

OVERVIEW OF PAEDIATRIC BONE AND JOINT : A SYSTEMATIC REVIEW

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Abstract

Mercur Rang well observed, "Children are not young adults." Children and adults have different skeleton physiology and morphology. Depending on bone growth and remodelling, skeletal conditions should be treated differently. Because bone growth and modelling differ. Children's bones are more flexible than those of adults, so they can move more before they break. People often use the word "plastic deformation" to describe a condition in which the bone changes shape but does not break. Sometimes, the bone might just bend, causing a type of break called a torus fracture. Adults don't have these patterns because their bones are much less flexible and resistant to bending at angles than those of a growing skeleton. When two bones touch, they make a joint. Groups of joints can be made based on how they look or how they work. Functional classification is based on how much movement is allowed, while histological classification is based on the type of connective tissue that makes up most of the body. The mesoderm gives rise to joints, which are made up of bones and connective tissue. Bones can form either directly or indirectly through endochondral ossification or intramembranous ossification. The blood supply and nerve supply to each joint follow different rhythms.

Keyword: *Anatomy; Bone; Cartilage; Joint*

INTRODUCTION

As Mercer Rang has so astutely stated, "Children are not young adults." In terms of the physiology and morphology of the skeleton, there are substantial differences between children and adults. Conditions that involve the skeleton should be regarded and managed differently depending on the individual's bone growth and modelling, as well as their remodelling. This is because of the differences in bone growth and modelling.¹ There are significant differences in the skeletal anatomy of adults and that of children and toddlers. The following are some of the most important distinctions between the two.^{2,3}

The bones of children are more flexible than adult bones, thus they may bend further before breaking. Plastic deformation is a term commonly used to describe a state in which the bone undergoes distortion but does not fracture. On other occasions, the bone could simply buckle, resulting in a type of fracture known as a torus fracture. These patterns are not observed in adults because an adult's bones have substantially less resistance and suppleness to angular deformation than a developing skeleton does.^{4,5}

A joint is where two bones touch each other. Joints can be put into groups based on how they look or how they work. Histological classification is based on the type of connective tissue that makes up most of the body, while functional classification is based on how much movement is allowed.⁶ Joints, which consist of bones and connective tissue, derive embryologically from mesoderm. Bones develop either directly via intramembranous ossification or tangentially via endochondral ossification. There are distinct patterns in the vascular supply and innervation of each joint.⁷ This article discusses the anatomy of children's bones and joints.

GROSS ANATOMY

There are significant differences in the skeletal anatomy of adults and that of children and toddlers, as can be seen in the photographs below. The following are some of the most important distinctions between the two. Bone in children and toddlers is more porous than bone in adults, and the haversian canals in this type of bone are larger. The bones of a youngster have greater elasticity than those of an adult. Plasticity and elasticity are two concepts that are essential to understand in this context.^{2,3}

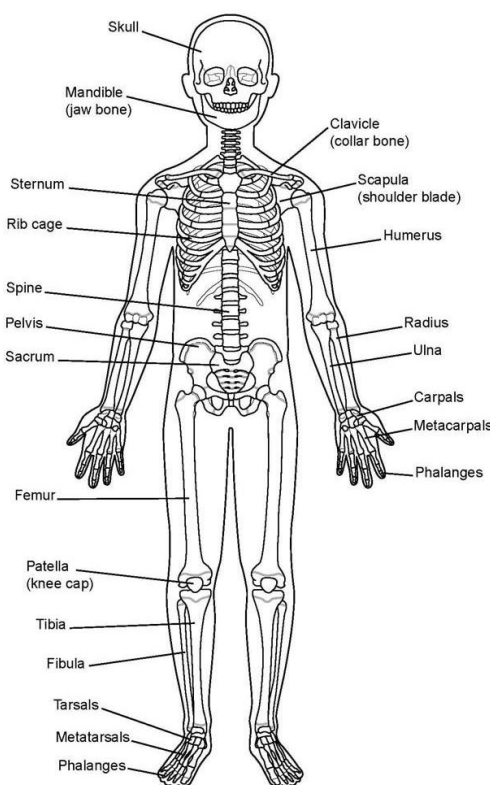


Figure 1. Child skeletal system

The bones of children are more flexible than adult bones, thus they may bend further before breaking. Plastic deformation is a term commonly used to describe a state in which the bone undergoes distortion but does not fracture. On other occasions, the bone could simply buckle, resulting in a type of fracture known as a torus fracture. These patterns are not observed in adults because an adult's bones have substantially less resistance and suppleness to angular deformation than a developing skeleton does.^{4,5}

