

## **Radiographic patterns evaluation of bone fractures in three paediatric hospitals**

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## Aims and objectives

Bone formation, in humans, begins during the first weeks of intrauterine life and ends only, definitely, at the end of adolescence. Initially, the skeleton is mostly cartilage. Hyaline cartilage is the one most associated with bone development.<sup>1,2</sup> As the bone is formed, and increasing in length, the cartilage disappears and is replaced by bone tissue.<sup>1</sup>

Long bones of the upper and lower limbs in the first years of life are proportionally equal in length. However, from the age of two, their length begins to differentiate and increases due to the existence of growth cartilages.

It is in these zones that the formation of a new bone begins.<sup>2</sup>

The paediatric bone has growth cartilages, greater elasticity and porosity, and the *periosteum* is more resistant compared to the adult bone. These characteristics, which allow differentiation between the two types of bone, are important for determining the type of lesion, treatment and prognosis in case of fracture.<sup>1,3</sup>

Due the fact of paediatric bone present different characteristics of the adult, is possible to determine some advantages such as, a faster recovery and a greater capacity of bone remodeling after the occurrence of the fracture. However, it also presents some disadvantages of which may be highlighted the delay in the growing that may cause deformation and severe deficits.<sup>4</sup>

During childhood, the occurrence of bone lesions is frequent, and is often considered a consequence of physical activity. Studies show that about 20% to 25% of children suffer on average one lesion per year and, from these lesions, about 10-25% cause a fracture.<sup>5</sup>

Fractures in the paediatric population are common, with about one third of children suffering at least one fracture before the age of 17.<sup>5</sup>

In children between the ages of 2 and 16, the forearm is the bone structure with the highest incidence of fractures, that is, this segment of the upper limb corresponds to about 45% of all paediatric fractures. Of these, approximately 75% affect the distal third, and 80% occur in both bone structures (radius and ulna).

The incidence of forearm fractures has increased over time while fractures of the femur, leg, hand and foot have been decreasing. The occurrence of fractures in the skull, pelvis and spine are rare.<sup>5-7</sup>

Any classification has the overall objective of producing a common lexicon and a standard form of evaluation.

For each fracture there are several scales of classification. According to Müller et al. (1987), any classification system should consider the type and severity of the fracture as the basis for treatment and guide the evaluation.<sup>8-9</sup>

In order to obtain a better definition and specification of each clinical case, several sub-classifications were created according to the type of fracture. These types of fractures are referred to as complete fractures, incomplete, comminute, green branches, transverse, oblique and spiral, among others.<sup>10</sup>

With the aim to develop specific preventive programs, this study follows an epidemiologic assessment to characterize, through plain x-ray, the most common signs, or patterns, of bone fractures from paediatric population according Muller-AO lexicon.<sup>11-13</sup>

The bone fractures considered occurred in paediatric population (range 2-16 years old) graded on 1-type of fracture; 2-bone involved and 3-fracture's frequency by age group.

## Methods and materials

An exploratory-descriptive study of the observational and retrospective type was carried out. The research unit was the bone fractures in children of both female and male gender. The age group corresponded to ages ranging from pre-school through adolescence (2-16 years). The choice of this group was based on the activities to which the children are daily exposed.

The images included were collected from the databases of three paediatric hospitals in the district of Lisbon, with emergency unit. Letters were sent asking for the collaboration of the hospitals, describing the purpose of the study and ensuring the confidentiality of the hospital's identity and patients.

In total, 100 x-ray images were analysed, constituting a non-random sample according to inclusion criteria: the age range (from 2 to 16 years), the presence of bone fracture, an examination performed in the urban district and an examination by conventional radiology. Exclusion criteria were: children with ages above and / or below the age group determined and the mechanism of fracture. A visual analysis of the radiographic images was made according to a qualitative evaluation where it was intended to verify the fractured bone structure.

For the correct analysis of bone fractures, in the vast majority of cases, two projections were used, being antero-posterior and profile projections providing, each one, different and important information for the study. The anteroposterior projection allows the evaluation of the type of fracture trait as well as, in case of deviation, if it occurred to the medial or lateral side. On the other hand, the incidence in profile allows information about the anterior and posterior sides of the bone and, in case of deviation, the type of fracture trait. The use of two projections allowed a better and more correct analysis of the bone fractures giving important information for later characterization.

There were cases where only one projection was made.

