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ORIGINAL ARTICLE

A 5-year Overview of Forearm Fracture Etiology and Treatment Options in 7-15 Years Old Children

Janis Upenieks */, Sintija Sloka***, Aigars Petersons */**, Anita Villerusa******
* Department of Pediatric Surgery, University Children's Hospital (Riga, Latvia)
**Department of Pediatric Surgery, Riga Stradins University (Latvia)
***The Centre for Disease Prevention and Control of Latvia
****Department of Public Health and Epidemiology, Riga Stradins University (Latvia)

Summary
Introduction. Forearm fractures make up a significant part of overall fracture rate in pediatric population, especially in 7-15 years old children. Different methods of treatment have been used, depending on the age of children and type and localization of fracture. Most controversies can be seen among conservative and surgical methods of treatment.
Aim of the Study. The aim of our study is to identify common localizations and types of forearm bone fractures in pediatric population, as well as analyze patient data and treatment process depending on selected method of treatment for out-patients and in-patients.
Materials and Methods. Retrospective analysis of out-patient and in-patient records, treated in University Children's hospital from 2007 to 2011 was made, including first time patients with fractures of one or both forearm bones, according to ICD-10 codes S52.0–S52.9. Demographical data, trauma mechanisms, localization and type of fracture, as well as applied treatment and stay length at hospital were analyzed. 1742 out-patients and 1029 in-patients, 7–15 years old at the moment of trauma, were included in this research.
Results. 2771 forearm fractures were registered, 62.9% patients were treated on out-patient basis, 37.1 % patients required treatment in hospital. Forearm bone fractures were gender specific – 2235 boys and 536 girls had to be treated (Male:Female ratio was 4.2 : 1). The peak incidence was seen in 13 years old boys and girls. Boys suffered from forearm fractures more often in any age group. Most common mechanisms of injuries causing forearm fractures in children were related with sports trainings - 22.1%, skiing - 15.0% and traffic injuries - 10.0%. Most common activities at the moment of trauma differ by season – during winter months they include skiing, skating and sledging while in summer falls from height, bicycles and swings are dominant. Several trauma mechanisms, like sport trainings, are not season-dependent. Some injury mechanisms differ significantly by gender. Boys were more often as girls injured during sports trainings and skiing, while girls experience forearm fractures due to bicycling and skating. Occurrence of forearm fractures in children has seasonal differences with two peaks: from June to August and from December to February. Distal forearm fractures are the most often seen localization of overall forearm fractures (42 % in boys and 36 % in girls). In out-patients group conservative treatment was performed – plaster immobilization in 1339 cases and closed reduction, followed by plaster immobilization in 403 cases. In-patients were treated both – conservatively with immobilization in 21 cases and closed reduction in 188 cases, and surgically with K-wire osteosynthesis in 137 cases or elastic stable intramedullary nailing (ESIN) in 683 cases. The type and localization of each fracture, along with the age of patient, are the key factors for choosing the right treatment method. K-wire osteosynthesis was performed in all age groups for unstable fractures in distal or proximal third of forearm. ESIN was a method of choice for unstable or comminuted midshaft fractures of one or both bones, metadiaphyseal fractures and some specific conditions (radial neck fractures, Monteggia fractures-dislocations), especially in older patients. Stay length at hospital was ranging from 1 to 2 hospital days in case of immobilization (mean = 1,05 days), from 1 to 4 days in closed reduction group (mean = 1,32 days), but 1 to 12 days in hospital spent children after K-wire osteosynthesis (mean = 1,99 days) or ESIN (mean = 2,38 days).
Conclusions.
1. Forearm fractures in children have a significant gender diversity (M : F ratio is 4,2 : 1).
2. Peak incidence group is 13 years old adolescents of both genders.
3. Seasonality and season-specific injury patterns are typical for pediatric forearm fractures.
4. The most common anatomic localization is the distal segment of forearm bones.
5. Younger children (7–9 years) are mainly treated by conservative methods, while methods of choice for treatment of forearm fractures in adolescents (13–15 years) are operative.
6. Surgical treatment of fractures do not significantly increase stay length at hospital.
Key words: Forearm fractures, children, treatment options.