The periosteal sleeve, which acts as a constraint to displacement, is significantly thicker in youngsters than it is in adults (see the image below for an example). The term "greenstick fracture" refers to a fracture in which there is no

displacement of the cortices and occurs as a result of angular deformation of the bone in a youngster. The thick periosteal sleeve is essential for the remodelling of the skeletal framework in children. Subperiosteal resection of a child's bone demonstrates the possibility for regeneration connected with the periosteum.^{4,5}

Eventually, the tubular bone recovers inside the periosteal sleeve after the procedure is performed. Therefore, the child's bone possesses the inherent capacity to mend itself naturally. An essential component of the developing skeleton is known as the epiphysis. A secondary ossification centre can be found there. When discussing these components of the developing skeleton, Mercer Rang places a strong emphasis on the significance of employing correct nomenclature.^{4,5}

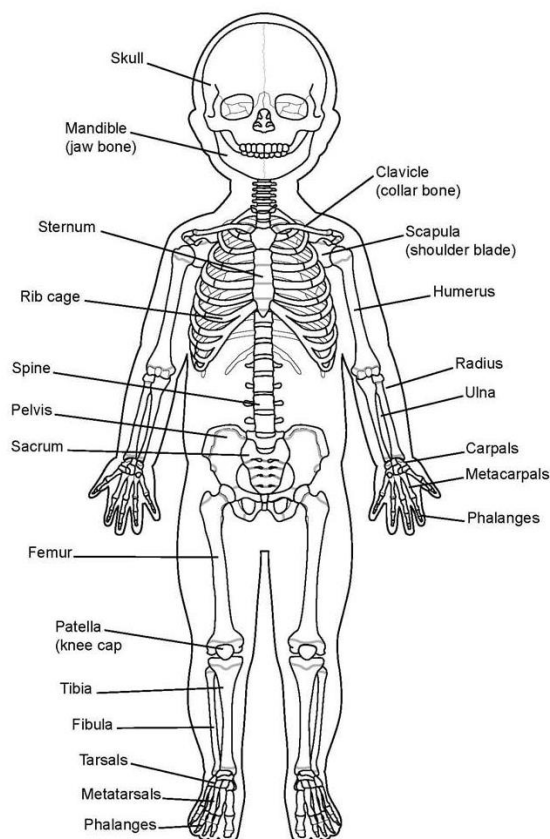


Figure 2. Toddler skeletal system

The physis is the cartilaginous structure that lies on top of the growth plate, which is known as the epiphysis. The growth plate is a structure that looks like a disc and is located at the very end of the metaphysis. When compared to the response of the adult skeleton to trauma and infection, the response of the growing skeleton is unique. Conditions that have an effect on the physis and the growth disruptions that may emerge from such conditions can cause difficult management challenges.^{4,5}

There are three main types of joints in the body: joints that are fixed, or don't move, like the seams between the bones that make up the skull; joints that move only a little, like the ones in the spine; and joints that move a lot, like the ones in the knee, elbow, and shoulder. In the joints that can't move, the bones have joined together, or fused, after being separate when the person was young. This joining is called synarthrosis (in Greek, syn means "together"). The six bones in a baby's head can move closer together when they are first born. This makes it easy for the baby to get through the birth canal. Later, the bones grow closer together until the spaces between them are filled.^{1,8}

At the bottom of the spine, five bones slowly join together to form the sacrum, which is a strong connection for the hips. This is another example of a stable joint. Around a squeezed jelly-like disc between the vertebrae, the joints of the spine allow for a slight tilt in any direction. Amphiarthrosis is the second type of joint. The Greek word amphi means "both sides" or "around." When the back bends, each joint only moves a little bit, but the overall result is like a big movement. Along the front and back of the spine, long straps of tough, flexible ligaments hold the joints and bones together and limit how much they can move.^{1,8}