When the fracture involved a long bone, the separation between the proximal or distal epiphysis, metaphysis and diaphysis was made.<sup>12</sup>

After identification of the bone and region fractured, bone fracture was classified according to the classification of Müller AO<sup>11-13</sup> as well as classification of the type of fracture.

The AO group proposed a systematic classification that covers all long bone lesions in children.<sup>11-14</sup>

The data were organized and categorized statistically through Microsoft Excel. The results were presented in descriptive form (text and tables) and graphs (graphs).

## Results

Were analyzed 100 images belonging to children, aged between 2 and 16 years old, of both genders.

### **Bone fractures by gender and anatomy**

The radiographic images stratification was made considering the anatomical structures and gender of the child. The purpose of this division was to understand the structure of a higher incidence of fractures.

In this study, there was a higher occurrence of fractures in the male gender, 60%, compared to the female gender, corresponding to 40%.

Within the male gender, it was verified that, 29% of the fractures are in the forearm, being the structure that presents a higher percentage. In the female gender, as in the male, the percentage of forearm fractures is also higher than the other anatomical structures, taking 19%. In figures 1 and 2, the examples are showing. The following structure is the clavicle occurring about 8% of fractures in boys and 5% in girls. (Graph 1)

### **Bone fractures according to age**

Was verified the propensity for the occurrence of fractures and the forearm is the one that presents a higher incidence rate in the three age groups.

In the 2-6 range, the anatomical structure that presents the second highest percentage corresponds to the arm (umerus) with 6%, and after, the clavicle with 4%.

The ages of 7 to 11 correspond to the age range with the highest incidence of forearm fractures. The structures that follow the forearm are the hand, the clavicle and the leg (tibia and fibula), all of which have a percentage of 4%. (Figure 3)

Also in this age group (7-11), the thigh (femur) is the bone structure that suffers the least number of fractures presenting a value of zero.

From 12 to 16 the anatomical structures that follow the forearm correspond to the clavicle and the foot, both of which present a percentage of 5%. At 0% level, the thigh (femur) is found as seen in the 7-11 age range. (Figure 6)

### **Long bone fractures according to the anatomical segment**

In the long bones, arm, forearm and leg, was analysed the region where the fracture occurred. That is, the six distinct regions in this type of bone were considered: proximal

epiphysis, proximal metaphysis, proximal diaphysis, distal diaphysis, distal metaphysis, and distal epiphysis.<sup>12</sup>

In the arm, the region with high number of fractures corresponds to the distal epiphysis (56%). From this segment follows the proximal diaphysis with 22%. To the forearm about 81% occur in the region of the distal diaphysis, being the region where there is a greater percentage. The second region with the highest incidence of fracture is the distal metaphysis with 9% and, after this, the proximal diaphysis with a percentage of 6%. The lowest percentage is in the distal epiphysis (0%). In the leg, 73% of the fractures occur in the distal diaphysis, where it was found to be more common. To this region the proximal diaphysis is followed by a percentage of 18% and after this the distal metaphysis with 9%. The remaining three regions have a percentage of 0%.

An evaluation over the region of high occurrence of bone fractures were made. It was verified that, in the arm (humerus), there are a total of 9 fractures and, 5 (56%) corresponded to the region of distal epiphysis, region with higher incidence. The distal epiphysis follows the proximal diaphysis with 22%.

In the forearm the region, with the highest percentage is the distal diaphysis and with the lowest percentage, the distal epiphysis. In the clavicle the age group with the highest incidence is 12 to 16.

In the hand, the age group with the highest incidence of fractures is 7-11 with a total of 4 fractures. From 2 to 6, the total number of fractures is 2, being the age group with the least incidence.

The lower limb presents a total of 21 fractures, 9 of which occur in ages between 12 and 16. In this set of ages, the foot (phalanges and metatarsals) corresponds to the anatomical zone that presents a superior number of fractures. However, the leg, in the region of the distal diaphysis, presents an incidence rate very close to the foot.

The 7-11 age range is the second with a higher incidence rate in the same anatomical structures (foot and leg).

