Comparison of two different surgical treatments of forearm double diaphysis fractures in adolescents

Adolescent period forearm double bone diaphysis fractures

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Abstract

Aim: In this study, it was aimed to compare the clinical and radiological results of the two different surgical methods for the treatment of forearm double bone diaphysis fractures in children at early and mid-adolescence (ages 10–16).

Materials and Methods: Children aged between 10 and 16 years who underwent surgical treatment for a forearm double bone fracture between the years 2015–2019 were evaluated retrospectively after the approval of the local ethics committee. The patients were separated into two groups: TEN group included 34 patients for whom both bones were fixated with TEN following closed reduction; plate-screw osteosynthesis (PO) group included 18 patients who had fixation with PO following open reduction.

Results: A total of 52 children with forearm double bone diaphysis fracture with the mean age of 12.40±1.79 (10–16) years, 86.5% (n=45) of whom were males and 53.8% (n=28) had left side fracture were followed up for 30.40±14.03 (12–64) months. When the data of both groups were compared, it was observed that average union time was shorter compared with the PO group and the difference was statistically significant (p=0.007). When the functional results and complication rates of the two groups were compared, there was no statistically significant difference found between the two groups (p=0.756 and p=0.052, respectively).

When the number of radiographs of both groups was compared, it was observed that the number of radiographs during the operation, during implant extraction, and total radiography was higher in the TEN group compared with the PO group and that the difference was statistically significant (p=0.000, p=0.002, p=0.000, respectively).

Discussion: TEN after closed reduction can be safely preferred for pre-adolescent period children with adequate remodeling capacity and incomplete skeletal maturity because of its positive outcomes including less operation and hospital stay duration, fast union, better cosmetic results. However, plate-screw following open reduction can be preferred for mid-adolescent period children with complete or near-complete skeletal maturity and limited remodeling capacity because of its positive aspects such as rigid fixation, anatomic reduction, and less radiation exposure.

Keywords
Adolescent; Forearm double; Diaphysis fractures
Introduction

Double bone fractures of the forearm constitute 5.4% of all fractures and 30% of upper limb fractures in pediatrics [1, 2]. They are the 2nd most common type of fractures in the adolescent age group [3]. The incidence rate of forearm double bone fractures among children has been increasing in recent years [2]. Approximately 85% of pediatric forearm double bone fractures are treated perfectly by conservative methods, but some children may develop limitations in forearm rotation [4, 5]. However, surgical treatment is needed for patients with fragmented, unstable, irreducible fractures or fractures with an unacceptable angling after reduction, open fractures, and fractures along with soft tissue damage [6-9]. In recent years, despite the lack of evidence guiding optimal surgical methods, there is a tendency toward surgical treatment in pediatric and adolescent forearm double bone fractures [10]. However, the ideal method of fixation in children aged 10–16 years with a double fracture of the forearm is still controversial [2]. Elastic intramedullary nailing technique was first described in the late 1970s and has been successfully applied with little change since then to the present day [10]. TEN is considered to be the ideal treatment for children with incomplete skeletal development due to its many positive aspects, such as less damage to the soft tissue, short operation duration, and fast union duration [11-13]. Perfect results are achieved in pediatric forearm double bone fractures by providing rigid internal fixation after anatomical reduction with plate-screw osteosynthesis (PO) after traditional open reduction [14]. The objective of this study was to compare the clinical and radiological outcomes of treatment of forearm double bone diaphysis fractures via two different types of surgical techniques among early and mid-adolescence children aged 10–16 years.

Material and Methods

Children aged 10-16 years who underwent surgical treatment for a double bone forearm fractures between the years 2015–2019 at our clinic were evaluated retrospectively after the approval of the local ethics committee (Session: 2020/07, Date: April 15, 2020, Decision no: 11). Patients aged 10–16 years who had surgical treatment performed due to forearm double bone fracture, who had type 1 open fracture, fractures that were 5 cm or farther from both joints (wrist and elbow), for whom both fractures were fixed with TEN or plate-screw, who had arterial injury without nerve damage to the soft tissue, short operation duration, and unacceptable post-reduction position (n=14), respectively. The most common surgery indications were irreducible fracture (n=15), loss of reduction (n=15), and unacceptable post-reduction position (n=14), respectively. The demographic data of the cases by groups are shown in Table 1.

Results

A total of 52 children with forearm double bone diaphysis fracture with the mean age of 12.40±1.79 (10–16) years, 86.5% (n=45) of whom were males and 53.8% (n=28) had left side fracture, were followed up for 30.40±14.03 (12–64) months. When the etiological factors of the cases were evaluated, it was observed that the fractures occurred most commonly as a result of falling in the house (n=15), sports injuries (n=15), and playgrounds accidents (n=15). Most common surgery indications were irreducible fracture (n=15), loss of reduction (n=15), and unacceptable post-reduction position (n=14), respectively. The demographic data of the cases by groups are shown in Table 1. When the data of both groups were compared, it was observed that the average union time was shorter compared to the PO group, and the difference was statistically significant (TEN: 8.14±2.74, PO: 11.22±4.41, p=0.007). When the functional results and complication rates of the two groups were compared, no statistically significant difference was observed between the groups (p=0.756 and p=0.052, respectively). The duration of hospital stay in the TEN group was shorter compared with the other group (p=0.000).