INTRODUCTION

Child traumatism rates are one of the highest in Latvia if compared to other countries of the European Union. Statistical values do not show signs of improvement year by year (Central Statistical Bureau of Latvian Republic). Forearm trauma is one of the most common traumatic localizations in children, significantly being composed of fractures at different anatomical levels. Incidence of these fractures differs depending on the patient age but the highest levels are shown in 7–15 year old children

(4,5,8,12), therefore this group is analyzed in this research.

Most of the forearm bone fractures are treated conservatively, without invasive intervention; still significant part of patients must undergo surgical stabilization of bone fragments. Modern methods of treatment help us to improve treatment parameters (the amount of intervention, length of treatment, expenses, functional outcomes and quality of life).

Evaluation of forearm fracture parameters may emphasize new details in prophylaxis, showing direction towards reducing trauma prevalence among children. Although forearm fractures are a common pathology in children, there are still significant details of etiology and pathogenesis as well as an optimal selection of treatment methods that underlies this research.

AIM OF THE STUDY

The aim of this study is to evaluate parameters of forearm bone fractures in elementary school age children (7-15 years old), therefore following objectives were set:

* To identify common localizations and types of forearm bone fractures in pediatric population;
* To analyze patient data and treatment process depending on selected method of treatment in University Children's hospital out-patients and in-patients.

MATERIALS AND METHODS

Retrospective analysis of out-patient and in-patient records, treated in University Children's hospital from 2007 to 2011 was made, including first time patients with fractures of one or both forearm bones, according to ICD-10 codes S52.0–S52.9. Demographical data, trauma mechanisms, localization and type of fracture, as well as applied treatment and stay length at hospital were the main issues analyzed in this research. 1742 out-patients and 1029 in-patients, 7–15 years old at the moment of trauma, were included in this research. Collected data was generalized, analyzed and compared to foreign research in this area. Descriptive and conclusive statistical methods were used for the study data analysis. χ^2 (chi-square) test was used, based on the p values, to determine the statistical reliability, recognizing the results to be statistically significant if the ratio was less than .05 ($p < .05$). Cross tables and 95% confidence interval were set to compare characteristics of data. SPSS v20.0 and Microsoft Excel software were used for statistical data processing.

RESULTS

In the five year (from 2007 to 2011) period 2771 forearm fractures were registered in 7-15 years old children. Most of these patients were treated on out-patient basis (n = 1742, or 62.9%; 95% CI 61.0 - 64.7%), still 37.1 % (n = 1029; 95% CI 35.6-39.0%) patients required treatment in hospital. Forearm bone fractures were gender specific – 2235 boys and 536 girls had to be treated (Male:Female ratio was 4.2 : 1). It is obvious that male:female ratio increased with the age.

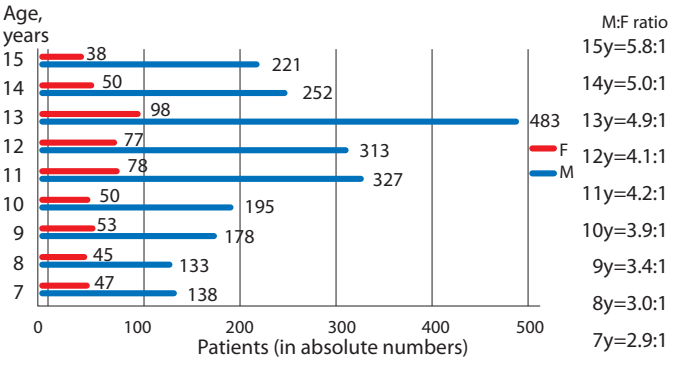

Fig. 1. Number of patients with forearm fractures by gender and age and male:female ratio by age

Patients were divided into three age groups: 7-9 years, 10-12 years and 13-15 years old children. The peak incidence was seen in 13 years old boys and girls. Gender differences among age groups were not statistically significant ($p > .05$) – boys suffered from forearm fractures more often in any age group.