### **Classification of bone fractures**

The classification of Müller AO<sup>11</sup> was the basis of this study for the classification of fractures in long bones. Thus, for each long bone reference numbers are used, which correspond to the different regions of these structures. The long bones are divided into proximal, diaphysis and distal regions and are assigned numbers respectively 1, 2 and 3. These are further divided into A, B and C taking into account the severity of the fracture being A the least severe and the most severe C.<sup>15</sup>

The arm (humerus) corresponds to the number 1 and its region corresponds to the numbers 11, 12 and 13 respectively. According to the data obtained, it was verified that the most common region refers to the number 13, that is, the distal end and the letter A. As for the fracture type, the most verified corresponds to the complete type. By grouping of the classifications, taking into account the age range of 2-6, no conclusions were obtained regarding the most common type of fracture, as there are equal numbers of complete, incomplete, oblique and transverse fractures.

The number 2 belongs to the forearm (radius and ulna) and its regions take the numbers 21, 22 and 23. In this anatomical structure, the distal third of the diaphysis corresponds to the region that presents a greater occurrence of fractures. In it, the most common types of fractures refer to incomplete and transverse types in the age range of [7-11]. The type of green branch fracture corresponds to the second type of fracture most visualized for the same set of ages. Considering the Müller AO classification it was found that the most frequent is the 22-A2 that corresponds to the distal end of the diaphysis in the forearm. The latter is found to be larger in the age group [7-11].

On fracture classifications for the hand, it was found that the most common types of fractures correspond to the complete and oblique types.

For the other anatomical structure, the clavicle, the most common types of fractures were the complete type (most common at ages 7 to 11) and the transversal type (equally common in the three age groups).

The thigh (femur) corresponds to number 3 and its regions 31, 32 and 33. The most common classification in this structure is the number 32 (refers to the diaphysis and A).

Regarding type of fracture in this region, no conclusion is obtained because of the small number of fractures in this anatomical zone. Number 4 belongs to the leg (tibia and fibula) and its regions take the numbers 41, 42, 43 and 44, the latter referring to the malleolus.

It was found that the region with the highest incidence of fracture corresponds to the distal third of the diaphysis. In this region the most common types of fractures are full and transverse types. The classification 42-A2 and 42-A3 are the most verified in this anatomical region taking into account the Müller AO classification. In the most distal anatomical structure, the foot, it was verified that the fractures most incident are the complete and oblique types that occurs most frequently in the age group of 12 to 16.

Images for this section:



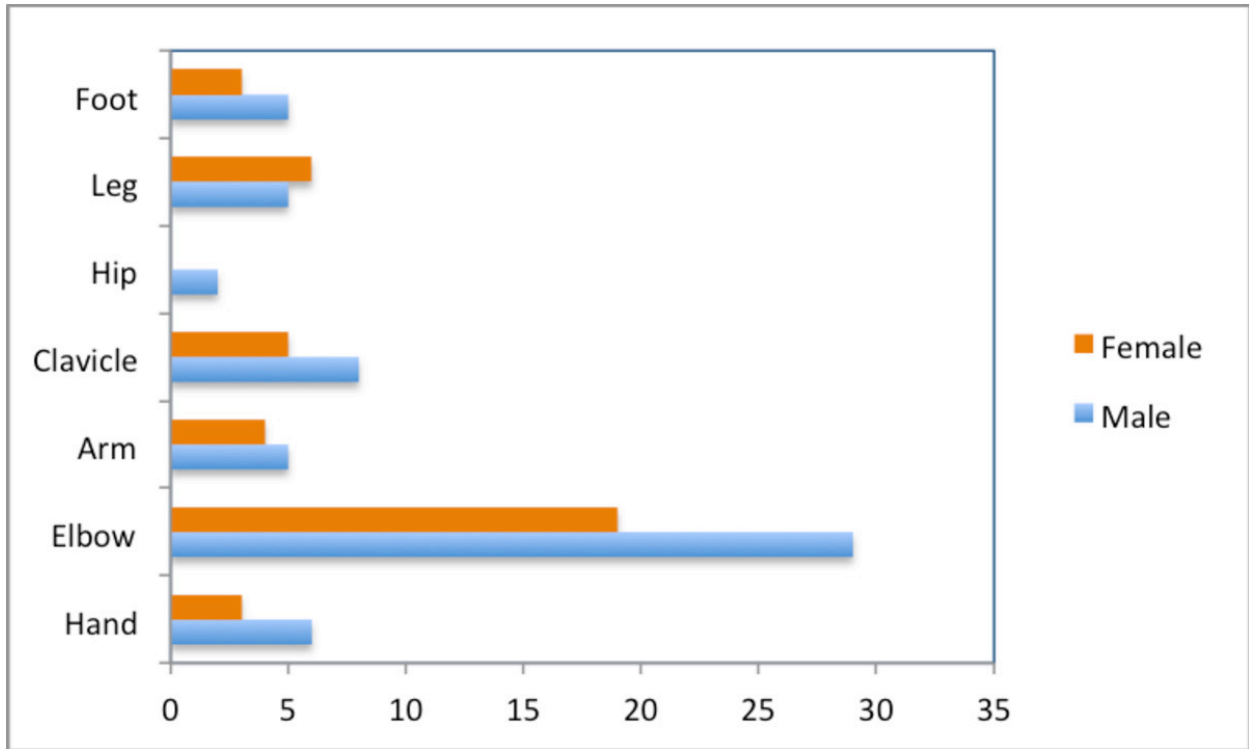
**Fig. 1:** 23-A2 fracture.