Fracture reduction, implant extraction, and total operation durations were shorter in the TEN group and the difference was found to be statistically significant (p=0.000, p=0.000, and p=0.000, respectively). When the number of radiographs of both groups was compared, it was observed that the number during the operation, during implant extraction and total radiography images was higher in the TEN group compared with the PO group with 18 patients in whom the bones were fixed with PO after closed reduction.
group and that the difference was statistically significant (p=0.000, p=0.002, and p=0.000, respectively). A comparison of groups is shown in Table 2.

**Table 1. Distribution of demographic data by groups**

|                    | Group 1 (n=34) | Group 2 (n=18) |
|--------------------|---------------|---------------|
| **Age (year)**     | 11.73±1.60 (10-15) | 13.66±1.45 (12-16) |
| **Gender**         |               |               |
| Girl               | 6             | 1             |
| Boy                | 28            | 17            |
| **Side**           |               |               |
| Right              | 18            | 6             |
| Left               | 16            | 12            |
| **Etiology**       |               |               |
| In-Home Fall       | 12            | 3             |
| Sports Injuries    | 8             | 7             |
| Falling down the stairs | 1          | 0             |
| Playground Accidents | 10           | 5             |
| Motor Vehicle Injury | 3           | 3             |
| **Surgical Indication** |           |               |
| Non-Reducible Fracture | 11           | 4             |
| Unacceptable Position After Reduction | 8       | 6             |
| Loss of Position   | 12            | 3             |
| Refracture         | 2             | 3             |
| Vascular-Nerve Injury | 0           | 1             |
| **Functional Outcome** |             |               |
| Excellent          | 26            | 14            |
| Good               | 6             | 4             |
| Moderate           | 1             | 0             |
| Poor               | 1             | 0             |
| **Complications**  |               |               |
| Surgical Area Infection | 0          | 1             |
| Refracture         | 2             | 0             |
| Pin Entry Irritation | 5           | 0             |
| Hypertrophic Scar  | 0             | 2             |
| **Implant Removal Time (mounth)** | 9.08±0.66 (2-36) | 16.94±7.20 (8-36) |
| **Following Time (mounth)** | 30.85±13.91 (12-52) | 29.55±14.62 (12-64) |

**Table 2. Comparison Outcomes of Groups**

|                      | Group 1 (n=34) | Group 2 (n=18) | p-value |
|----------------------|---------------|---------------|---------|
| **Age (year)**       | 11.73±1.60 (10-15) | 13.66±1.45 (12-16) | 0.000   |
| **Union Time (week)** | 8.1±4.74 (4-13) | 11.22±4.41 (6-22) | 0.007   |
| **Operating Time_fracture (min)** | 34.32±9.10 (20-50) | 66.9±14.84 (45-95) | 0.000   |
| **Operating Time_implant (min)** | 22.94±5.70 (10-50) | 48.7±20.14 (25-125) | 0.000   |
| **Operating Time_total (min)** | 57.26±13.11 (35-85) | 115.6±20.32 (85-180) | 0.000   |
| **Fluoroscopy Time_fracture (min)** | 23.8±7.08 (12-47) | 7.27±3.49 (2-14) | 0.000   |
| **Fluoroscopy Time_implant (min)** | 3.3±2.76 (0-12) | 2.0±1.4 (0-8) | 0.002   |
| **Fluoroscopy Time_total (min)** | 27.26±7.67 (12-49) | 9.2±10.03 (2-29) | 0.000   |
| **Length of Hospitalization (day)** | 1.5±0.66 (1-3) | 2.5±1.04 (1-5) | 0.000   |
| **Functional Outcome (satisfactory result)** | 32 | 18 | 0.756   |
| **Complications**    | 7             | 3             | 0.052   |
| **Mean Follow-Up Time (month)** | 30.85±13.91 (12-52) | 29.55±14.62 (12-64) | 0.506   |

**Discussion**

The aim of this study was to compare the treatment results of 10–16 years old patients who had PO performed after TEN and open reduction in forearm diaphyseal double bone fractures. When the functional outcomes and complication rates were compared, it could be observed that both treatment options can be successfully performed in this age group. But the preferred method depends on the experience and preference of the surgeon because of the lack of scientific evidence. Surgeons often prefer fixation with titanium elastic nails after closed reduction for young children with incomplete skeletal maturity and adequate remodeling capacity, whereas they prefer PO after open reduction for older children with complete or almost complete skeletal maturity and decreased remodeling capacity. This is the cause of the age difference between the two groups in our study.

TEN is defined as a simple and easy-to-apply technique that does not disrupt fracture biology as it is applied with mini...
Adolescent period forearm double bone diaphysis fractures

In conclusion, there is no complete consensus among surgeons for the surgical treatment of double bone forearm fractures in adolescence. The applied technique depends on the experience of the surgeon because of the lack of scientific evidence.

TEN after closed reduction can be safely preferred for pre-adolescent children with adequate remodeling capacity and incomplete skeletal maturity because of its positive outcomes such as less operation and hospital stay duration, fast union, and better cosmetic results. However, plate-screw following open reduction can be preferred for mid-adolescent children with complete or near-complete skeletal maturity and limited remodeling capacity because of its positive aspects such as rigid fixation, anatomic reduction, and less radiation exposure.

It should be noted that there is a need for randomized prospective studies with a sufficiently large scale to allow the separate comparison of pre-adolescent and mid-adolescent age groups for definitive results.

Scientific Responsibility Statement

The authors declare that they are responsible for the article’s scientific content including study design, data collection, analysis and interpretation, writing, submission of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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