INTRODUCTION

Since its description by Aitken[1], proximal femoral focal deficiency (PFFD) has attracted the attention of many clinicians. It is a rare congenital malformation, characterized by failure of normal development of the proximal part of the femur.[2] In its severe forms, the femur is shorter than normal and there is apparent discontinuity between the femoral neck and the shaft.[3] The condition implies lack of integrity, stability and mobility of the hip and knee joints. The defect may be unilateral or bilateral. Bilateral cases can be symmetrical or asymmetrical, but have a tendency to be of a more severe degree.[4] In most cases the cause of the femoral deficiency is unknown. The disorder normally does not have a genetic link.[5]

The exact incidence of congenital limb deficiencies is hard to quantify because of differing methods of data collection, criteria for reporting and variation with geographical location.[6] The incidence of PFFD has been reported to be 1 per 52,000 live births.[7]

The etiology of PFFD is not known exactly, but certain theories have been proposed and agents implicated. Sclerotome subtraction is one such theory that has been offered to explain several different limb deficiencies. Specifically, this theory states that injury to the neural crest cells that form the

precursors to the peripheral sensory nerves of L4 and L5 results in PFFD.[9]

A second theory, advanced by Boden, states that PFFD may be the result of a defect in proliferation and maturation of chondrocytes in the proximal growth plate.[8] Agents implicated in causing such injuries include anoxia, ischemia, irradiation, bacterial and viral infections and toxins, hormones, mechanical energy, and thermal injury.[9-11] Thalidomide, when taken by the mother between the fourth and sixth weeks of gestation, has been demonstrated to be a definite cause of PFFD in humans.[9] Currently, no evidence indicates a genetic etiology. [10-12]javascript:showrefcontent('refrenceslayer');

The appearance of PFFD is not subtle, so it is easily recognized. The femur is shortened, flexed, abducted, and externally rotated. [9, 11, 13] Gillespie noted that, in his patients, the hips were never normal and the knees were dysfunctional.[11-14] Flexion contractures of the hip and knee are also present. The bulbous proximal thigh quickly tapers to the knee. Because of the short femur and bulbous thigh, examination of the hip can be difficult. As a result of hip instability, pistoning may be present. The knee is uniformly unstable in an anteroposterior plane secondary to absent cruciate ligaments. Additionally, generalized knee hypoplasia has been reported. [13]

A high incidence of fibular deficiency and valgus feet is associated with PFFD.[11]

Fibular deficiencies are found in as many as 70-80% of persons with PFFD. Approximately 50% of patients with PFFD have other limb anomalies. [13] However, Aitken reported almost a 70% incidence of other anomalies.[14] javascript:showrefcontent('refrenceslayer');Cleft palate, clubfoot, congenital heart defects, and spinal anomalies, although rare, occur as well. PFFD is bilateral in 15% of the cases.[12]

Several classification systems describe congenital anomalies of the femur, but most have been based on radiographic appearances alone. The Amstutz and Pappas classifications provide detailed radiologic descriptions of the various forms of PFFD that these researchers encountered.[21,22] Hamanishi described a progressive reduction of the femur, ranging from simple shortening to total absence.[23] Fixsen and Lloyd-Roberts divided their patients into stable and unstable categories.[24] javascript:showrefcontent('refrenceslayer');

Gillespie and Torode reviewed their patients from both a radiographic and, more importantly, a clinical viewpoint and found that most could be divided into 2 groups.[26] The Aitken classification, which is the most widely used classification,

divides PFFD into 4 categories based on the radiographic appearance.[24]

No single treatment approach applies to all cases. Each person with PFFD must be assessed individually.

Cosmoses is much less of an issue. Knee arthrodesis, foot amputation, Van Nes rotationplasty, hip stabilization, iliofemoral arthodesis and lengthening procedures all are methods for dealing with PFFD. [20-25]

IF the predicted discrepancy is greater than 20cm, or if for any reason the child's condition is not suitable for lengthening, a decision must be made about the best approach to fitting a prosthetic device. The patient with PFFD always requires prosthesis for ambulation; therefore, any procedure that is attempted must be with the intent of improving function or fit of a prosthesis. [20]

Limb preserving and reconstruction has become the therapy of choice, as the Ilizarov is a method for lightening of the short bones although amputation is still recommended by some authors.[20]

Aim of the study

This study aims to review the literature regarding proximal femoral focal deficiency with particular emphasis on the recent methods of its treatment.

