Pathomorphology of Femoral Head Lesions and Some Clinical and Morphological Dependences in Patients with Dysplastic Coxarthrosis

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Received: March 26, 2021; Published: April 28, 2021

Abstract

Introduction: Quantitative morphological changes in the tissues of the proximal epimetaphysis of the femur with dysplastic coxarthrosis may differ from those observed in the hip joint in other diseases.

Objective: Based on the study of the pathohistological characteristics of the femoral head tissue and some frequency differences between them, establish correlation dependencies between clinical and morphological parameters in dysplastic coxarthrosis patients.

Methods: We studied femoral head tissue in 22 patients. Clinical parameters were taken into account - the age of patients, the duration of the disease, the intensity of the pain syndrome according to the visual analogue scale. Based on the detected pathohistological changes in the tissues of the femoral head, several morphological gradation indices were taken into account, which diversify the degree of severity of dystrophic-destructive changes.

Results: In the complex of pathomorphological changes in femoral head, the most significant are: deformation of the articular surface, degeneration and destruction of articular cartilage, bone-cartilaginous growths, pathology of subchondral spongiosis tissue. They occur with different frequencies and in some cases are combined at different degrees of severity. Between the individual clinical manifestations and morphological indices of the condition of the femoral head tissues, correlation dependencies are established, which should be taken into account when predicting the degree of hip joint lesion in dysplastic coxarthrosis.

Conclusion: The revealed morphological features and clinical and morphological dependencies are important for planning the fixation of the femoral component of the endoprosthesis in the case of hip replacement in patients with dysplastic coxarthrosis of different time of presentation, the type of displacement of femoral head by Crowe and the degree of disruption of joint function.

Keywords: Dysplastic Coxarthrosis; Femoral Head; Pathomorphological Changes; Clinical Indices; Morphological Indices; Statistical Analysis; Correlation Analysis

Introduction

Congenital dysplasia is a severe orthopedic pathology, which, together with its complications, accounts for a significant proportion of diseases of the hip joint [1-3]. Over decades of life, such patients develop significant morphological changes in the tissues of the hip joint and functional disorders that lead to dysplastic coxarthrosis (DKA). Eventually, more than 20% of patients with severe dysplasia need...
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total hip arthroplasty (TEP CS), sometimes at a young age [2,4]. However, according to some studies, the risk of unsatisfactory surgical treatment in cases of displacement of the femoral head, which in severity correspond to grade III-IV according to Crowe [5], is almost twice as high as in the case of standard hip arthroplasty, which indicates a lack of coverage of the tactics of treatment of patients with DKA [6-8].

Pathomorphological changes of the tissues of the hip of the joint and adjacent muscles of patients with long-term consequences of congenital hip dysplasia are less often studied by anatomists, radiologists and pathologists [3,4,9-11] than changes in joint tissues in rheumatoid arthritis or ankylosing spondylitis [12,13]. However, the characteristic quantitative and morphological changes of the tissues of the proximal epimetaphysis of the femur in the case of DKA, probably may have topographic, qualitative and quantitative differences from the pathological changes observed in the tissues of the hip joint in other diseases, which should be considered during diagnostic and therapeutic measures [8,11].

Purpose of the Study

The purpose of the study: based on the study of patho-histological characteristics of the tissues of the femoral head and some frequency differences between them to establish correlations between clinical and morphological parameters in patients with DKA.

Material and Methods

The material of the study was the tissues of the femoral heads of 22 patients with DKA (9 men, 13 women), who performed TEP CS. Osteoarthritis of the CS developed after a long time due to congenital dysplasia of the acetabulum. The following clinical indicators were taken into account for statistical and correlation analysis: age of patients, the general duration of the disease, the intensity of pain on a visual-analog scale (VAS) [14] before and after surgery, and also calculated the difference between the absolute parameters of this indicator “before - after” surgery. Based on the distribution of points, the following classification is recommended: no pain (0.0 - 0.4 cm), mild pain (0.5 - 4.4 cm), moderate pain (4.5 - 7.4 cm), severe pain (7.5 - 10.0 cm) [15].