Most common mechanisms of injuries causing forearm fractures in children were related with sports trainings (22.1%; 95% CI 20.5 - 23.6%), skiing (15.0%; 95% CI 13.7 - 16.4%) and traffic injuries (10.0%; 95% CI 8.9 - 11.1%) - see Fig.2. Most common activities at the moment of trauma differ by season – during winter months they include skiing, skating and sledging while in summer falls from height, bicycles and swings are dominant. Several trauma mechanisms, like sport trainings, are not season-dependent. Some injury mechanisms differ significantly by gender. Boys were more often as girls injured during sports trainings ($p < 001$; $df=1$; $\chi^2=30.118$) and skiing ($p < .001$; $df=1$; $\chi^2=13.188$) especially in winter months, while girls experience forearm fractures due to bicycling ($p < .001$; $df=1$; $\chi^2=32.916$) and skating ($p < .001$; $df=1$; $\chi^2=31.404$), especially in summer months. Such injury mechanisms, like fall from height ($p=0.059$; $df=1$; $\chi^2=3.566$) and fights ($p=0.206$; $df=1$; $\chi^2=1.596$) do not have statistically significant gender differences.

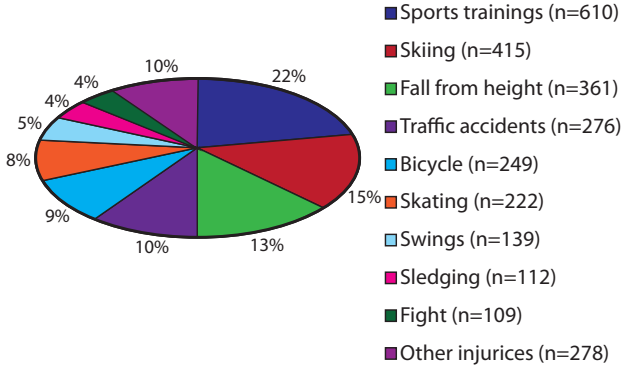

Fig. 2. Injury mechanisms, causing forearm fractures in children, in absolute numbers and %.

Occurrence of forearm fractures in children has seasonal differences with two peaks: from June to August and from December to February. Seasonality has gender differences mainly due to the mechanism of injury – boys were more often injured in winter months, while skiing and sledging, but bicycling and roller skating caused more fractures in girls during summer. Seasonality of forearm bone fractures is depicted in Fig. 3.

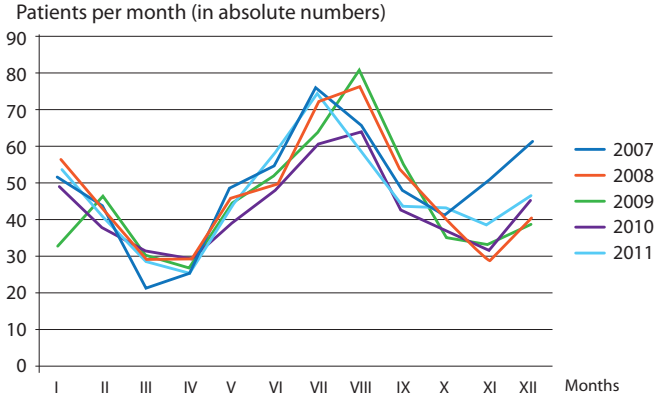

Fig. 3. Distribution of forearm fractures in children by months of the year (absolute numbers).