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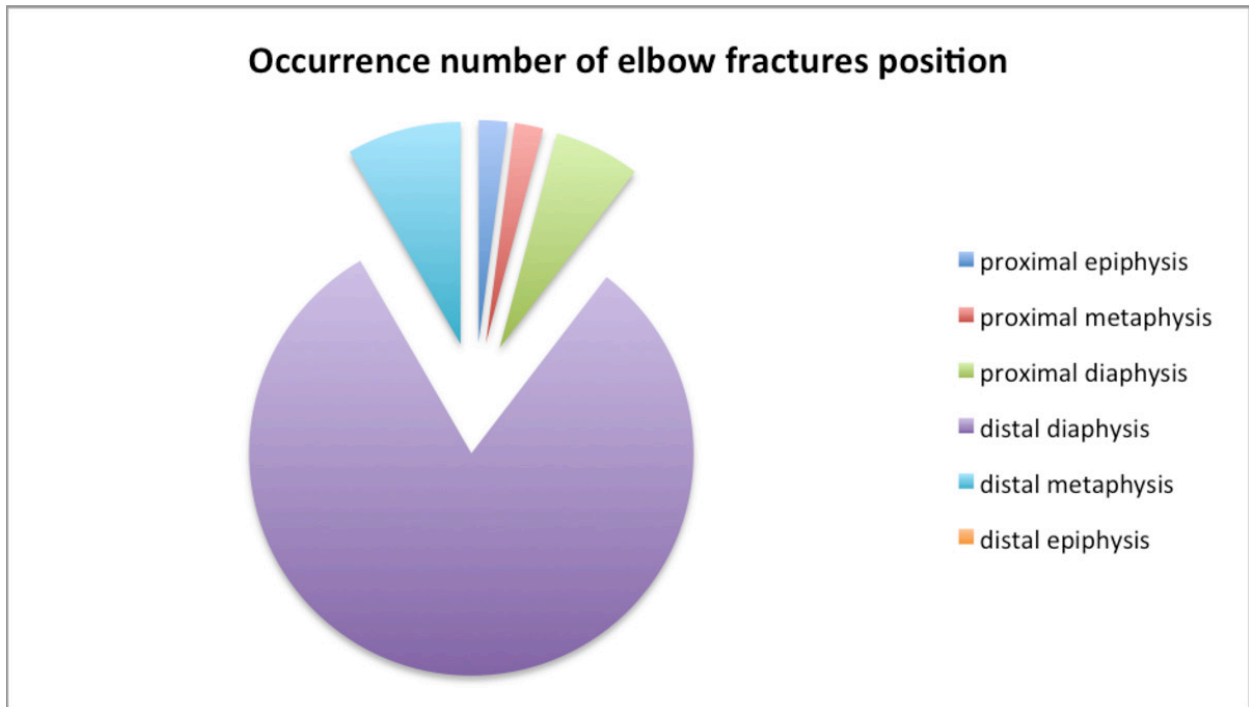
**Fig. 2:** 22-B3; Diaphysis fracture of radius and ulna

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**Fig. 3:** Graph 1 - Bone fractures by structure and gender.

