

GROWTH ZONES OF THE KNEE AND OSTEOCHONDRAL DEFECTS IN CHILDREN

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Abstract

The growth zones of the knee are very important parts in the normal development of bones in children. Injuries in these areas and osteochondral defects can affect growth, movement, and the function of the knee. Osteochondral defects include damage to the cartilage and the underlying bone, causing pain, swelling, and limitation of movement.

This paper discusses the anatomy of the knee in children, the importance of growth zones, the causes and symptoms of osteochondral injuries, as well as the methods of diagnosis and treatment.

It also presents the importance of early diagnosis and rehabilitation in preventing complications and preserving the normal function of the knee.

Keywords: Clinical importance of growth zones, osteochondral defects, osteochondritis dissecans (OCD), diagnosis.

Introduction

The knee represents one of the most complex and functionally important joints of the musculoskeletal system. In children and adolescents, this joint is characterized by the presence of developing structures, especially the growth zones (epiphyseal plates), which are essential for the longitudinal growth of bones.

The biological and biomechanical changes that occur during growth make the knee more sensitive to specific injuries that are not commonly seen in adults.

Two of the most important pathologies in this context are: growth plate injuries osteochondral defects

These conditions are of great clinical importance, as they may lead to permanent deformities, functional limitations, and in some cases long-term disability.

Functional Anatomy of the Knee in Children

The knee joint is a synovial hinge-type joint (with flexion-extension movement), but it also has important rotational components.

Main Components

- Distal femur
- Proximal tibia
- Patella

Stabilizing Structures

- Anterior cruciate ligament (ACL)
- Posterior cruciate ligament (PCL)
- Collateral ligaments
- Medial and lateral menisci

2.1. Pediatric Characteristics

- Presence of the growth cartilage (physis)
- Less mineralized bones
- Higher tissue elasticity

These characteristics make children more likely to transfer traumatic forces to the growth zones rather than to the ligaments, unlike adults.

2.2. Growth Zones (Epiphyseal Plates)

Growth zones are cartilaginous structures located between the epiphysis and metaphysis of long bones.

2.2.1 Histological Structure

The growth plate consists of several zones:

-Reserve zone – This zone contains small chondrocytes with low metabolic activity. It serves as a cellular reserve and provides structural stability to the growth plate.

-Proliferative zone – In this layer, chondrocytes divide by mitosis and are organized into parallel columns. This zone is responsible for the active longitudinal growth of the bone.

-Hypertrophic zone – It is characterized by enlargement of chondrocytes and thinning of the cartilaginous matrix. This part is considered mechanically weaker and more susceptible to trauma and fractures.

-Zone of calcification – In this phase, the cartilaginous matrix begins to calcify, while the chondrocytes gradually degenerate.

Any disruption in this organization can directly affect the ossification process, where cartilage is replaced by bone tissue through the process of endochondral ossification. Osteoblasts form new bony trabeculae that contribute to the normal development of the skeleton.

2.2.2 Localization in the Knee

- Distal femur** → contributes about 70% of femoral growth
- Proximal tibia** → contributes significantly to the growth of the leg

2.3 Clinical Importance of Growth Zones

- Injuries to these areas are particularly problematic because they:
- May cause premature closure of the growth plate
 - May lead to axial deformities (valgus/varus)
 - May create limb length discrepancy

2.3.1 Growth Plate Injuries

Salter-Harris Classification

This is the most commonly used clinical classification system:

- Type I** – complete separation through the growth plate
- Type II** – involves the metaphysis (most common type)
- Type III** – involves the epiphysis
- Type IV** – involves both the epiphysis and metaphysis
- Type V** – compression injury

Mechanisms of Injury

- Direct trauma
- Violent rotation
- Axial loading

2.4 Osteochondral Defects: Osteochondral defects involve damage to: the articular cartilage the subchondral bone

These injuries are particularly problematic because of the limited regenerative capacity of cartilage.