Localization of forearm fractures was classified in accordance to ICD-10 classification codes S52.0-S52.9 and is depicted in Fig.4. It is obvious that distal forearm fractures are the most often seen localization of these fractures (42 % in boys and 36 % in girls). However analyzing statistical significance of gender differences, we can see that neither distal *radius* (S52.5) nor distal *radius* and *ulna* fractures (S52.6) have prevalence in boys (p = .583 and .415 respectively). The same situation is with proximal *ulna* (S52.0) and proximal *radius* (S52.1) fractures (p = .166 and .585, respectively). Opposite tendency can be seen in diaphyseal fractures – in all three groups (S52.2 - *ulna* frx, S52.3 – *radius* frx and S52.4 – both bone frx) boys prevale significantly with p values < .01, < .01 and p = .021, respectively.

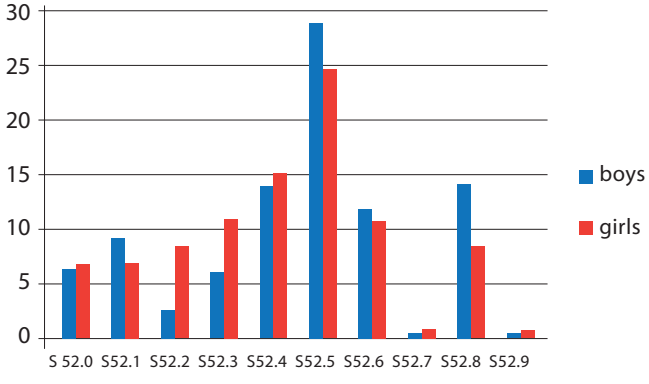

Fig. 4. Distribution of forearm fractures according to ICD-10 in gender groups (%).

In out-patients group 2 conservative treatment options were performed – plaster immobilization in 1339 cases and closed reduction, followed by plaster immobilization in 403 cases. In-patients were treated both – conservatively with immobilization in 21 cases and closed reduction in 188 cases, and surgically with K-wire osteosynthesis in 137 cases (percutaneous n = 87, open n = 50) or elastic stable intramedullary nailing (ESIN) in 683 cases (percutaneous n= 616, open n = 67). Overview of treatment methodology is depicted in Fig. 5-1 and Fig. 5-2.

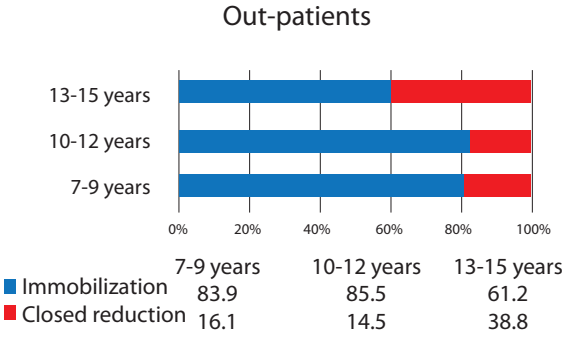

Fig. 5-1. Out-patient treatment methods of forearm fractures in different age groups (%).

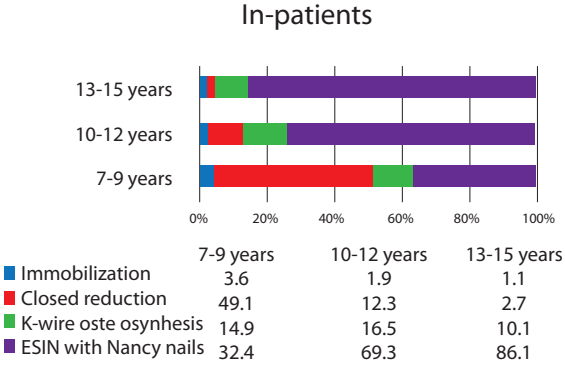

Fig. 5-2. In-patient treatment methods of forearm fractures in different age groups (%).