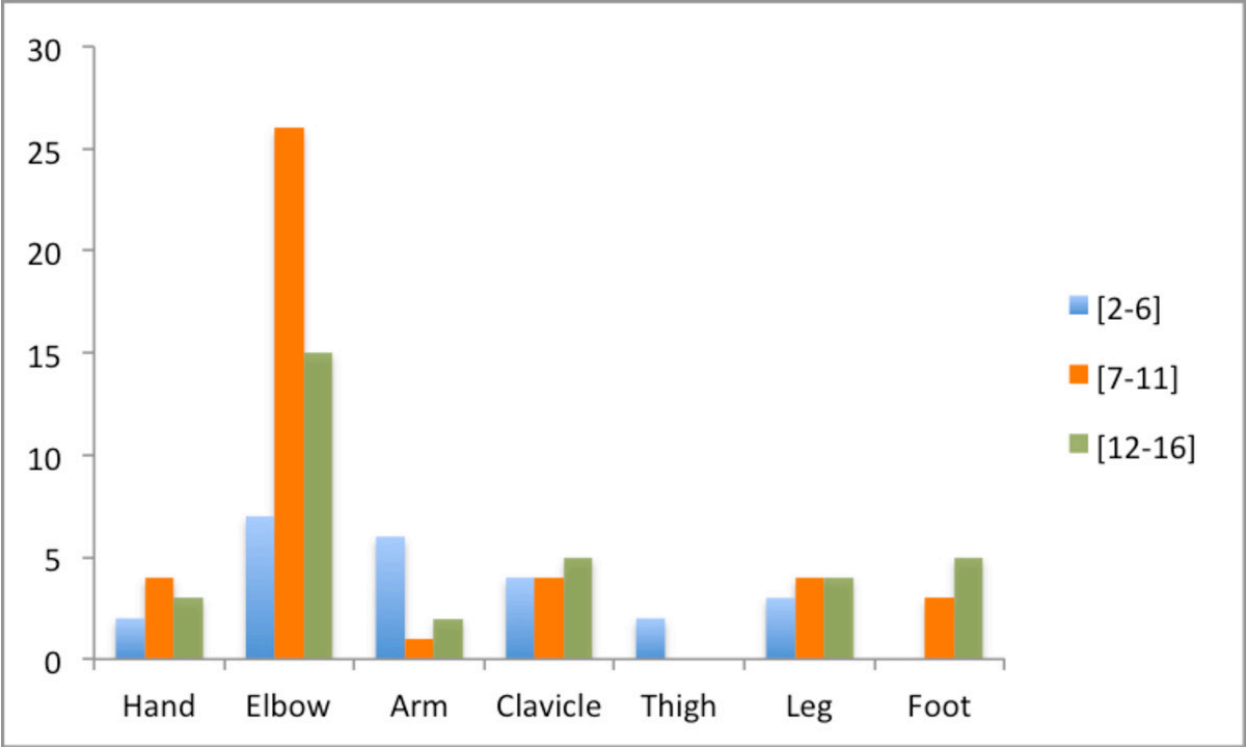
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**Fig. 4:** Graph 2 - Occurrence number of the elbow fractures.png



**Fig. 5:** 42-A2; Tibial oblique fracture.



**Fig. 6:** Graph 3 - Incidence of fractures by bone and age range.

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## Conclusion

It was concluded that the forearm is the anatomical structure that suffers a higher incidence of fractures (48%), of which 29% correspond to the male gender and 19% to the female gender. In paediatrics, the ages of 7 to 11 correspond to the age group where the occurrence of fractures is higher (26%).

In the forearm, the region most affected refers to the distal diaphysis where the percentage is 83%. The classification, according to Müller, is more frequent in 22-A2 corresponding to the distal diaphysis of the forearm. The region where there was no fracture concerns the distal epiphysis with an incidence of 0%. The incidence of fracture is most reduced in the thigh (femur). Only two cases aged 2 to 6 were included in the sample. In these two cases, a percentage of 2% of fractures occurred in the male gender and in this anatomical structure. One limitation of this study is, to be a retrospective study and it was not possible to evaluate some data that would help to interpret the results.

In a future perspective we intend to produce useful recommendations for the prevention of the occurrence of fractures in schools, places of physical activity practices and domiciliary contexts.

We can, however, recommend that in secondary schools, in this city, the floor should be non-slip, avoid stairs or barriers and promote day-to-day preventive practices such as wearing non-slip shoes and low-heeled shoes.

In sports it may be recommended the use of protective equipment with a reinforced tarpaulin, on the forearms and legs, developed by orthopaedics.

An observational study may help to better define the mechanism and context of fracture's occurrence.

## Personal information

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