Because the bone ends are separated, the arms, legs, hands, feet, hips, and shoulders can move freely. Diarthrodial (Greek: "separate") describes this joint. Joint cavities separate bones. The sac-like joint capsule covers the bone ends. The hollow often forms bursas. Synovial membrane covers capsule. It secretes a fluid that lubricates bone ends and nourishes joints. Movement spreads fluid, thus joints must move regularly to stay healthy. Synovial joints are

diarthrodial joints. Smooth bone ends aid movement. Cartilage is softer than bone and springier. Tendons connect muscles to joints, whereas ligaments bandage them.^{1,8}

Opposing muscles surround joints. One muscle shortens while the other extends, bending the joint. Movement classifies diarthrodial joints. Finger and knee joints move like door hinges. Hinge joints. The saddle-shaped thumb-hand joint is exceptionally flexible. The thumb can move side-to-side and front-to-back at this joint. Palm-facing forearms can rotate at the elbow. The elbow hinges and pivots. A pure pivot joint between the top vertebrae allows the head to turn. Shoulder and hip joints are flexible. Because one bone's head is spherical and fits into the other's cuplike depression, they're called ball-and-socket joints.^{1,8}

MICROSCOPIC

The epiphysis is the part of the long bone that is important for growth, as it is this part that causes the long bones to get longer as we get older. One of the following two mechanisms leads to the formation of bones: This process, known as endochondral ossification, includes the production of bone from a cartilaginous anlage. Endochondral ossification is principally responsible for the formation of long bones. Ossification of flat bones and skull bones typically occurs as a result of this process. Membranous ossification is characterised by the absence of the cartilaginous phase in most cases.⁹ The process of bone creation is reflected histologically in the physis as a series of distinct layers that make up the structure. Resting cartilage cells make up the basal layer of the layer structure.⁹ These multiply as a result of the action of growth factors in the zone of multiplication, which results in the appearance of rounded cells. These spherical cells develop and organise themselves in rows within a cartilaginous matrix that is somewhat loose.¹⁰

This zone is invaded by blood vessels coming from the metaphysis (see the image below for an example), which lays down minerals into the matrix. Loose woven bone is then laid down in the zone of provisional calcification after this process. In the metaphysis, the mature bone is deposited for the first time. If this process is allowed to continue, it will eventually result in an increase in the length of the long bone.^{10,11}

Internally, the connection between the epiphysis and the metaphysis is made by mammillary processes, and outwardly, it is made by the robust, fibrous periosteum. Both of these connective tissues are able to withstand displacement stresses. This connection is not rigid and allows for tiny translation forces; the structure is protected from injury as a result of the flexibility provided by this attachment. According to Rang, the epiphysis is located within the periarticular space, and he notes that pressures that are known to cause dislocation in adults are also likely to result in epiphyseal or physeal injury in children.^{10,11}

The process of remodelling an injury, such as a fracture or deformity, is one that is carried out more effectively in children than in adults. By the development of new bone in an asymmetrical apposition, a deformity can cure itself over time. The process of remodelling is affected by a variety of elements, some of which are as follows: When it comes to the potential for remodelling, the younger the age, the better. Fractures that are located further away from the physis tend to heal more poorly than those that are located closer to the physeal.^{10,11}

In relation to the axis of joint motion, malformations that are located within the axis of joint motion remodel more successfully than deformities that are located outside the axis of joint motion. The difference between rotational and nonrotational abnormalities is that rotational deformities do not remodel and fix themselves. An injury to a long bone might cause excessive development in that bone, which can effectively result in a temporary difference in the length of the limbs. The most typical illustration of this phenomenon is the promotion of new bone development at the proximal femur following a fracture in the shaft of the femur.^{10,11}

Because of this phenomena, the surgeon is able to treat these fractures with a degree of shortening even if it is predicted that they will eventually correct themselves over the course of time. In contrast, a physeal injury can cause severe development stop and lead to limb length discrepancies and abnormalities that can require years of treatment to rectify. This type of injury is more likely to occur in children. The aftermath of paediatric infections is where these impairments manifest themselves in their most debilitating forms. Hip infection caused by septic arthritis results in significant differences in limb length as well as a loss of function and stability.^{10,11}

NATURAL VARIANT OF PEDIATRIC BONE AND JOINT

As a child grows older and their body matures, their bones go through a series of modifications and adjustments that help them attain their adult shape. This process can take several years. The secondary ossification centres emerge at a variety of ages; these can be used as a pointer to bone age and true skeletal age, and as a result, they are frequently helpful in addressing forensic and medicolegal concerns.^{3,12}

