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Preoperative qualitative assessment of acetabular spongious bone applicable to THR during DDH

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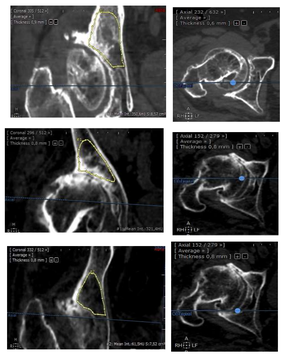
Background. Total hip replacement (THR) during developmental dysplasia of the hip (DDH) is associated with a large percentage of unfavourable results comparatively with other hip joint pathology, firstly resulted from cup instability due to markable acetabular spongious bone degeneration. Since the implantation of acetabular component into poor-quality bone is considered to be a risk factor for its instability, and routine DXA is invalid for intimate assessment of acetabular bone density, preoperative evaluation of bone density directly in the presumed implantation site via special technique seems to be required.

Materials and methods. There were revealed a complex comparative MSCT-mophometric assessment of acetabular spongious bone X-ray density (attenuation coefficient) due to proposed technique of 32 normal hips and 65 hips with DDH (Crowe I - 26 hips, Crowe II – 23 hips, Crowe III - 16 hips). Evaluation of qualitative changes of the acetabular medial wall bone stock during DDH was performed via determining the MSCT-radiological density of spongious bone tissue according to the developed method among patients of the norm group and pathology group, after preliminary dual-energy X-ray absorptiometry (DXA) of the lumbar spine with the following excluding of patients with the signs of osteoporosis at the pre-analytical stage of the study in order to eliminate the impact of systemic disorders of mineral metabolism on the local spongious bone density of the presumed AC implantation site and on the dynamics of their changes during the dysplastic process.

Fig.1. Methodic for measuring the X-ray density of the spongious bone tissue of the supraacetabular area.



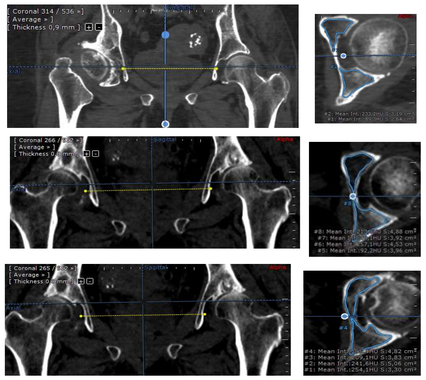
a - MSCT topogram for measuring the X-ray density of the spongious bone tissue of the supraacetabular area at the site of projection of the round ligament's bed;

b - MSCT topogram for measuring the X-ray density of the spongious bone tissue of the supraacetabular area at the level of 10 mm in the ventral direction from the round ligament's bed;

c - MSCT topogram for measuring the X-ray density of the spongious bone tissue of the supraacetabular area at the level of 10 mm in the dorsal direction from the round ligament's bed.

After measuring the absolute values of the attenuation coefficient at each of these points were determined the average values for each of the respective zones: supraacetabular area, anterior and posterior walls. This method of data processing allowed to obtain averaged values of the coefficient of a particular zone and to minimize the bias of the assessment due to possible local cystic-sclerotic processes.

Fig.2. Methodic for measuring the X-ray density of the spongious bone tissue of anterior and posterior acetabular walls.



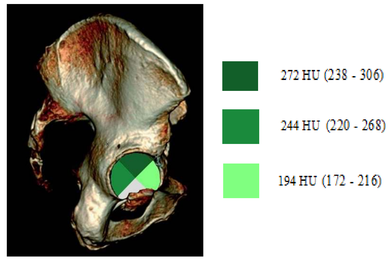
a - MSCT topogram for measuring the X-ray density of the spongious bone tissue of anterior and posterior acetabular walls at the site of projection of the round ligament's bed;

b - MSCT topogram for measuring the X-ray density of the spongious bone tissue of anterior and posterior acetabular walls at the level of 5 mm in the cranial direction from the level of the bed of the round ligament;

c - MSCT topogram for measuring the X-ray density of the spongious bone tissue of anterior and posterior acetabular walls at the level of 10 mm in the cranial direction from the level of the round ligament bed.

Obtained results were stratified due to dysplastic sectoral deficiency subtype: antero-lateral, postero-lateral or total deficiency. Mann-Whitney test and one-way analysis of variance was used to compare continuous variables between groups. Correlations between two continuous parameters were evaluated using Spearman's rank correlation coefficient. A p value < 0.05 was considered significant. Data presented as Me (95% CI).

Fig. 3. Normal distribution of the acetabular spongious bone X-ray density with regard to the topographical areas: supraacetabular area, anterior and posterior acetabular walls.



Results. There were defined physiological norm values of acetabular spongious bone X-ray density due to proposed topographic zones (fig. 3) as well as it's values during DDH with regard to the sectoral deficiency subtype (tab.1). All dysplastic hips showed increasing of X-ray density of supraacetabular area up to 334 HU (302 - 366 HU), 292 HU (268 - 316 HU), 428HU (402 - 454 HU) in cases of antero-superior, postero-superior and total deficiency, respectively (fig.4).

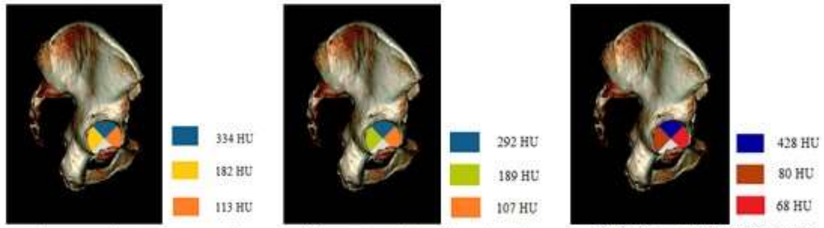


Fig. 4. Distribution of the acetabular spongious bone X-ray density respectively to the sectoral deficiency patterns and topographical areas

Topographical location for index evaluation	Norm values	Acetabular sectoral coverage deficiency subtype		
		Antero-superior sectoral deficiency	Postero-superior sectoral deficiency	Total deficiency
Supraacetabular area	272 HU (238 - 306 HU)	334 HU * (302 - 366 HU)	292 HU*,** (268 - 316 HU)	428HU*,** (402 - 454 HU)
Anterior acetabular wall	194 HU (172 - 216 HU)	113 HU * (99 - 127 HU)	107 HU * (88 - 126 HU)	68 HU*,** (52 - 84 HU)
Posterior acetabular wall	244 HU (220 - 268 HU)	182 HU * (167 - 197 HU)	189 HU * (160 - 209 HU)	80 HU*,** (64 - 96 HU)

Table 1. Values of the acetabular spongious bone attenuation coefficient respectively to the sectoral deficiency patterns and topographical areas.

There were determined progressive increase of the X-ray density in supraacetabular area ($r = 0,89$, $p < 0,00001$) and steady decrease of anterior ($r = -0,85$, $p < 0,00001$) and posterior ($r = -0,75$, $p < 0,00001$) walls' ones in correlation with the femoral head cranial displacement.

Conclusion. There were proposed a method of preoperative assessment of X-ray bone density of the presumed acetabular component's implantation site according to local topographic landmarks. MSCT HU-quantification seemstobeanreliable method for evaluation of the spongious bone tissue density of the acetabular area based and diagnosing of its local changes during preoperative planning for THR in case of DDH.

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