

## ***MRI-semiotics of the gluteal muscles in patients with avascular necrosis of the femoral head and Legg-Calve-Perthes disease***

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**Objective** To explore the gluteal muscles in patients with avascular necrosis of the femoral head and Legg-Calve-Perthes disease using magnetic resonance imaging (MRI). **Material and methods** MRI was used to examine gluteal muscles in 20 patients with avascular necrosis of the femoral head and Legg-Calve-Perthes disease. There were 8 female and 12 male patients aged from 6 to 18 years. **Results** The extent of MRI changes detected in femoral abductors of patients with avascular necrosis of the femoral head and Legg-Calve-Perthes disease was dependent on the grade and onset of the disease and patient age. There were differences found in thickness, length and area of the m. gluteus maximus, m. gluteus medius and m. gluteus minimus in unilateral involvement. Maximum changes were revealed in children aged 14-17 years with grades 3 and 4 of the disease. There was a greater decrease in length of m. gluteus minimus as compared to that of m. gluteus medius. **Conclusion** The findings revealed anatomical (area, thickness, length) and radiomorphological changes in the gluteal muscles of patients with avascular necrosis of the femoral head and Legg-Calve-Perthes disease that were dependent on the grade and onset of the disease and patient age, and indicated to close relationship between anatomy and function of the joint and muscles. **Keywords:** hip joint, avascular necrosis of the femoral head, Legg-Calve-Perthes disease, gluteal muscles, MRI

### INTRODUCTION

Although juvenile osteochondrosis of the femoral head (Legg-Calvé-Perthes disease) and avascular bone necrosis have been studied extensively for at least 100 years there are still controversies in etiology of the disease and optimal treatment of the condition [1–8]. Changes in the femoral head in Legg-Calvé-Perthes disease and avascular necrosis evaluated with imaging modalities (MSCT, MRI, US) are well described at different stages of the disease [9–11]. MRI provides good visualization of the cartilage of the femoral head and evaluation of the genuine shape of the proximal femur, severity of extrusion and superior lateral capital displacement, and condition of the articular

labrum. Subchondral fracture can be identified at early stages [12–17]. There are studies reporting of normal picture of the soft tissues surrounding the hip joint and the osseous components examined with MRI and MSCT [18, 19]. Contractility of thigh muscles with biomechanically disturbed functioning was studied in patients with hip pathologies as well as condition of lower limb muscles in children with affected hip [20, 21]. However, there have been no studies that would quantitatively examine gluteal muscles in pediatric hip pathologies using MRI. Nevertheless, there are studies describing hypotrophy or atrophy of gluteal or thigh muscles in Perthes disease [12, 22–24].

### MATERIAL AND METHODS

Magnetic resonance imaging was performed for 20 patients with avascular necrosis of the femoral head and Legg-Calvé-Perthes disease. The patients' age ranged from 5 years to 16 years prior to the treatment. Two patients had bilateral involvement. MRI was performed with a 1.5T unit (Siemens Magnetom Symphony). T2 tse and t1 fl2d coronal, axial and sagittal images of the hip joints were obtained with or without fat suppression to measure gluteal thickness, length and area and compare MR-signal with contralateral side (Fig. 1).

The study was performed in accordance with ethical principles for medical research involving human subjects stated in the Declaration of Helsinki developed by the World Medical Association as revised in 2000 and Order No. 266 of June 19, 2003 On Approval of Rules of Good Clinical Practice in the Russian Federation. Written informed consent was obtained from all patients and their legal representatives for publication of the findings without identifying details.

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**Fig. 1** MR T2WI axial image of the hip joints of a 5-year-old patient M. with Legg-Calvé-Perthes disease showing measurements of an area and relative density of gluteal muscles

## RESULTS

Changes in gluteal muscles of patients with Legg-Calvé-Perthes disease and avascular bone necrosis were characterized by general manifestations taking into consideration general etiological factors and clinical features. An area and thickness of muscles appeared to decrease as compared to the normal side. An extent of changes was dependent on severity of destruction of the femoral head, presence of limb shortening, onset of the disease, presence of pathology in the contralateral side. The older the patient the greater decrease in the muscle area was observed (Fig. 2).