Fragments of resected femoral heads were subjected to the usual histotechnical treatment: fixation in 10% formalin, decalcification with 5% nitric acid, filling the blocks with celloidin, cutting on a sled microtome, staining sections with hematoxylin and eosin. Histological examinations were performed on MBS-2 and Olympus CX41 microscopes.

After studying the histopathological changes in the tissues of the femoral heads, using a blind method (clinical and laboratory data were not known in advance), assessed the condition of articular cartilage (CX) and subchondral spongiosis. During the statistical study, the mean group parameters and parameters of variation (standard deviation and standard error), the frequency of individual gradations of clinical and morphological parameters in the study material, taking into account the load loci, were calculated, correlation analysis was performed between clinical data of patients and morphological indicators of the lesion. The work was approved by the local bioethics committee of the State Institution "ITO NAMS" (Minutes № 2 dated 14.05.2014).

Results and Discussion

Clinical indicators of patients with dysplastic coxarthrosis. The results of the clinical examination (Table 1) show that the average age of patients with DKA on the day of surgery was almost 50 years, of which on average half of life expectancy was DKA. Among the patients who underwent TEP CS, the majority, according to clinical and visual signs, which took into account the degree of damage to both the femoral head and the acetabulum, were cases of stage IV DKA. According to the main clinical types according to Crowe [5], which characterize the degree of displacement of the femoral head relative to the upper edge of the acetabulum, most cases corresponded to a low degree of displacement (Crowe I), slightly less - with a medium and high degree of displacement (Crowe II - IV). In the process of assessing

Citation: Valeriy Hryhorovskyi, et al. “Pathomorphology of Femoral Head Lesions and Some Clinical and Morphological Dependences in Patients with Dysplastic Coxarthrosis”. EC Orthopaedics 12.5 (2021): 22-34.
the intensity of pain in a patient before and after arthroplasty for DKA on the parameters of VASH it was found that the average parameter of the studied indicator was in the range of values of mild pain. After the operation, in all patients, the parameters of pain intensity for VAS decreased, but the average value also remained in the range of values of mild pain. Pathomorphological changes of the femoral head were characterized by a complex nature and varying degrees of severity. In some cases, a significant deformation of the surface was observed, in particular conical, saddle-shaped (Figure 1) or irregularly wavy, which was designated as a high-grade gradation. If the sphericity of the head was slightly disturbed, the gradation corresponded to a low degree. The most significant pathological changes were observed in the tissues of the articular surface of the femoral head. CX rarely looked unchanged or slightly changed, which would correspond to a low degree of dystrophic-destructive changes (Figure 2). Slightly altered CX occurred mainly in the areas unloaded head surface. The thickness of the CX in different parts of the surface of the femoral head varied significantly: from slightly altered CX to its complete absence on the articular surface (Figure 3). Areas of exceptionally dystrophic changes differed from normal hyaline CX by uneven matrix density, unmasking of collagen fibers (Figure 2) and sometimes by chondrocyte necrosis, which was regarded as low-grade dystrophic-destructive changes (DDD). For the most part, in addition to dystrophic changes, signs of destruction of the CX of the femoral head were determined: superficial and deeper defects of the matrix, horizontal and vertical cracks, delibering, fragmentation and desquamation of CX areas (Figure 4) large areas of interstitial chondronecrosis, large clusters-proliferates of chondrocytes. If the destruction of CX did not extend deeper than the intermediate zone of CX, the severity of DDZ was regarded as average. In cases where only areas of deep zone cartilage remained from CX or cartilage tissue on the surface of sclerosed bone tissue was absent, the severity of DDZ was high.