Conservative versus operative methods varied by the age of the in-patients. Half of younger children (7–9 years) were treated by conservative means (immobilization or closed reduction followed by immobilization) – 52.7 % cases (95% CI 46.8-58 %), in 10–12 year age group this proportion was 14.2 % (95% CI 10.8-18.5 %), but 13–15 year old adolescents were treated conservatively only in 3.9 % cases (95% CI 2.4-6.13 %). The type and localization of each fracture, along with the age of patient, are the key factors for choosing the right treatment method. K-wire osteosynthesis was performed in all age groups for unstable fractures in distal or proximal third of forearm. ESIN was a method of choice for unstable or comminuted midshaft fractures of one or both bones, metadiaphyseal fractures and some specific conditions

(radial neck fractures, *Monteggia* fractures-dislocations), especially in older patients.

Stay length at hospital was ranging from 1 to 2 hospital days in case of immobilization (median = 1, mode = 1, mean value = 1,05 days), from 1 to 4 days in closed reduction group (median = 1, mode = 1, mean value = 1,32 days), but 1 to 12 days in hospital spent children after K-wire osteosynthesis (median = 1, mode = 1, mean value = 1,99 days) or ESIN with *Nancy* nails (median = 3, mode = 3, mean value = 2,38 days). Prolonged stay at hospital (> 1 week) was documented in 4 patients after K-wire osteosynthesis (2.9 %) and 14 cases (2.1 %) of patients treated by ESIN.

DISCUSSION

Forearm bones are very common fracture localization in pediatric population. Several authors mention that almost 50 % of boys and 40 % of girls have experienced at least one fracture episode until their 18 years. Forearm fractures make up 25 % of overall fracture rate in children (4, 8,12).

Data from this survey show that in five year period number of registered patients with forearm fractures does not show tendency to reduce. Of course, data from our hospital reflect the situation in Riga and closer regions only, but taking into account that University Children's Hospital is the only specialized institution in Latvia, and inhabitants of Riga make up approx 1/3 of the whole population (n= 657424, data from Census in 2011), it can be used to reflect situation in the whole country. To achieve more precise result, data from other hospitals should be collected proportionally, in order to reduce data selection error.

Most patients undergo conservative treatment however the number of children treated by surgical intervention due to forearm fractures remains high. Most of the in-patients and out-patients are boys that can be explained by higher activity level in male population. The highest documented levels are in 11-13 years old patients that coincide with other authors (5,7,9).

Patterns of injury mechanism also differ a lot. Most of the injuries during the cold period of year are connected with snow activities – skiing, skating, sledging, etc. Summer period comes with increased numbers of falls from height and bicycle caused injuries. Some of injury patterns, e.g. sports trainings, are not influenced by the seasonal differences. Patterns of injury mechanisms differ in literature, however most of the authors indicate seasonal influence (1,4,8).

Seasonality is seen with two peaks – one is in June-August and corresponds to summer holidays of children and vacation time of their parents, which are usually spent without proper looking after them by nannies or grandparents. The other peak is seen in December-February and can be explained by increased popularity of winter sports that manifests in Latvia during last decade – more and more people involve their children in skiing, skating and other winter activities that inevitably lead to the increase of traumatic injuries. These trauma parameters are high in countries where winter sports are wide-spread and popular (5,10,12).

Analyzing types of fractures, the distal segment seems to be the most common localization for pediatric fractures, followed by diaphyseal fractures. High proportion in distal segment forearm fractures consists of growth plate injuries, that correspond to results of other authors (2,11).

Diagnosis of forearm bone fractures is based on detailed history about circumstances of injury, clinical evaluation of the injured segment and X-rays usually in 2 standard views – AP and LL. If the fracture line is clearly seen, no further investigation is necessary. In case of doubt axial and oblique X-ray views or a CT-scan of injured region can be useful. Ultrasonography or MRI can be used for evaluation of the soft tissue – ligaments, tendons etc. (3,9).