Table 1 presents an area of gluteal muscles in patients with Legg-Calvé-Perthes disease depending on patient's age and stage of the disease.

Decreased length of m. gluteus medius and m. gluteus minimus was observed in coronal MR images. Measurements of the m. gluteus minimus showed greater decrease in length than the m. gluteus medius as compared with the contralateral side of all patients. Figure 3 demonstrates the length of the m. gluteus medius and the m. gluteus minimus on the left (pathologically changed femoral head) being decreased by 14.0 % and 31.4 %, respectively.

Statistical data analysis was performed using Microsoft EXCEL-2010 and Attestat-2001 computer program. The Shapiro-Wilk test was used to examine normal distribution in a population. We performed Student t test for normally distributed variables and nonparametric Mann-Whitney U-test and Wilcoxon rank-sum test for variables that were not normally distributed. We set the significance threshold at 0.05. The research was performed as a retrospective unicenter full-design study.

Changes in the muscles' length were likely to be associated with hypotrophic and short muscles.



**Fig. 2** MR T2-tse axial image of the hip joints of an 8-year-old patient M. with grade 2 Legg-Calvé-Perthes disease showing measurements of an area of m. gluteus maximus, m. gluteus medius and m. gluteus minimus. A decrease in area of the right-side m. gluteus minimus was 20.8 %, m. gluteus medius, 3.3 % and m. gluteus maximus 22.1 %

Alterations in the thickness of the m. gluteus medius and the m. gluteus minimus were more expressed in unilateral involvement with a longer period of the disease and more considerable changes identified in the femoral head. Maximal changes were observed in patients aged 13 years and over, 15-16 years, in particular, and with grade III of the disease (Fig. 4, 5).

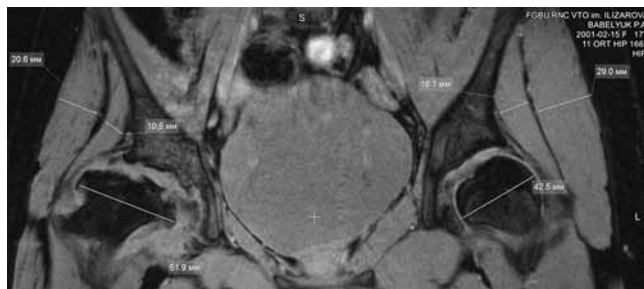
Table 1

Area of gluteal muscles in patients with Legg-Calvé-Perthes disease depending on patient's age and stage of the disease (mm<sup>2</sup>)

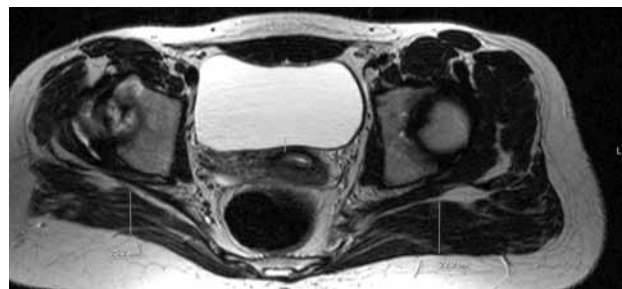
Site of interest	Stage of the disease					
	2			3–4		
	Age					
	5–8	9–12	13–16	5–8	9–12	13–16
Musculus gluteus maximus	1302 ± 186.6	1588.9 ± 234.4	–	1248.4 ± 175.1	1548 ± 211.1	1856.7 ± 475.6
Musculus gluteus medius	677 ± 92.7	1341.3 ± 132.6	–	699.8 ± 85.5	1246.7 ± 117.2	1499.3 ± 278.1
Musculus gluteus minimus	452 ± 56.1	577.4 ± 48.6	–	472.9 ± 56.2	347.5 ± 98.7	896.9 ± 17.5