2.4.1 Pathophysiology

The process includes:

Initial cartilage injury

Changes in the subchondral bone

Local necrosis

Possibility of fragment detachment

2.4.2 Contributing Factors

Local ischemia

Repetitive microtrauma and genetic predisposition



Figure 1. osteochondral lesions

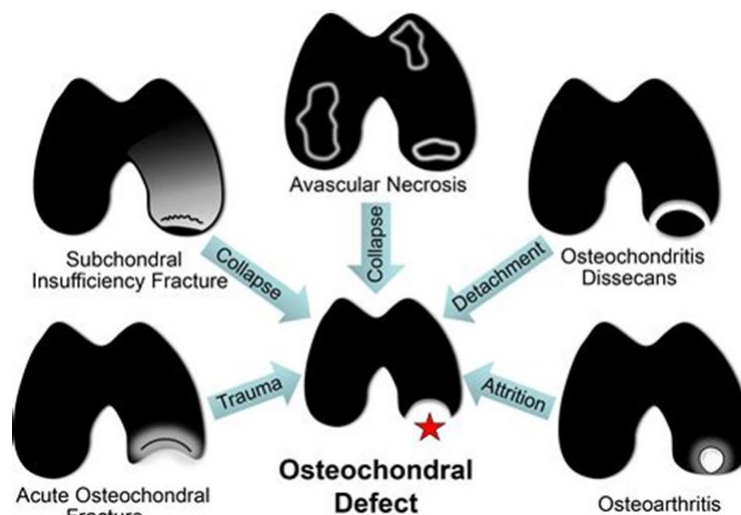


Figure 2. osteochondritis dissecans

2.5. Osteochondritis Dissecans (OCD)

It is a chronic pathology that mainly affects active children and adolescents. Most common localization is medial femoral condyle

Stages: Stable, unstable, free intra-articular fragment

2.5.1 Clinical Importance

If left untreated: it progresses to articular degeneration
it increases the risk of osteoarthritis at a young age

2.5.2 Clinical Presentation

Symptoms include:

- Progressive pain
- Intermittent swelling
- Limitation of movement
- Knee "locking" (mechanical blockage)

2.5.3. Diagnosis

Clinical Examination: Stability tests, evaluation of range of motion

Imaging

- X-ray → initial identification
- MRI → gold standard
- CT scan → evaluation of bone structure

MRI allows the assessment of: lesion stability, cartilage integrity

2.5.4 Conservative Treatment

Indicated in:

- young patients with active growth plates
- stable lesions

It includes:

- relative immobilization
- reduction of physical activity
- controlled physiotherapy

2.5.5 Surgical Treatment:

Indications

- unstable lesions
- failure of conservative treatment

Techniques

- Fixation with bioresorbable screws
- Microfracture
- Osteochondral autograft
- Chondrocyte implantation

2.6. Rehabilitation

Rehabilitation is critical for long-term success:

- gradual restoration of mobility
- muscle strengthening
- phased return to sports activities

2.7 Complications

- Limb deformities
- Functional limitation

- Early osteoarthritis
- Nonunion of the lesion

2.8 Prevention

Strategies include:

- management of sports load
- education on proper techniques
- early diagnosis
- monitoring of active children

2.9 Discussion

Literature shows that:

- early diagnosis is a key factor
- MRI has revolutionized management
- treatment must be individualized

There is still ongoing debate regarding:

- the optimal timing of surgical intervention
- the choice of the most effective technique

Conclusion

The growth plates of the knee represent essential structures for the normal development of the skeletal system in children, enabling the longitudinal growth of bones. Due to their high sensitivity to trauma, these structures are often at risk during physical activities and sports, making early diagnosis very important.

Osteochondral defects, which involve damage to the articular cartilage and subchondral bone, represent another significant clinical problem in pediatric orthopedics. They can cause pain, limited range of motion, and in more advanced cases, long-term functional impairment of the knee joint.

From the analysis presented in this paper, it is evident that understanding the anatomy and histology of growth plates, along with knowledge of the mechanisms of osteochondral injury, is essential for accurate diagnosis and effective treatment. Modern diagnostic methods, particularly magnetic resonance imaging (MRI), have significantly improved the early detection of these conditions.

In conclusion, successful management of these conditions requires a multidisciplinary approach, early diagnosis, and individualized treatment in order to prevent long-term complications and ensure normal musculoskeletal development in children.

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