Original article

Evaluation of the bone mineral density of the subjects with avascular necrosis of hip joint

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Summary

Background. **The head of femur is deformed in subjects with Leg Calve Perthes Disease (LCPD). It may be due to an increase in loads applied on the hip, decrease in hip joint containment and decrease in bone mineral density (BMD) of femur. Unfortunately there is not enough evidence regarding BMD of femur in subjects with LCPD. Therefore, the aim of this study is to evaluate BMD in subjects with Perthes disease.**
Method. **Two subjects with LCPD participated in this study. The BMD and Young modulus of elasticity (E) of different parts of femur of both Perthes and sound sides were evaluated by use of Mimics software. The difference between BMD of femur in both sides of each subject was compared by use of two sample t test.**
Results. **There was no difference between the BMD and E modulus of femur in Perthes and sound sides in both subjects (p-value>0.05).**
Conclusion. **As there is no difference between the BMD of femur in Perthes side, it can be concluded that the deformation of femur in these subjects may not be due to a change in BMD.**

KEY WORDS: bone mineral density; Perthes; mimics.

Introduction

Leg Calve Perthes Disease (LCPD) is defined as a disease in which the blood supply of femoral head is disconnected and the bone temporarily dies (1, 2). The femoral head of involved side deformed due to excessive loads applied on it, or decrease in hip joint containment and decrease in bone mineral density (BMD) (1, 3, 4). Various types of treatment have being used to decrease the loads applied on the hip joint and to improve hip joint containment (4-10). Although various types of assistive devices and surgeries methods have being used to enhance the aforementioned goals, the output of treatment is not successful, based on final deformation of femoral head (4). The results of gait analysis studies confirmed that the magnitude of loads applied on femoral head in Perthes subjects was less than that of normal subjects, due to their gait pattern (11-13). Therefore, the deformation of femoral head may be due to decrease in BMD.
There is no doubt that BMD depends on the loads applied on the bone (14). Baily et al. measured BMD of femoral head in Perthes subjects. They showed that BMD of femoral head in Perthes side was less than that in normal side, which may be due to decrease in loads applied on the bone (14). Moreover, they showed that the minimum and maximum difference between BMD of normal and Perthes sides was related to femoral neck (3.9%) and all other regions. Unfortunately there is no information regarding the change in BMD in Perthes side in these subjects at the time of diagnosis. If the BMD of the bone decreased in the first stage of the disease, the deformation of the femoral bone may be due to this factor. Therefore, the aim of this study was to check the change in BMD in this group of subjects. The main hypothesis associated with this study was that the BMD in Perthes side decreased significantly.

Material

Two subjects with LCPD in the right side participated in this study. Their weight, height were 24.2±1.5 Kg and 1.52±0.12 m, respectively. The severity of LCPD was scored using the classification recommended by Mose et al. based on the latest follow up X-ray (15). An ethical approval was obtained from Isfahan University of Medical Sciences, ethical committee. A consent form was signed by the parents of each participant before data collection.
The BMD of the Perthes and sound sides was determined based on CT scans of the subjects. CT scans produced multiple X-ray slides of the hip joints of the subjects which can be reconstructed digitally into a volume. The output is divided up into small volume called voxels, which contains a gray level value derived from X-ray attenuation at that point (16-18). It has been shown that the number of voxel directly related to the density of material. The raw voxalized output from CT was used to produce C3D models of the hip joint by use of Mimics software. The models were exported to Abaqus to change the mesh format from three to tetra. The produced volume mesh was imported to Mimics to assign the materials. This software defines a number of sampling points within each element and interpolates the gray level relating to their coordinates from the original CT (19).
Gray level is proportional to apparent bone density. Young modulus (E) was the other parameter evaluated in this study. The calculation of E was done automatically by Mimics software based on equation developed by Schileo et al. and Morgan et al. (16, 18)

$$E= 6850\rho^{1.49}$$

in which E was Young modulus and ρ was apparent bone density. As can be seen from Figure 1, the BMD of different segments of the bone was determined by the software. The difference be-

Table 1 - The mean values of BMD and E modulus of the different parts of the femur of both subjects.

Participants	Subject 1		Subject 2	
	BMD (g/mm³)	E modulus (Pascal)	BMD (g/mm³)	E modulus (Pascal)
Sound side	784604.2±445901.4	4619368361±3252805990	928249.5±570285.2	4941866205±3056360410
Perthes side	805129.9±467632.5	4770396420±2770722483	900077.3±564158	4648782493±2642671981
p-value	0.46	0.46	0.45	0.41

tween BMD of the bone in the sound and effected sides was determined by use of two sample t test in each subject.

Results

The mean values of the density of femoral bone in Perthes and sound sides were 805129.9±467632.5 g/cm³ and 784604.2±4459019.4 g/cm³, respectively in subject 1 (p-value=0.46). The density of the bone in both sides of both subjects is shown in Table 1. As can be seen from this table there was no difference between the density and E modulus of bone in the sound and Perthes sides.

