential [7]. But so far, there is no clear standard as to

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the exact amount of angulation or malrotation that is acceptable in this age group. Common operative indications include open fractures, inability to achieve or maintain adequate alignment by closed reduction, and displaced fractures in children approaching skeletal maturity [8–10].

The most common options for surgical intervention of pediatric forearm fractures include elastic stable intramedullary nailing (ESIN) and open reduction and plate screw fixation. The advantages of dual ESIN fixation over dual plate fixation for pediatric both-bone forearm fractures include improved cosmesis, limited soft tissue dissection, decreased operative time, ease of implant removal, and early return to activity after implant removal [11–15]. However, in recent years, some studies have reported many complications of ESIN fixation, including delayed union and nonunion of the ulna, skin irritation over prominent hardware, implant migration or failure, compartment syndrome, and wound problems [16–20]. More recently, several reports emphasized that the rate of complications was obviously increased in children over 10 years old than that in younger children [21–23]. Open reduction and dual plate fixation has been criticized for the amount of soft tissue dissection and periosteal stripping required for exposure and fixation, and the increased risk of refracture [24,25]. Extensive periosteal stripping has been hypothesized as a risk factor for nonunions [26,27]. Additionally, violating the tenuous soft-tissue envelope may lead to wound problems. However, it remains a surgical option in this age group and offers some potential benefits, including immediate fracture stabilization and anatomic reduction that is important for restoring forearm rotation [12,28,29].

In an attempt to decrease the rate of complications and improve the clinical efficacy, we introduced hybrid fixation, in 2008, using an ESIN fixation for the radius, and open reduction and plate screw fixation for the ulna (Fig. 1). Compared with dual plate fixation, hybrid fixation not only reduces soft tissue dissection and potentially refracture rates after implant removal, but also incorporates some advantages of ESIN fixation. The purpose of this study was to compare the functional and radiographic outcomes and complications of hybrid fixation with dual ESIN fixation for the treatment of both-bone forearm fractures in children between 10 and 16 years of age.

2. Patients and methods

Approval for this investigation was obtained from the authors' Institutional Review Board and informed consent from all patients. Between January 2008 and December 2013, 50 patients, with a both-bone forearm fracture and a mean age of 13.7 years (range, 10–16 years), were included in this study. Patients were divided into two groups for surgical treatment with either hybrid fixation using an ESIN for the radius and plate screw fixation for the ulna (Hybrid group) or dual ESIN fixation for both the radius and ulna (D-ESIN group).

The inclusion criteria were: 1) failure to obtain or maintain adequate closed reduction in the middle third both-bone forearm fractures, 2) age between 10 and 16 years, and 3) closed fracture. The exclusion criteria were as follows:1) fixation of only one bone, 2) fixation of two bones with dual plate, 3) bilateral forearm injuries and previous forearm injuries in either arm, and 4) open fractures, complex forearm fractures (Monteggia fractures, Galeazzi fractures, intra-articular elbow, or wrist fractures) and pathologic fractures.

2.1. Demographics and perioperative data

Hospital charts and imaging studies were reviewed for each patient. Recorded patient characteristics such as age, sex, side of injury, fracture classification, and mechanism of injury. Perioperative data included duration from injury to surgery, duration of surgery, times of fluoroscopy intraoperatively, duration of immobilization postoperatively, and postoperative complications.

2.2. Clinical evaluation

Functional outcomes were evaluated at the last follow-up according to the criteria developed by Price et al. [5], and graded as: excellent, if no complaints with strenuous physical activity or a loss of pro-supination of <10°; good, if mild complaints with strenuous activity and/or 11°–30° loss of forearm rotation; fair, if subjective complaints during daily activities and/or 31°–90° loss of forearm rotation; and all other results were considered poor. Excellent, good, and fair results were classified as satisfactory, whereas poor results were classified as unsatisfactory. The loss of forearm motion in the affected side was compared with that in the unaffected forearm.

2.3. Radiological evaluation

The preoperative forearm radiographs were obtained to classify all fractures according to the Orthopaedic Trauma Association (OTA) classification of diaphyseal forearm fractures [30]. Fracture union was defined by bridging callous across at least three cortices of bone on the anteroposterior and lateral radiographic views. Based on the description by Schmittenbecher et al. [31], fracture

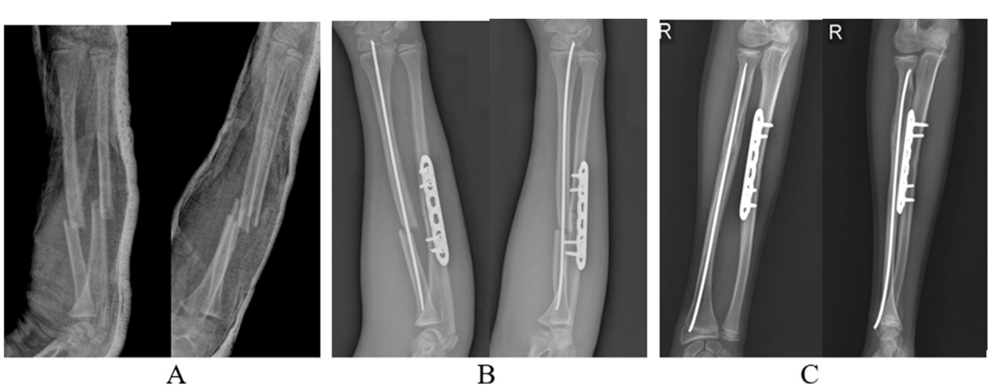

Fig. 1. A 13-year-old boy with a right both-bone forearm fractures caused by fall damage. (A) Preoperative anteroposterior and lateral radiographs showing a fracture in the middle third of the radial and ulnar shafts. (B) Radiographs taken on the day after the surgery. (C) Anteroposterior and lateral radiographs showing bone union of both radius and ulna three months postoperatively.