If trauma history and clinical signs of possible fracture are present, yet it cannot be clearly seen on X-rays, especially if involving the growth plate region – one should always keep in mind a possibility of undislocated fracture. These cases substantiate plaster immobilization followed by control X-ray after 7-10 days in which periosteal reaction or other late X-ray signs, showing initial consolidation and confirming diagnosis of fracture, can be seen. Most control X-rays should be performed without plaster as it can contribute to visual artifacts, compromising proper evaluation of them. After confirmation of fracture, immobilization must be restored and kept on the hand for the whole period necessary for full consolidation of the bone fragments (6,10).

All the patients, involved in this survey, underwent treatment on out-patient or in-patient basis. Out-patients were treated by plaster immobilization for undislocated fractures or closed reduction, followed by plaster for dislocated fractures. In-patients consist of two groups. The biggest group is that of surgically treated patients by K-wire osteosynthesis or elastic stable intramedullary nailing (ESIN) with *Nancy* nails. These procedures were performed in percutaneous technique in most cases, only small part of children required open reduction due to anatomically difficult variations of fractures or intraoperative difficulties. The other – smaller group was that of conservatively treated in-patients. This group consisted mainly of younger children, who required general anesthesia for closed reduction.

It is worth mentioning that younger children were mostly treated by conservative means, the proportion of surgically treated children increase with the patient age - from 20.9 % (in 7-9 year patient group), reaching 40.7 % in 13-15 year old patient group. Comparing these parameters across the five year period, we can see overall decrease of operative activity in younger group from 53.4 % in 2007 to 18.3% in 2011 ($p<0.001$; $df=1$; $\chi^2=16.431$), remaining high in 13-15 year old patients (35.2 % in 2007 and 31 % in 2011; $p > .05$). This means that intramedullary stabilization has permanently

become the method of choice for adolescents with midshaft and some specific forearm fractures (radial neck, *Monteggia* fractures-luxations etc.), as it increases stability of bone fractures, reduces immobilization period and complications due to prolonged plaster wearing - joint stiffness and reduction in ROM (6,10). The type and localization of each fracture, along with the age of patient, were the key factors for choosing the right treatment method. Younger children have more capability of remodelation, that allow conservative treatment, immobilizing even fractures with significant displacement, yet achieving almost as good results as after surgical treatment. If surgical treatment is on the issue, one knows that K-wires are excellent for bone end fractures (proximal or distal metaphyses), reserving ESIN with *Nancy* nails for most of unstable diaphyseal fractures, especially in older adolescents. Stable diaphyseal fractures sometimes do not require surgical treatment in any age, so proper immobilization with or without closed reduction, can be used, depending on the amount of dislocation.

Stay length at hospital is rather low for both – K-wire and ESIN patients, ranging from 1-12 days with mean values of 1.99 and 2.38 days, respectively. Prolonged stay at hospital (> 1 week) in 2.9 % of patients after K-wire osteosynthesis and 2.1 % of patients treated by ESIN can be explained by complication occurrence – wound infection, massive hematomas, or pain syndrome, compromising primary healing process.

CONCLUSIONS

1. Forearm fractures in children have a significant gender diversity (M : F ratio is 4,2 : 1).
2. Peak incidence group is 13 years old adolescents of both genders.
3. Seasonality and season-specific injury patterns are typical for pediatric forearm fractures.
4. The most common anatomic localization is the distal segment of forearm bones.
5. Younger children (7–9 years) are mainly treated by conservative methods, while methods of choice for treatment of forearm fractures in adolescents (13–15 years) are operative.
6. Surgical treatment of fractures do not significantly increase stay length at hospital.

Conflict of interest: None

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Address:
Janis Upenieks
Department of Pediatric Surgery
Childrens`s University Hospital
Vienibas gatve 45,
LV – 1004, Riga, Latvia
E-mail: Janis.Upenieks@rsu.lv