| Clinical indicators                                      | General characteristics of the indicator | Characteristics of index gradations | Number of cases taken into account | Mean value and standard error or frequency of occurrence in the material |
|----------------------------------------------------------|------------------------------------------|------------------------------------|-----------------------------------|---------------------------------------------------------------------|
| Age of the patient on the day of operation, years       | Parametric                               |                                    | 22                                | 48,05 ± 2,61                                                          |
| The duration of the disease, years                      | Parametric                               |                                    | 20                                | 23,00 ± 3,66                                                          |
| Type of displacement of the femoral head by Crowe       | Gradational                              | Low grade: Crowe I                 | 11                                | 52,38%                                                              |
|                                                         |                                          | High degree: Crowe II - III - IV   | 10                                | 47,62%                                                              |
| The stage of coxarthrosis according to clinical visualization methods | Graduation (nonparametric)              | Low degree: stage III              | 1                                 | 6,25%                                                               |
|                                                         |                                          | High degree: stage IV              | 15                                | 93,75%                                                              |
| Assessment of functional status on your scale: Before the operation, points |                                    |                                    | 20                                | 3,35 ± 0,37                                                          |
| After the operation, points                             | Parametric                               |                                    | 20                                | 2,30 ± 0,24                                                          |
| The difference between the estimates of the parameters of the functional state on the scale of YOUR, points | Parametric                               |                                    | 20                                | 2,00 ± 0,27                                                          |

*Table 1: The main parameters of clinical indicators of patients with DKA, which conducted histopathological examinations of the tissues of the hip joints.*
Figure 1: Microphoto. Deformation of the saddle-shaped head of the femur. The articular surface is in a state of osteosclerosis with remnants of dystrophic CX, cartilaginous nodule-regenerate (arrow). Hematoxylin and eosin. Coll. 12.

Figure 2: Microphoto. Moderately pronounced dystrophic changes in the tissues of the articular surface of the head: unmasking of collagen fibers CX, significant thinning of the subchondral bone plate (arrow). Hematoxylin and eosin. Coll. 75.
Figure 3: Microphoto. The head of the femur with almost complete destruction of the CX, the remains of cartilage on the articular surface (arrow). Hematoxylin and eosin. Coll. 12.

Figure 4: Microphoto. Area of well-defined mechanical damage CX (arrow). Hematoxylin and eosin. Coll. 30.

In some femoral heads on the articular surface, a certain thickness and area of bone and cartilage layers were determined. In their depth there were remnants of cartilage tissue parallel to the articular surface, on the surfaces of such cartilaginous plate, immersed deep into the spongiosa, found thin overlays of lamellar bone tissue and/or bone trabeculae (Figure 5). Such bone and cartilaginous lamellar formations were observed relatively rarely and cartilage tissue in them was mostly in a state of chondronecrosis. Directly on the articular surface, bone and cartilage growths sometimes occurred and were relatively small.
Marginal bone and cartilage growths were registered mostly in unloaded areas of the heads, the sizes of which varied greatly: from marginal exostoses of insignificant size to large pterygoid and labial outgrowths, which to some extent increased the size of the articular surface of the head. Marginal cartilaginous growths were mostly capricious in shape, were very unevenly covered with hyaline-like cartilaginous tissue and contained a spongy bone with yellow marrow inside.

Pathomorphological changes of subchondral spongiosis reflected a complex combination of manifestations of dystrophic, ischemic-necrotic, mechanical and reparative processes in the cancellous bone of the head. In some cases, the cancellous bone that formed the articular surface contained interstitial or focal osteonecrosis (Figure 6), which covered the tissue of the subchondral bone plate and adjacent bone trabeculae. Bone marrow cavities in these areas contained necrotic masses and accumulations of fibrinous exudate. Occasionally, fracture sites with a step-like displacement of adjacent areas were recorded in the bone tissue of the joint surface. Peripherally to the most pronounced ischemic-necrotic and microtraumatic changes of femoral head spongiosis, spongy endostal bone regenerates in the form of polymorphic layers on the surfaces of bone trabeculae were determined.
Among the frequent and characteristic pathological changes in the subchondral bone plate of the femoral head should be mentioned areas of dystrophic CX (Figure 7). In some places, they were close to the cartilage preserved on the surface, but often such cartilaginous islets were not directly associated with the cartilaginous tissue of the deep CX zone and had a rather polymorphic appearance.

![Figure 7: Microphoto. Polymorphic cartilaginous nodules (arrows) on the articular surface and among the spongiosis of the head. Hematoxylin and eosin. Coll. 12.](image1)

The altered bone tissue of the articular surface of the femoral head also contained the characteristic round-oval shape of the fibrosing site - in these places the mature fibrous tissue replaced the site of osteoresorption, which probably occurred due to osteonecrosis of the trabeculae of spongy transplantation predominance of resorption. Finally, in such areas, polymorphic, of different sizes, cystic cavities filled with myxoid contents were visualized in the middle of the fibrous connective tissue (Figure 8). In individual heads, dystrophic cysts of the articular surface formed paired formations.