EMBRYOLOGY

Normal development of the limbs begins at the end of the fourth week after fertilization, with buds forming in the mesoderm along the flank of the embryo.[27]

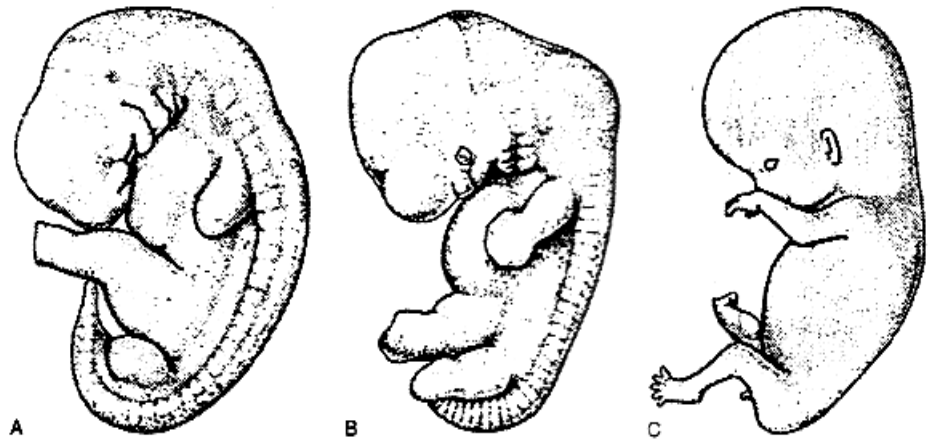

Figure (1): Limb Bud Development

A. The limb buds appear at the end of the fourth week post fertilization as mesodermal out pouching's on the flank of the embryo.
B. During the sixth week, the terminal portion of each bud flattens to form the hand and foot plates, complete with digital rays.
C. By the 12th week, cartilage appears in proximal segments and ossification centers are present in the long bones.[28]

The limbs develop in a proximo-distal direction from the limb girdle to the digits (Fig 1) . The proximal bone of the limb girdle and the femur forms prior to the differentiation of ridge ectoderm, while development of the remaining bones and digits depends on the apical ectodermal ridge (AER). [29]

The AER is formed by thickening of lateral plate mesoderm, which signals the overlying ectoderm to thicken and establish a ridge over the tip of the limb bud and regulates the proximo-distal growth of the limbs (Fig 2).

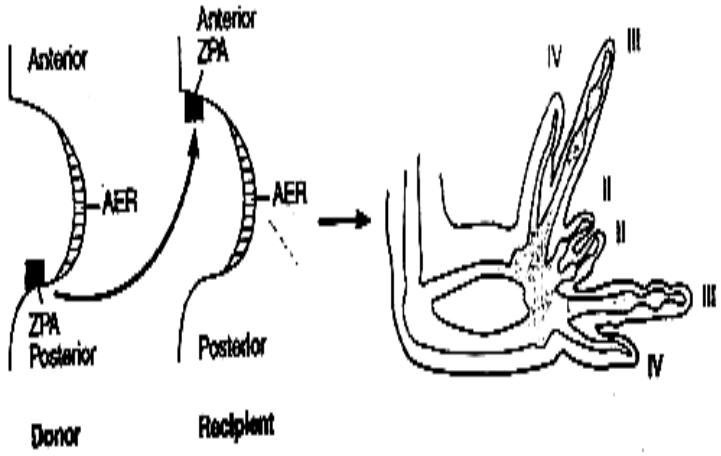

Figure (2): Regulation of antero-posterior limb development by zone of polarizing activity (ZPA).[27]

The underlying mesenchyma stimulates and preserves the AER which maintains the mesenchyma in the distal portion of the limb in an undifferentiated, rapidly proliferating state. The AER causes outgrowth of the limbs, but the mesenchyma determines the type of the limb that will develop. [28]

The bone and connective tissues of the limbs are formed by lateral plate mesoderm, while the muscles originate from myotome regions of somatic mesoderm.

