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Review

Epidemiological and characteristic features of childhood fractures

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ABSTRACT

Childhood fractures are becoming an important public health problem around the world due to the increasing incidence. Fractures in children are more than twice as common as in adults. The incidence of pediatric fractures is affected by many factors such as the age and sex of the child and seasonal and sociocultural factors. One of the leading causes of childhood fractures is simple falls and approximately 50% of childhood fractures were reported to occur after a simple fall. On the other hand, childhood fractures are also very common at home or school and after traffic accidents. A child's bone has a lower density and more porous structure than an adult's bone. The periosteum of bone in children is thicker and stimulates new bone formation more strongly. As a result, new bone formation is completed in less time. The remodeling potential of a child's bone is also an advantage that differentiates pediatric treatment from adult treatment. Complications like delayed union, nonunion, re-fracture, myositis ossificans, and joint stiffness are also very rare in children. But physeal damage may cause serious complications like growth arrest or angular deformities. Despite the advancement in technology and increasing options for minimally invasive surgeries, closed reduction and conservative treatment methods are still the mainstay of treatment in children.

Keywords: Childhood fractures, remodeling, torus fracture, conservative treatment

INTRODUCTION

Childhood fractures are becoming an important public health problem around the world due to increasing incidence. Fractures in children are approximately more than twice as common as in adults. One in three children has a fracture at least once up to adolescence and the incidence of childhood fractures is affected by many factors such as the age and gender of the child and seasonal and sociocultural factors.[1,2]

Sex

While there is no difference in terms of sex in the first two years of life, boys are more prone to fractures after the age of two. It is reported that under the age of sixteen, the cumulative risk of a fracture is 27 % in girls and 42 % in boys. The increase in fractures in boys is due to several factors such as the use of sports equipment, cycling, or other sporting activities that are more common in boys.[3,4]

Trauma

One of the most common causes of childhood fractures is simple falls. Approximately 50 % of fractures in children are reported to occur after a simple fall.[3-5] On the other hand, childhood fractures are also very common at home or in the school environment and after traffic accidents. These accidental injuries can be reduced by various measures. Another important thing to keep in mind is that child abuse may cause childhood fractures. Long bone shaft fractures, burns, ecchymoses at different stages in various parts of the body, and late admission to health institutions should alert the physician to child abuse. Fractures without trauma or

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with minor trauma may be related to the pathology of the bone such as metabolic bone diseases, tumoral lesions, or infection.[6]

Anatomical Location

The most common fracture in children is at the distal end of the radius. It accounts for 15.3% to 30.4% of all fractures.[2,3,7] The reason for this localization is due to transient osteopenia during the rapid growth period of children.[8]

The most common fracture sites after the distal radius are the distal humerus, clavicle, tibia, and femur respectively.[3]

Social Factors

The incidence of childhood fractures is also affected by geographical and sociocultural conditions. According to the literature, children living in a low sociocultural environment are more affected by trauma than children living in a high sociocultural environment.[9] Similarly, there is also a difference in fracture incidence between the children living in high-rise apartments in cities and those living in rural areas.[3] Also, children with problematic parents, such as alcoholics, have a higher fracture incidence.[4]

Seasonal Factors

The incidence of childhood fractures is significantly affected by seasonal differences. Outdoor activities for children increase in sunny weather and hot seasons, and traumas and fractures in children become more common. According to Masterson et al., the number of fracture cases is 2.5 times higher in summer months than in winter months.[10] Fracture incidences also increase especially in the afternoon between two and three o'clock in the day.[10,11]

Biological Properties and Remodulation

As in adults, fracture healing in children is composed of three stages: inflammation, repair, and remodeling.[12] In the acute stage of inflammation, a fibrin-rich hematoma starts to form a collagen skeleton after vascular damage. Hematoma also contains cellular components such as osteoblasts and chondroblasts that will promote new bone formation. At the repair stage, the hematoma surrounded by fibrovascular tissue begins enchondral and intramembranous ossification and a temporary callus is formed.

In some fractures, the remodeling stage can take years. During this phase, new bone formation is completed. The main factors affecting the remodeling capacity are age, the proximity of the deformity to the physis, and the remaining growth capacity of the physis.[13] According to Wolf's law, the bone remodels according to the stress applied to it and the remodeling capacity is much greater if the deformity is in the same axis of the movement plan.[14]

Excessive elongation (overgrowth) at the remodeling stage of childhood fractures is usually encountered in the diaphysis of long bones, most commonly in the femoral diaphysis, and may be problematic. However, a difference of up to 2 cm as a result of excessive elongation is usually compensated.[15]

Local Features of Remodeling

Metaphyseal bone has a high capacity for remodeling. Spongious bone produced by the adjacent physis displaces the diaphysis with structurally stronger bone. This area has a high osteogenic capacity and is also rich in vascular activity.

Bone formation in the diaphysis is less active compared to other parts of the bone and there is a balance between endosteal bone reabsorption in the medullary canal and new bone formation. As a result, the remodeling capacity of diaphyseal bone remains limited due to the rigidity and relatively avascular structure of bone in this region.[15,16]

How Does Remodeling Happen?

Angulation in the physis: Until the skeletal development is complete, 75-80% of the angular remodeling is performed by the physis.[16] The physis adjacent to the fracture grows asymmetrically and perpendicular to the forces acting on it.[17,18] The concave side grows rapidly to regenerate the long axis of the bone. After the physis is aligned, symmetrical growth begins again.