![Figure 8: Microphoto. Pronounced DDZ of head tissues: fracture of subchondral bone plate surrounded by remnants of CX tissue (white arrows), fibrous nodule and dystrophic fibro-myxoid cysts (black arrows). Hematoxylin and eosin. Coll. 20.](image2)
General morphological assessment of the severity of DDZ in the femoral heads of patients with DKA. The general morphological assessment was made according to the known stages of osteoarthritis [16-19]. The criteria were changes that reflected the degree:

- Decrease in the thickness of the CX and the severity of the DDZ of its CX matrix (leading feature).
- Severity and prevalence of characteristic pathological changes in the tissue of subchondral spongiosis of the head.
- Deformation of the articular surface of the head.

According to the available pathological changes of the head, the low degree of DKA (I) is exposed only in one case, medium (II) - in 9, high (III) - in 11.

Differences in the frequency of pathological changes in certain areas of the femoral heads. In the loaded areas of the femoral heads, in contrast to the unloaded, changes of high severity were more often observed (Table 2): deformation of the joint surface, changes in the thickness of the CX, high or medium degree of DDZ in subchondral spongiosis. In unloaded areas of the femoral heads, the values of a high degree of the index were found for marginal cartilaginous growths. However, the comparison of the incidence of cases of a certain degree of severity of pathological changes in different parts of the articular surface of the heads did not reveal statistically significant differences.

| Morphological index                                      | Gradations of expression | Loaded | Unloaded | Probability of frequency difference by criterion $\chi^2$ |
|----------------------------------------------------------|--------------------------|--------|----------|--------------------------------------------------------|
| Deformation of the articular surface of the head         | Low degree               | 8      | 6        | 0.655                                                  |
|                                                          | High degree              | 11     | 3        |                                                       |
|CX thickness                                              | Low or medium degree     | 7      | 7        | 2.346                                                  |
|                                                          | High degree              | 14     | 3        |                                                       |
| Dystrophic and destructive changes of CX                 | Low or medium degree     | 10     | 4        | 0.268                                                  |
|                                                          | High degree              | 10     | 6        |                                                       |
|Superficial cartilaginous growths                         | Missing or small         | 16     | 9        | 0.299                                                  |
|                                                          | Common                   | 2      | 1        |                                                       |
| Marginal cartilaginous growths                           | Missing or small         | 8      | 4        | 0.753                                                  |
|                                                          | Common                   | 7      | 7        |                                                       |
| Dystrophic-destructive changes in subchondral spongiosis | Low or medium degree     | 13     | 5        | 0.394                                                  |
|                                                          | High degree              | 8      | 5        |                                                       |

Table 2: Frequency of cases of different morphological indicators of lesions and reparations in loaded and unloaded areas of the articular surface of the femoral head of patients with DKA.

Notes.
1. A more detailed description of the gradations in the text.
2. HB - the difference in the frequency of occurrence of cases of different gradations is not probable ($p > 0.1$).
Correlations of clinical and morphological parameters in patients with DKA. Correlation analysis of indicators that made up the pairs of cases “clinical - morphological” (Table 3) revealed the relationships that had the highest parameters of the association coefficient, between the following indicators: - “duration of the disease” - “the thickness of the CX on the surface of the head” - the dependence is positive, medium strength, with a probability of error $p < 0.1$. This means that more than a third of patients with DKA with a disease duration of more than 18 years, the thickness of the CX of the femoral head is significantly reduced and corresponds to the gradation of a high degree of this indicator; - “type of displacement of the femoral head (according to Crowe)” - “Marginal cartilaginous growths” - the dependence is positive, close to the range of average strength, probable ($p < 0.05$). This means that almost half of patients with DKA with displacement heads of degree II - IV according to Crowe marginal cartilaginous growths of high degree are probably present; - “VAS index before surgery” - “marginal bone and cartilage growths” - the dependence is positive, close to the range of medium strength, probable ($p < 0.05$), i.e. almost half of patients with DKA who had high parameters degree indicator of VAS, marginal bone-cartilage growths of considerable expressiveness are probably present; - “your difference before - after surgery” - “thickness of CX on the surface of the head” - the dependence is positive, weak, probable ($p < 0.05$), i.e. almost half of patients with DKA who had a high degree of parameter indicator “YOUR difference before - after surgery” (more than 2), it is probably combined with a significant reduction in the thickness of the CX; - “indicator of your difference before - after surgery” - “dystrophic-destructive changes in the sponge of the head” - the dependence is positive, weak ($p < 0.1$), i.e. almost half of patients with DKA who had a high degree of parameter indicator “YOUR difference before - after surgery” (more than 2), it is probably combined with a high severity of DDZ in subchondral spongiosis of the head. In our clinical and morphological study based on qualitative and semi-quantitative study of pathomorphological changes in the femoral head, the frequency parameters of cases with certain gradations of pathomorphological changes, their frequencies in areas of the head with different loads and correlations of morphological parameters with some clinical manifestations in patients with DKA, about which they were performed TEP COP.