Forelimb and hind limb development occurs via similar mechanisms, with upper limb growth preceding lower limb growth by 1 to 2 days. By 6 weeks, as the buds extend distally, the terminal parts of the limbs flatten to form hand and foot plates, complete with distal rays, and cartilage begins to appear in the proximal portions of the limbs. During the seventh week the limbs begin to rotate, with the forelimb turning 90 degrees laterally and the hind limb turning 90 degrees medially. Digital rays appear in the hand and foot plate. By the eighth week the limbs have rotated to their final position and all segments are complete, including the digits. During this time, the ossification starts. By 12 weeks, ossification centers are present in all of the long bone. **(28)**

ETIOLOGY

In general, in individuals with PFFD , the proximal femur is partially absent, and the entire limb is overall shortened. A few main biomechanical abnormalities are present in children with PFFD, as well as in adults with limb deficiencies. These include limb length discrepancies, malrotation, proximal joint instability, and inadequacy of the proximal musculature. PFFD is an uncommon but complex problem. PFFD is commonly grouped with other disorders, such as coxa vara and short bowed femurs, which led to confusion and misunderstanding.[30]

Epidemiology

The incidence of the deficiency ranges from 1 case per 50,000 population to 1 case per 200,000 population. The specific cause of congenital limb deficiencies is unknown in most cases. Although there are a few limb abnormalities with genetic bases, most limb deformities develop sporadically, with no identifiable environmental factors, trauma, or familial incidence.[30]

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Specifically, this theory states that injury to the neural crest cells that form the precursors to the peripheral sensory nerves of L4 and L5 results in PFFD.

A second theory, advanced by Boden et al, states that PFFD may be the result of a defect in proliferation and maturation of chondrocytes in the proximal growth plate. Agents implicated in causing such injuries include anoxia, ischemia, irradiation, bacterial and viral infections and toxins, hormones, mechanical energy, and thermal injury. Thalidomide, when taken by the mother between the fourth and sixth weeks of gestation, has been demonstrated to be a definite cause of PFFD in humans.[20]

CLASSIFICATIONS

Several classification systems describe congenital anomalies of the femur, but most have been based on radiographic appearances alone. The Amstutz and Pappas classifications provide detailed radiologic descriptions of the various forms of PFFD that these researchers encountered. Hamanishi described a progressive reduction of the femur, ranging from simple shortening to total absence. Fixsen and Lloyd-Roberts divided their patients into stable and unstable categories.[20]

Gillespie and Torode reviewed their patients from both a radiographic and, more importantly, a clinical viewpoint and found that most could be divided into 2 groups. The first group included persons with congenital short femurs, and the second group was composed of individuals with true PFFD. These 2 groups not only differed with respect to clinical and radiographic appearances but also were functionally unique and had different surgical and prosthetic requirements.[22]

The Aitken classification, which is the most widely used classification, divides PFFD into 4 categories based on the radiographic appearance.[31]

Aitken classification (1969):

The Aitken classification system has some clinical relevance and is the most widely used system for classifying femoral deficiency (Fig 3). PFFDs are categorized as type A, B, C, or D (Tab 1).