Angulation in the diaphysis: There is an increased pressure that stimulates bone formation on the concave side of the diaphysis.[19] The convex side, on the other hand, stimulates bone resorption under the effect of distraction force. Only 20% of the angular remodeling takes place in the diaphysis.

Overgrowth

Although post-fracture bony overgrowth is known to be caused by increased blood flow to growth cartilage in the proximal bone segment, its relationship with age, fracture segment, and fracture position has not been demonstrated.[19]

Differences Between Child and Adult Fractures

A child's bone has a lower density and more porous structure than an adult's bone.[20] The periosteum of bone in children is thicker compared to adults and stimulates new bone formation more strongly by covering the fracture hematoma. More vascular structure and high osteoblastic capacity of bones in children cause the inflammatory response to be stronger. Thus, bone development is excessive and may lead to overgrowth. As a result, new bone formation is completed in less time compared to adults.[21,22] Complications such as delayed union, non-union, re-fracture, myositis ossificans, and joint stiffness are also very rare in children. On the other hand, physeal damage may cause serious complications such as growth arrest or angular deformities.

Torus Fractures

Torus is derived from the Latin word "tori", which means swelling or protrusion. The torus fracture is located at the metaphysis-diaphysis junction with intact periosteum and a single cortex fracture.[23] It is a wide spectrum, ranging from a mild deformity to a complete fracture of the cortex (Figure 1). Torus fracture treatment is usually conservative.[23,24] Fracture healing is rapid and three to four weeks of rigid immobilization is usually sufficient for pain relief.

Plastic Deformation

The size and shape of the bone may change under the influence of loads applied to the body. There are two types of deformation processes: reversible (elastic) and residual (plastic) deformation. In elastic deformation, the bone returns to its original shape when the load on the bone is removed. On the other hand, plastic deformation is permanent, and it cannot return to its original shape even if the load over the bone is removed. Thus, plastic deformation is non-recyclable and permanent.

Figure 1. A-P and lateral radiograms of torus fracture

Immature bone is not resistant to bending forces, but before the bone fractures, it absorbs a lot of energy that leads to plastic deformation.[25] Plastic deformation is generally seen in the forearm bones. Although there is a high capacity for major remodeling in cases of plastic deformation, some authors suggest reduction of the remodelling capacity in children older than four years and in deformities with more than 20° angulation.[26]

Greenstick Fractures

In the greenstick fracture, there is a plastic deformation with an intact periosteum in the cortex at the compressive site and a complete fracture in the cortex at the traction site (Figure 2). Thick periosteum is the main determinant of the development of greenstick fracture and this type of fracture is specific to the childhood period. Correction of the deformity is usually recommended in the treatment of greenstick fractures, although this topic has been discussed in the literature.[27]

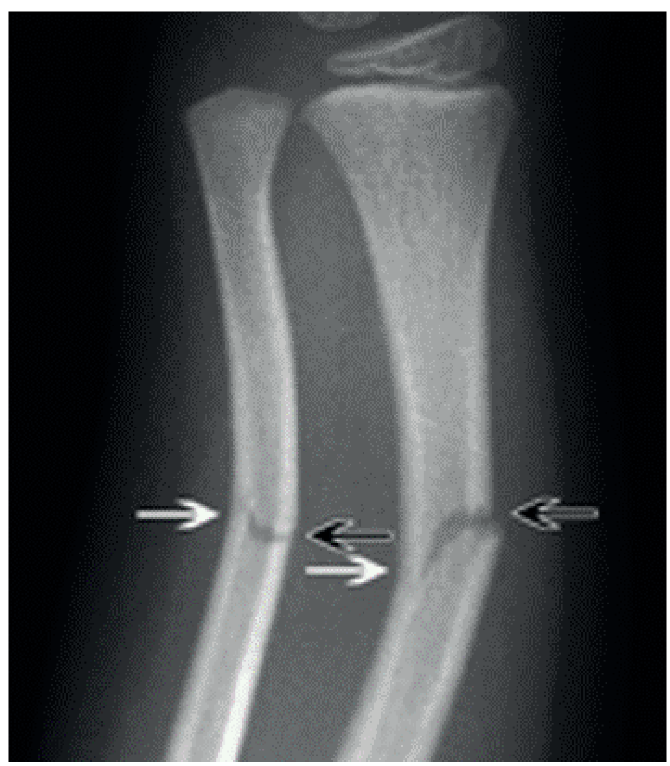

Figure 2. A-P radiogram of greenstick fracture

Treatment

Despite the advancement in technology and increasing options for minimally invasive surgery, closed reduction and conservative treatment methods, including casting, are still the mainstay of treatment for most of pediatric fractures. The incidence of childhood fractures that require surgery is only 16% of pediatric fractures.[7]

Conclusion

Childhood fractures are an important public health problem around the world due to the increasing incidence. Despite the high incidence of fractures in children, complications are very rare compared to adult fractures due to different properties of child bone such as the high potential of osteogenesis and remodeling capacity. Features that distinguish the child skeleton from the adult skeleton are having a thick periosteum and growth potential by the presence of physis. In this way, the healing time of fractures in children is shorter and they have a high remodeling potential.

On the other hand, prevention should be the mainstay of health strategy. Strict precautions should be taken in the environments where the children spend a lot of time, such as schools and playgrounds. All the children should be educated about traffic rules to minimize the risk of traffic accidents, starting from kindergarten through all grades..

Author contribution

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Conflict of interest

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