Discussion

Increase in loads applied on the hip joint articular surfaces; decrease in hip joint containment and decrease in bone mineral density of femoral head are the main three reasons mentioned for deformation of femoral bone (4). The results of previous studies confirmed that the loads on Perthes side decreased compared to sound side. It is not cleared that the BMD of femoral head differed in Perthes side compared to normal side or not. Therefore, the aim of this study was to check the BMD of femoral head in Perthes side compared to sound side.

The results of this study showed that there was no difference between the BMD of femur in Perthes side compared to normal side, Table 1. Moreover, the Young Modulus of elasticity did not differ significantly between normal and Perthes sides. Therefore, the deformation of femoral head in this disease is not due to change in BMD.

Based on the available literature, the femoral head in Perthes subjects deformed as the bone temporarily dies (1, 3). This may be due to change in BMD of femoral bone. There is no doubt that BMD depends on the loads applied on the bone. However in Perthes subject, the loads applied on femoral head in Perthes side decreased significantly (11, 12, 20). Therefore, the BMD of femoral head should be decreased due to a change in applied loads. In the research done by Bailey et al., the BMD of femoral bone in Perthes and sound sides was evaluated (14). They measured the BMD in trochanter, intertrochanteric, femoral neck and total region. Based on their study the BMD of Perthes side differed significantly compared to sound side. However the results of the current study did not support the finding of Bailey et al. (14). The main reason may be due to deformation of the hip bone. It means that the deformed femoral bone had the same and also a little bit more density than normal side.

The interesting point is that the subjects with Perthes disease referred to clinicians when they have pain and some walking limitations. It seems that it happened when the bone deformed. If this assumption be true, it may be the reason why most of treatment

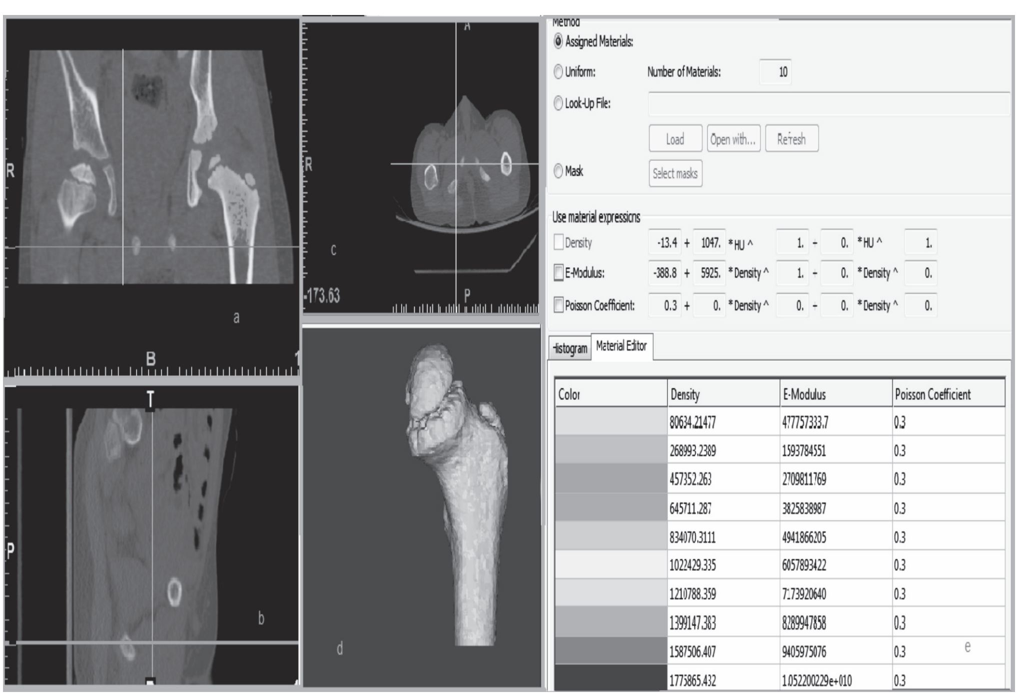

Figure 1 - Calculation of BMD and E modulus by use of Mimics software, a: frontal view of femur, b: sagittal view, c: transverse view, d: 3d view of femur and e: the calculated parameters.

approaches are not successful. The subjects examined in this study were referred to clinicians after 6 months of symptoms. Therefore, they had deformed femoral bone with no change in BMD. It should be emphasized that only two subjects were recruited in this study. Therefore, it is recommended that this study be done in more number of subjects.

Conclusion

The results of this study confirmed that the BMD of femoral head did not differ from normal side. It may be the reason why most of the treatment approaches are not successful to decreased the deformation of the hip bone.

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