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Structural Peculiarities of the Proximal Femur Meta-Epiphysis in the Idiopathic Coxarthrosis According to Localization

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Abstract **Background:** The hip essentially represents the major weight-bearing joint of the human organism. It is conspicuously characterized by its mobility and complex origination, specific organization and development. The anatomic structures referred to as acetabulum and femoral head arise from the same primitive mesenchymal cells and, by the end of the 11th week of gestation, the hip joint becomes fully formed and continues to develop throughout intrauterine life. During embryonic life, the femoral head grows at a faster rate than the acetabulum, and at the end of gestation the femoral head is approximately less than 50% covered, and after birth, the growth rate of the acetabular cartilage surpasses that of femoral head thus resulting in progressively increased coverage. **Methods:** Cartilaginous at birth, the ossification of acetabulum is set at around a three-month age period, while ossification centers of the proximal femur start to appear at 4 to 7-months. Several developmental abnormalities regarding the relationship between femoral head and acetabulum are therein described; all of those anatomic aberrations may technically result in hip instability, manifested by dislocation, subluxation, dysplasia and arthrosis. **Results:** From a biomechanical standpoint, three pathological conditions are shown to have arisen mainly at the region of the femoral neck: i) congenital *coxa vara*, ii) *pseudoarthrosis* of the neck of the femur and iii) *coxarthrosis*. All of the aforementioned conditions are caused and maintained by different types of mechanical stress and, in advanced stages, they may necessitate surgical interventions to alter the angle of the femoral neck in order to relieve the pressure at the level of the affected joint mainly during movement. Furthermore, we indicate that there is no standard to adopt regarding the surgical change of the femoral neck angle, though biomechanical assessment has to be worked out and established in each of the affected individual. **Conclusion:** Plain film radiography plays an important role in the assessment of a dysplastic hip, especially in adults, where operative management is essentially based on various radiographic measurements. Several average values of stresses and strains of the proximal femur were identified on the basis of Wolff's trajectorial hypothesis, where they revealed a trabecular architectural changes and structural remodeling in response to mechanical stress. It is concluded that these pathological conditions (congenital *coxa vara*, *pseudoarthrosis* of the neck of the femur and *coxarthrosis*) that were shown to have arisen mainly at the region of the femoral neck may contribute to understanding pathophysiologic and patho-anatomic peculiarities of the femoral bone.

Keywords: *coxarthrosis, proximal femur meta-epiphysis, pseudoarthrosis, system asymmetry*

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1. Background

In retrospect analysis of a backlog of varied literature references and citations regarding the anatomy and biomechanics of the femur bone, we have encountered numerous destinations referring to the dissymmetry of the human extremities in relation to the right or left side of the body [1,2,3,4,5]. These peculiarities were recognized by organometric and radiological (e.g., X-ray) studies, as well as by specific analysis of the systemic organization [6-12].

The human femur is commonly regarded as a subsystem of the locomotor apparatus with four conspicuous levels of organization. This phenomenon is the result of the evolution of the locomotor apparatus, which encompasses both constitutional and individual variability [1,5,6,7,8]. The work therein reported, therefore, underlies the significance of observing anatomical system analysis of the proximal femur meta-epiphysis in normal conditions, according to the anatomic positioning with respect to the right or left side of the body, and the presence of system asymmetry in the meta-epiphysis structure, thus indicating structural and functional asymmetry [9,10,11,12].

We have previously reported specifically on the systematic organization of the femur [13], with subdivided groups into four levels of organization and anatomical values correlating with that of the human body joints. As the anatomy of the human body is characterized by the functional predominance of the right upper and left lower limbs [1-7,14-20], particular actuality was acquired in studying the value of parameters at different levels involved with forming the functional asymmetry of the femur bone [13,17,18,19,20]. Furthermore, we assessed authenticated observations of a systemic anatomical study encompassing the proximal femur meta-epiphysis behavior in normal condition, particularly on the asymmetry and structural system analysis of the proximal femur meta-epiphysis regarding Osteoarticular anatomical pathology [21]. Our studies conspicuously demonstrate a technical spontaneous significance in medical practice as the theoretical basis is also required in unraveling the decreased frequency and degree of severity of osteoarthritic pathologies in the dominant lower extremity, in accordance with recurrent experimental observations [13,21].

Nevertheless, the issue of the structural changes and specifically the dynamics associated with the proximal femoral bone meta-epiphysis in the idiopathic hip arthrosis with respect to body side is, to the best that we know of, not fully unraveled [12,13,14,15]. It's widely noted that the adaptive rearrangement of the osseous tissue in response to mechanical stress induction is caused by the physical effects that usually lead to changes in the spatial arrangement of the bone matrix elements towards each other [15,16,17,18,19,20]. Hence, bone mass tends to decrease in zones of minimal mechanical stress and maximal immobilization [13,21].

The specific aim of this research study was to investigate the system organization of the proximal femur meta-epiphysis, particularly in relation with idiopathic coxarthrosis. It is understood that the pathological conditions (mainly congenital *coxa vara*, *pseudoarthrosis* of the neck of the femur and *coxarthrosis*) associated with the femoral neck may contribute to understanding the pathophysiologic and patho-anatomic peculiarities of the femoral bone.