| Clinical indicator | Morphological index | Pearson’s tetrachoric index (association coefficient) and the probability of its parameter |
|--------------------|---------------------|--------------------------------------------------------------------------------------|
|                    |                     | $n$, the number of cases with values of both indicators $| ra^1 | \phi | probability ra for $k = n - 1$ by Student’s $t$ test |
| The duration of the disease, years | CX thickness on the surface of the head | 20 | +0.385 | 1.866 | $< 0.1$ |
| Offset type femoral head (by Crowe) | Pathological changes of CX (predominance) | 20 | -0.302 | 1.414 | HB |
| | Marginal cartilaginous growths of the articular surface | 15 | +0.491 | 2.183 | $< 0.05$ |
| | Stage DKA, assessment by histological signs | 20 | -0.302 | 1.414 | HB |
| Your indicator: | Marginal cartilaginous growths of the articular surface | 15 | +0.491 | 2.183 | $< 0.05$ |
| - Before the operation; | | | | | |
| - After the operation; | CX thickness on the surface of the head | 20 | +0.453 | 2.273 | $< 0.05$ |
| | DDZ in spongiosis of the head | 20 | +0.390 | 1.893 | $< 0.1$ |

**Table 3:** Correlation between individual clinical and morphological indicators of femoral head lesions in patients with DKA.

Notes:
1. Only correlation pairs are left, where $ra \geq |0.3|$.
2. HB - estimation of the parameter of the association coefficient is not probable ($p > 0.1$).

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Previously studied the condition of the hip joints in patients with DKA concerned biomechanical modeling of the analysis of clinical manifestations, anamnestic data, X-ray morphometric parameters and the results of treatment of patients with coxarthrosis caused by DCS [20]. It was found that the most prognostically significant X-ray morphometric marker of the course of DKA is the value of the angle of the bearing surface of the acetabulum relative to the horizontal: the larger it is, the sooner we can expect to compensate for the course. As the value of the angle of inclination of the surface of the acetabulum increases, the values of the shear forces directed laterally and forward increase proportionally. Using factor analysis, the most important indicators for predicting the course of DKA were established. Among the primary factors, in addition to the value of the angle of inclination of the bearing surface, is also determined by the age of onset of signs of the disease and the force of shear acting in the joint. In addition to these indicators, the classification developed by the author also considers the cervical-diaphyseal angle, which reflects the degree of dysplasia of the proximal femur. However, in this work it is suggested that the degree of dysplasia of the proximal thigh new bone (by the parameter of the cervical-diaphyseal angle) has a much smaller impact on the development and course of DKA compared with changes in the acetabular component of the hip joint. In particular, for the angle of the bearing surface of the acetabulum, the author proposed five steps, and for the cervical-diaphyseal angle - three. This study did not study the qualitative and quantitative features of DDZ tissues in the acetabulum and in the proximal femur, which should increase the provability of the results of correlation analysis of the links of biomechanical, X-ray morphometric and morphological parameters, which directly reflect the condition of the tissues of the affected joint surfaces.