**Fig. 3** MR T2WI coronal image of the hip joints of a 5-year-old patient M. with grade 3 Legg-Calvé-Perthes disease showing length measurements of the m. gluteus medius and the m. gluteus minimus



**Fig. 4** Postoperative MR t2-fl2d fs coronal image of the hip joints of a 17-year-old patient B. with grade 4 avascular necrosis of the femoral head on the right, grade 3 DOA showing measurements of thickness of the m. gluteus medius and the m. gluteus minimus. M. gluteus medius and the m. gluteus minimus on the left appeared to be thicker by 29.0 % and 34.8 %, respectively



**Fig. 5** Postoperative MR t2-fl2d fs axial image of the hip joints of a 17-year-old patient B. with grade 4 avascular necrosis of the femoral head on the right, grade 3 DOA showing measurements of thickness of the m. gluteus medius and the m. gluteus minimus. M. gluteus medius and the m. gluteus minimus on the left appeared to be thicker by 16.7 %.

Radiomorphological manifestations of impaired muscle structures were clearly observed with considerably increased distance and altered direction

between muscle fibres, alterations in signal muscle intensity in addition to changes in anatomical characteristics (length, thickness, shape).

## DISCUSSION

Early detection of avascular bone necrosis of the femoral head and Legg-Calvé-Perthes disease using a variety of imaging modalities constitutes an important objective [9, 10, 17, 25–27]. MRI can be useful early in the disease's course in order to change the clinical scenario of avascular necrosis of the femoral head and Legg-Calvé-Perthes disease, provide the possibility of multiple monitoring of the condition, visualize osseous and soft tissue structures of the hip joint and verify presence of synovitis [11]. Hip evaluation protocols have been suggested at suspicion of inflammation in the femoral head to identify localization and dimension of necrosis, integrity of articular surfaces and subchondral fractures with MRI-semiotics of stages of the disease properly studied [10, 15, 17, 27–29]. Unfortunately, there are very few publications describing changes in the para-articular tissues of the hip and there is

no evidence of gluteal muscles' condition having a significant role in the hip function [11, 12, 14, 24, 30]. Multiple studies focus on close relationship between the anatomy and biomechanics of the gluteal muscles and the hip joint and the spine [22, 30–34]. It is difficult to suggest that expressed changes in the hip, limited range of motion in the joint, decreased weight-bearing would not result in disturbed structure and function of the hip abductor muscles [22, 35, 36]. The extent of MRI changes detected in femoral abductors of patients with avascular necrosis of the femoral head and Legg-Calvé-Perthes disease was dependent on the grade and onset of the disease and patient age. There were differences found in thickness, length and area of the m. gluteus maximus, m. gluteus medius and m. gluteus minimus in unilateral involvement. Maximum changes were revealed in children aged 14–17 years with grades 3 and 4 of the

disease. There was a greater decrease in length of the m. gluteus minimus as compared to that of the m. gluteus medius. Our previous studies of the gluteal muscles evaluated in different pathologies as well researches performed by different authors allow us to suggest that the gluteal muscles can be employed for screening detection of a hip pathology in absence

of radiological evidence of the condition or can indicate to the necessity of rehabilitation of the affected joint since the muscle reaction to the limited range of motion and decreased weight-bearing on the joint with pain are most likely to rapidly lead to hypotrophy of the m. gluteus medius and the m. gluteus minimus [31, 33, 34, 36, 37].

## CONCLUSION

The findings revealed anatomical (area, thickness, length) and radiomorphological changes in the gluteal muscles of patients with avascular necrosis of the

femoral head and Legg-Calvé-Perthes disease that were dependent on the grade and onset of the disease and patient age, and indicated to close relationship between.

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