2. Materials and Methods

All studies therein undertaken have been performed according to the 1964 'Declaration of Helsinki' and its latter amendments, and subsequently approved by an ethical committee.

2.1. Sample Collection and Compilation

In order to analyze the osseous tissue peculiarities in normal condition and idiopathic hip arthrosis, we have assessed, in duplicate, the following values obtained from the antero-posterior (AP) plain X- ray images taken of the hip joint: i) upper and lower femoral head size, ii) upper and lower neck size, iii) proximal epiphysis transverse size, iv) intertrochanteric space, v) diaphysis transverse size, vi) diaphyseal neck angle (Figure 1), vii) femoral neck angle (Figure 2), viii) greater trochanter angle (Figure 3), and ix) angle of entry to the diaphyseal canal (Figure 4).

Figure 1. Diaphyseal-neck angle of the femur-pelvis X-ray; AP view

Figure 2. Femoral neck angle, X-ray proximal meta-epiphysis of the human femur; AP view

Figure 3. Greater trochanteric angle, proximal meta-epiphysis of the human femur; X-ray AP view

Figure 4. Angle of entry of diaphyseal canal, proximal meta-epiphysis of the human femur; X- ray AP view

2.2. Sample Analysis and Assessment

The control group consisted of AP X-ray films of twelve (12) right and fourteen (14) left hips free from any pathological signs or predicaments. In parallel, a group of forty-nine (49) X-ray films of the hip with idiopathic joint arthrosis (24 right-sided and 25 left-sided) were staged and analyzed (Table 1; Figure 5, Figure 6 and Figure 7), where a 3-point scale was used to evaluate the degree of deviation of the vertex in the angle of entry to the diaphyseal canal as regards the diaphysis axis (1 point: medial displacement; 2 points: normal location and 3 points: lateral displacement). The average values of the proximal femoral bone meta-epiphyses have been tabulated taking into account the stage of disease and localization to the left or right side of the body (Table 2).

Analytically, all received data of linear parameters have been standardized with transverse size of the diaphysis as a measurement unit for each bone and processed according to methods of descriptive and variation statistics (statistical package-Microsoft Excel 2013), as previously indicated [13,21]. Statistical difference was considered authenticated with $\alpha = 0.05$.

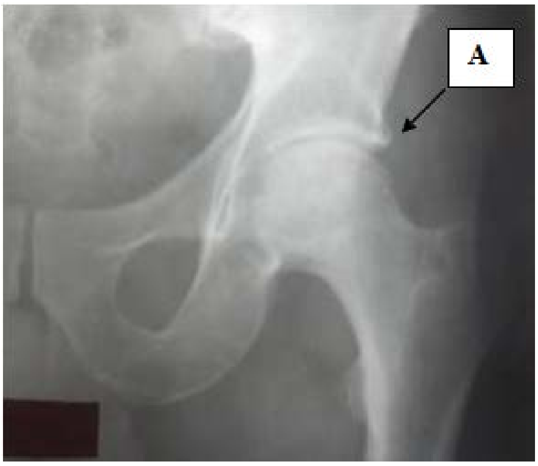

Figure 5. X-ray film of coxarthrosis stage I. A: Marginal osteophytes

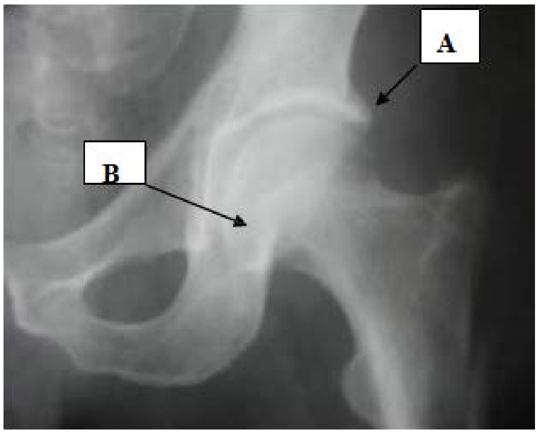

Figure 6. X-ray film of coxarthrosis stage II. A: Marginal osteophytes; B: Deformity of the femoral head

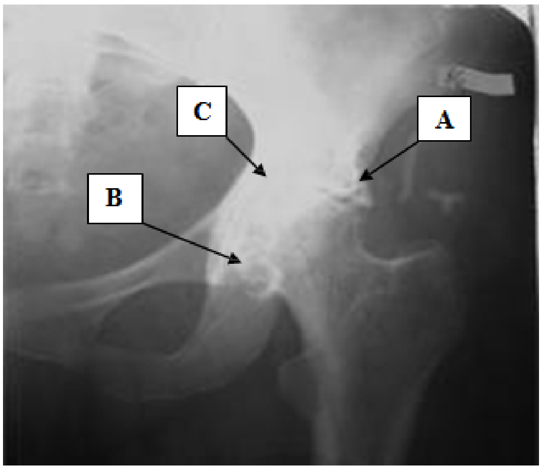

Figure 7. X-ray film of coxarthrosis stage III. A: Marginal osteophytes; B: Marked deformities of the femoral head; C: Complete destruction of the intra-articular cartilage

3. Results and Discussion

The results therein reported indicate that the radiological images of the idiopathic hip arthrosis (IHA) patients have a relatively increased femoral head and neck vertical diameter (expressed in a relative measurement unit) (Table 1; Figure 1,Figure 2, Figure 3, and Figure 4). With weighing of the main pathology stream of thinking, and in our opinion, this technically indicates a change in the qualitative characteristics of the functional stress volume of the femoral bone [22,23,24,25].