Another work devoted to the study of the structure of the acetabulum under the conditions of DKA, which determined the X-ray anthropometric characteristics of the acetabulum, found that DKA is characterized by an increase in the width of the acetabulum and the thickness of its bottom against a decrease in depth and index depressions, which made it possible to distinguish a special specific dysplastic deformation [3]. In this case, a probable direct strong correlation was found between the degree of DKA according to Eftekhar and the thickness of the bottom of the acetabulum. There are no similar analytical morphological data in the literature on pathological changes of the femoral head by DKA. The results of our pathomorphological study to some extent complement the information about the features of the damage to the tissues of the hip joint by DKA.

Pathohistological examination of the CX of the femoral head of 45 patients with spondyloepiphyseal dysplasia, performed with our participation, revealed some pathological changes mainly in the CX matrix. Violation of the distribution and orientation of type II collagen was found, which negatively affects the mechanical strength of CX and causes the development of DKA at a young age. It is also shown that in subchondral spongiosis of the femoral head an inflammatory process continues, which is accompanied by destructive disorders in the tissues of the subchondral bone plate. In some cases, productive inflammation was found in the capsule of the hip joint, which suggests its role as an important pathogenetic factor in the development of trophic disorders of the CX tissue and the progression of DDZ of the hip joint [2,9].

In one of our previous works, devoted to the study of histopathology of the tissues of the hip of the joint with determination of the frequency of occurrence and correlations between individual morphological parameters under conditions of severe DKA, the most significant changes of the articular surface of the head: deformation, reduction of CX thickness due to dystrophy and deep destruction, superficial and marginal bone and cartilage, DDZ of tissues of subchondral spongiosis [11]. Correlation dependences were established between the morphological indicators of the condition of the head tissues under the conditions of DKA, which had different parameters of the association coefficient (absolute value, sign and degree of probability). The obtained data on the dependences of the indicators of the type “morphology - morphology” can be used to predict the parameters of unknown values of some pathological changes of the femoral heads by known values of some others, which are determined, for example by clinical and visual methods, in patients with DKA, which is a consequence of long-term dysplasia of the hip joint.

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Due to the submitted clinical and pathomorphological a number of previously unknown features of the frequency of occurrence of certain pathomorphological changes of the articular ends, first of all in the femoral head of patients with DKA, and comparison of frequencies in the areas of the head with different loading conditions were established. Also, previously unknown correlations between some clinical manifestations in patients at the time of TEP CS and nonparametric morphological parameters were identified, with the determination of the absolute value, sign and degree of probability of the parameters of the association coefficient.

The conclusions made in the work open up ability to predict the condition of the tissues of the femoral head, which is important when planning the features of installation and fixation of the femoral component of endoprostheses in the case of TEP CS patients with DKA of different age, such as Crowe head displacement and the degree of joint dysfunction, visual-analog scale.

Conclusion

As a result of pathomorphological examination of the femoral head, performed on biopsy-resection material from patients with DKA, who performed TEP CS, found the presence of signs of dystrophic-destructive lesions of the articular end of the head and some features that give grounds to consider morphological manifestations of DKA as such that do not always coincide.

In the complex of pathomorphological changes of the articular surface of the femoral head the most significant are deformation of the articular surface, reduction of CX thickness due to its dystrophy and destruction, superficial and marginal cartilaginous growths, dystrophic, ischemic-necrotic, destructive and reparative and reparative. These pathological changes occur with different frequency and in some cases are combined in different degrees of severity.

There are correlations between separate clinical indicators of patients and morphological indicators of a condition of fabrics of a head of a femur on DKA from which the largest parameters of coefficient of association have such pairs.

"Clinic-morphology":

- "Prescription of the disease" - “the thickness of the CX on the surface of the head” - the dependence is positive, moderate.
- “Type Of displacement of the femoral head (according to Crowe)” - "Marginal cartilaginous growths" - positive dependence, close to the range of medium strength.
- "Your index before surgery" - “marginal bone and cartilage growths” - the dependence is positive, close to the range of average strength, probable.
- "Your difference before - after surgery" - “thickness of the CX on the surface of the head” - the dependence is positive, weak.
- "Your indicator difference before - after surgery" - “dystrophic-destructive changes in the spongiosis of the head” - the dependence is positive, weak.

Conflict of Interest

The authors declare no conflict of interest.
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Volume 12 Issue 5 May 2021
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