The fusing of these secondary ossification centres also occurs according to a predetermined pattern, which can be utilised in the process of determining the age of the skeleton. For instance, the ossification centre of the greater trochanter does not occur until the age of 3 in girls but not until the age of 6 in males. On the other hand, the ossification centre of the smaller trochanter does not appear until the age of 6 in both girls and boys.^{3,12}

The secondary ossification centres of the pubis don't appear in girls until they are 9-11 years old, whereas guys don't get them until they are 13-16 years old. When a baby is born, the sutures in the frontal and temporal regions of the skull have not yet fused together. On the other hand, whereas the posterior fontanelle closes up rather quickly after birth, the anterior fontanelle could remain open for a considerable amount of time (for example, 12–18 months).^{3,12}



Figure 3. Bowed tibia as result of rickets

A delayed closure of this fontanelle can be noted in individuals who are malnourished or who have rickets. Craniosynostosis is characterised by the premature and stiff fusing of the skull bones, and the condition's correction calls for sophisticated operations involving multiple disciplines. The alignment of the lower limbs also shifts as the kid develops from crawling to the unsteady bipedal gait of the toddler and, finally, to the established bipedal gait of the child. Crawling is the first stage of development in which a child walks on their own two feet.^{13,14}

The youngster walks with a waddle and has a varus alignment at the knee; nevertheless, their foot arches are not yet fully grown. By the time a child is about 2 years old, the knee's alignment has reached a "neutral" position. Knee position gradually shifts to a physiological genu valgum over the course of the subsequent few years, but it eventually self-corrects to a normal tibiofemoral alignment by the time a child is approximately 7 years old.^{13,14}



Figure 4. Destruction of proximal femoral epiphysis as consequence of tuberculous infection¹⁷

It is crucial to have a solid understanding of these variances because parents frequently seek the assistance of an orthopedist for problems like these, which require little more than a cautious clinical evaluation and reassurance. It is hypothesised that the relative growth rates of the articular cartilage and the neighbouring physal zone are responsible for dictating the varus and valgus alignments of the joint. The physis expands at a rate that is almost five times faster than that of the articular cartilage. This differential may be responsible for controlling varus and valgus alignment: varus develops when the medial sides grow more slowly than the lateral sides, but valgus develops when they grow more fast.^{15,16}

Differences between sexes and between races are common knowledge. Using the tibiofemoral measurement as well as measurements of the intercondylar and intermalleolar distances, a number of studies have been conducted to document the development of the angle formed between the tibia and the femur in children. According to the findings of a study conducted on youngsters in Europe, by the time they reached adulthood, boys have a larger predisposition towards varus than girls do. Additionally, boys have shorter intermalleolar and intercondylar lengths.^{15,16}



Figure 5. Injury to the proximal tibial epiphysis causing a short tibia

According to the findings of one study conducted in Turkey, the valgus angle of Turkish children was much greater than that of children evaluated in other publications found in the scientific literature. Alterations in children's skeletal architecture and physiology can be brought on by pathologic abnormalities that might develop during the growth phase. Rickets is the clinical manifestation of an abnormal mineralization of the osteoid. It's possible that this is due to a nutritional insufficiency in vitamin D, or it could be due to a more complex deficiency that's connected to improper renal tubular function.¹⁸

The bone becomes brittle as a result of rickets, which can lead to deformities that require medical attention, such as genu varum, genu valgum, and tibial bending. Osteogenesis imperfecta is the most well-known form of matrix deficiency, and it is characterised by a predisposition to many pathologic fractures and abnormalities in childhood. Matrix deficiencies can also result in a plethora of other disorders.¹⁸



Figure 6. Osteogenesis imperfecta

Stunted growth and dwarfism can also be caused by deficiencies in growth hormone as well as dysfunctions in the thyroid gland. Infections and trauma are also potential causes of total or partial physeal stoppage, which can result in abnormalities and differences in limb length (see the photos below for further explanation). Epiphyseal dysplasias are another factor that can contribute to impaired growth and abnormalities.¹⁸

CONCLUSION

An understanding of bones and joints in children is very important because it is different from adults in general. There are several joint diseases in children that are typical and occur during the bone growth period.

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