Initially, there is a decrease in the exertion support and as a result some reduction of average absolute values of the transverse diaphysis was observed thus leading to a relative increase in the abovementioned parameters [26-32]. The changes in degenerative and dystrophic hip joint diseases are confirmed by statistically establishing a decrease in the transverse proximal epiphysis size (Table 2) that can be explained by the external rotation, which is a manifestation of forced rearrangement in alleviating pain. In addition, this phenomenon is shown by the lateralization value of the vertical angle in the diaphyseal canal in the groups of right- and left-sided IHA [5-8,13,21,33-35].

Nevertheless, comparing the intensity and degree of confidence intervals range in all radiological studies has shown that left-sided localization of the pathological process leads to a more significant and prominent reorganization of the proximal femoral bone epiphysis [13,21,36-42]. The range of confidence interval of the values of the proximal epiphysis transverse size in stage II of IHA is, however, less than that observed in the left- sided localization.

Table 1. Qualitative distribution of the X-ray images of the patients with hip joint idiopathic arthrosis according to the stage of disease and body side

Disease stage	Left-sided hip arthrosis	Right-sided hip arthrosis	Total
Stage II	8	5	13
Stage III	16	20	36
Total	24	25	49

Table 2. Width of linear and angulated confidence interval parameters of the proximal femoral bone meta-epiphysis in normal condition and idiopathic hip arthrosis with α = 0.05. * Indicates the authenticity of difference with the control group. ** Indicates the authenticity of difference with the group of IHA at stages II and III

Parameters	Standards		Idiopathic hip arthrosis Stage II		Idiopathic hip arthrosis Stage III	
	Left	Right	Left	Right	Left	Right
Upper & lower femoral head size	1,59-1,72	1,66-1,81	1,52-1,81	1,29-1,64*	1,6-1,86	1,7-1,92**
Upper & lower neck size	1,09-1,13	1,1-1,27	1,02-1,26	0,92-1,20	1,14-1,28*	1,18-1,28
Proximal epiphysis transverse size	3,43-3,56	3,47-3,79	2,95-3,25*	2,72-3,35*	3,1-3,3*	3,05-3,24*
Intertrochanteric space	2,64-2,73	2,67-2,92	2,47-2,86	2,25-2,74	2,56-2,89	2,61-2,91
Diaphyseal neck angle	123,11°-126,88°	128,48°-132,95°	126,57°-136,17°	121,65°-129,14°	123,92°-132,44°	121,84°-130,35°
Angle of entry to the diaphyseal canal	57,22° -60,06°	55,47° -63,41°	46,67°-61,32°	50,15°-63,84°	46,37°-58,5°	46,36°-55,23°*
Deviation from angle of entry to the diaphyseal canal	-	-	0,97-2,02	1,46-2,93	1,13-1,61	1,46-2,23
Greater trochanter angle	31,4° - 34,3°	34,24° - 42,2°	27,74° - 47°	34,58°-56,21°	32,72°-44,77°	34,82°-46,27°
Femoral neck angle	41,83° - 45,29°	36,89° - 49,98°	46,41° - 73,33°*	49,04° - 63,35°	57,71°-69,16°*	52,44°-65,25°*

Furthermore, judging by the change of the angulated parameters, we can analyze the degree of compensatory and adaptive rearrangement of the proximal epiphysis in hip arthrosis [15-19,21,35-43]. In spite of the fact that the statistically established distinctions from the screening group can be viewed only in the angle between the femoral neck osseous trabeculae, the range of borders of the confidence intervals increased two times in each of the examined angulated parameters. Left-sided hip arthrosis localization revealed a more significant difference of this phenomenon in comparison with the right- sided process [1-7,13,23-30].

In conclusion, special attention should be drawn though to the analysis of the magnitude change in the femoral neck osseous trabeculae. This angle is measured between two groups of osseous trabeculae located in the femoral neck on the frontal X-ray view. This explains why the external rotation can cause distortion of the real values and hence can lead to differences in the statistically significant values, as compared with the screening group [8,12,15,18-25,35-38,42,43]. Systematically, the revealed changes of the relative values of the linear parameters and the absolute values of the angular parameters of the proximal femoral bone epiphysis (on X-ray images of hip arthrosis patients in different stages) essentially coincide with the conception of hip arthrosis staging and can be explained by the dynamics of its morphological and functional reorganization [13,21,44,45,46,47,48].

Authors' Contributions

All authors have squarely and equally contributed to developing the experimental, theoretical and statistical aspects of this article.

Declaration of Competing Interests

The authors declare that they have no competing interests.

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