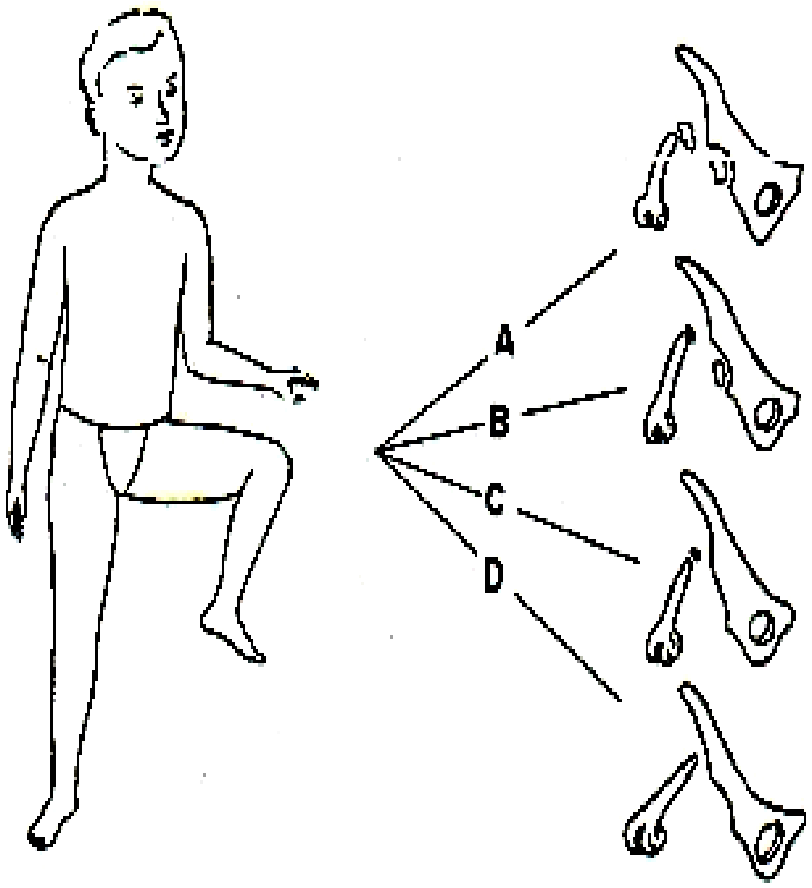

Figure (3): Aitken classification of PFFD.[31]

Table (1): Description and illustration of the Aitken classification of PFFD.[31]

TYPE		Femoral Head	Acetabulum	FEMORAL shortening	Relationship among components of femur and acetabulum at skeletal maturity
A		Present	Normal	Short	-Bony connection between components of femur -Femoral head in acetabulum -Subtrochanteric varus angulation, often with pseudoarthrosis
B		Present	Adequate or moderately dysplastic	Short, usually proximal bony tuft	-No osseous connection between head and shaft -Femoral head in acetabulum
C		Absent or represented by ossicle	Severely dysplastic	Short, usually proximally tapered	-Maybe osseous connection between shaft and proximal ossicle -No articular relation between femur and acetabulum
D		Absent	-Absent -Obturator foramen enlarged -Pelvis squared in bilateral cases	Short, deformed	(none)

In type A radiographs of young child reveal a defect in the upper femur that ossifies as the child matures. The femoral head is present and the acetabulum is well formed. A pseudoarthrosis in the subtrochanteric area normally resolves by the time the patient reaches skeletal maturity. A varus deformity of the upper segment of the femur, which can vary in severity, usually is present, and the shaft of the femur may be positioned above the femoral head.

In type B, the femoral portion of the limb is shorter than in type A, a tuft is often present at the proximal end of the femur, and the acetabulum is well formed. At birth, the upper portion of the femur may not ossify, but as the child matures, the femoral head develops. The proximal end of the femur is usually positioned above the acetabulum, and at maturity there is no ossific continuity between the femoral shaft and head (a definitive feature of Aitkin's type B deformity).

In type C, the femoral segment is short and there is a tuft at the proximal end. There is no ossification of the upper portion of the femur, and the femoral head is missing. The acetabulum is poorly developed or absent. In cases where there is no acetabulum, the flat, lateral segment of the pelvic wall is seen in its place.

In type D, the shaft of the femur is extremely short or absent, there is no femoral head, and the acetabulum is either poorly developed or not present.[31]

Fixsen and Lloyd-Roberts classification (1974):

This system categorizes PFFDs according to radiographic appearance of the proximal portion of the shaft of the femur. There are three types of maldevelopment.

In type I, The proximal femur is bulbous and there is continuity between the femoral head, neck, and greater trochanter. A pseudoarthrosis may form distal to greater trochanter.

In type II, There is a tuft or cap of ossification at the proximal end of the femur that is separated from the blunt upper femoral shaft by an area of lucency. A pseudoarthrosis is often present, and, if it heals, the femoral neck has a varus deformity. The hip is usually unstable.

In type III, The femur is blunt or pointed in shape (not bulbous), there is no tuft at the proximal end of the shaft, and all have unstable pseudoarthrosis. They recommended surgical stabilization of all unstable pseudoarthrosis (types II, III), but recent studies do not support the need to operate on the pseudoarthritic area except in unusual progressive deformities.[23]