Does the classification systems used in case of dysplastic hips actually aid in the planning of the acetabular replacement?

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Abstract
The authors would like to know how accurately the superolateral coverage of the acetabular component can be determined by using the most wide-spread classification of Hartofilakidis[17] and Crowe[5] on AP radiographs of the pelvis. Can it determine whether there will be a need for replacement of the acetabular defect during surgery?
At the University of Debrecen MHSC, Department of Orthopaedics we performed measurements on X-rays and CT scans of 21 hips from 16 patients. With the data obtained by geometrical and mathematical methods we can conclude that neither of the classifications alone provides enough information for accurate preoperative planning. The scale of the superolateral acetabular defect is influenced by other factors beside the cranial migration. For precise surgical planning further X-ray and CT scans are necessary. Based on our own experiences we also recommend the use of 3D models made with the rapid prototyping technique.

Keywords: acetabular replacement, surgical planning

Introduction

The prosthetic replacement of the dysplastic hip can still be challenging even with research and development made in the last decades.

The main problem is due to the geometric incompatibility of the acetabulum with the replacement cup. During the development of the acetabulum the relationship between the femoral head and the acetabulum show abnormal changes resulting in the deformities characteristic of the disease. The dysplastic acetabulum is shallow, cranially elongated and the roof is steep. Different anterior wall defects are also common due to the increased antitorsion of the femur.

The characteristic deformities are shown on a 3D printed model *(Figure 1)*.

It can be seen that if we would like to implant a hemisphere shaped acetabular cup into an environment like this there will be incompatibility depending on the degree of dysplasia *(Figure 2)*.

Even after the proper positioning of the acetabular cup this incongruence will be mostly noticeable by the different uncovered areas on the cup *(Figure 3)*.

One of the pivotal questions when positioning the cup is whether the implantation should always be at the primary rotational

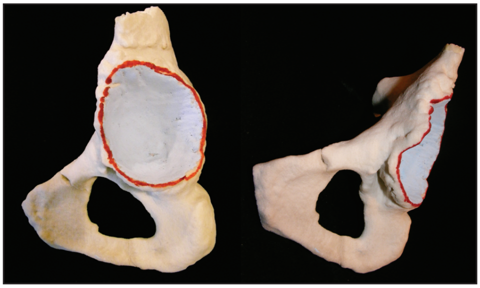

Figure 1. Dysplastic acetabulum

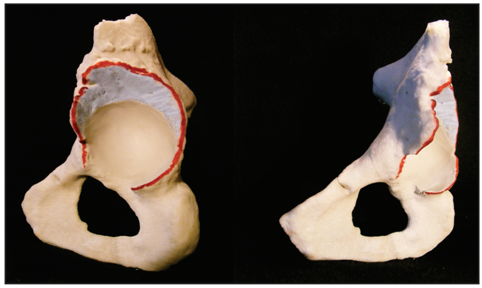

Figure 2. Dysplastic acetabulum after preparation for the replacement cup

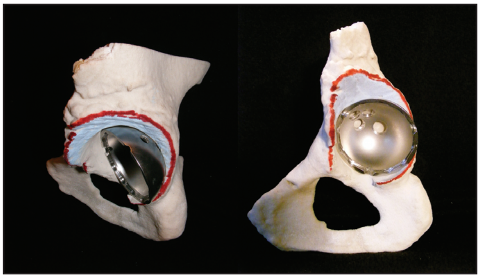

Figure 3. The superolateral uncovered area of the cementless acetabular cup

center of the hip joint, or are different locations allowed. Most of the authors in the literature dealing with this topic[22,30,35] prefer to place the prosthesis in the primary rotational center taking into consideration the bone stock of the pelvis and the function of the muscles responsible for stabilization this is the best way to restore normal biomechanical relations. There are some publications of good results following a more cranial positioning[2,8,21,28]. Opinions seem to agree that the lateralization of the acetabular cup[27] gives unfavorable results.

The quality and quantity of bone surrounding the acetabular implant is in direct correlation with the short and especially long term stability, dealing with this is unavoidable for the surgeon.

The literature provides a number of solution for dealing with this problem[1,4,13,15,16,18,19,20,26,29,31,32,34,35], but all the authors seem to agree that the superolateral defect does not necessarily have to be augmented if the anterior and posterior columns are intact and the coverage of the cup is no less than 80%[2,11,18].

We found a number of different classification systems for adult hip dysplasia[5,10,17,23,25]. We studied the two most accepted in the international literature in detail, that is the Hartofilakidis and Crowe classification.

Hartofilakidis formed 3 groups based on the relationship of the acetabulum and the femoral head:

- I. Slight dislocation: the femoral head is contained within the original true acetabulum
- II. Low dislocation: the false and the true acetabulum overlap each other
- III. High dislocation: the femoral head has migrated superoposteriorly into a false acetabulum

Within each group he examined 4 parameters:

1. the segmental defect of the acetabulum
2. the anteversion and depth of the primary acetabulum, the distance between the anterior and posterior wall
3. the quantity of the acetabular bone stock
4. the presence of osteophytes in the true and false acetabulum

The Hartofilakidis classification is based on the surgical findings from a 158 hips of 102 patients. In 87.4% of the cases the classification of the 3 independent examiners concord with the intraoperative findings[33].

Crowe examined the degree of cranial dislocation of the femoral head on AP pelvic X-rays. His results were given in the percentage of dislocation of the femoral head.

Degree of cranial dislocation:

I. less than 50%
II. between 50–75%
III. between 75–100%
IV. above 100%, complete dislocation

The value of the two classifications was assessed by Decking[7]. Three observers independently classified 62 dysplastic hips of 51 patients according to the criteria defined by Hartofilakidis and by Crowe. Inter-observer reliability displayed a weighted kappa coefficient of 0.82 in the case of the Crowe and 0.75 in case of the Hartofilakidis classification. To assess intra-observer reliability the examination was performed by the same observers three months later and showed a kappa coefficient of 0.86 and 0.79 respectively.

Due to the complications in surgical technique that can arise, all prosthetic replacement of dysplastic hips requires thorough preoperative planning. At the University of Debrecen, Department of Orthopaedics besides the usual X-rays we also routinely perform CT scans in spiral mode to be used for 3D reconstruction. We also have the opportunity to cooperate with the University of Debrecen, Department of Biomechanics where with the aid of rapid prototyping[6,24] we have a chance to print the tough cases for preoperative modeling of the planned procedure. During the preoperative planning is when the question arouse, that do the above mentioned classifications besides making communication easier really aid in surgical planning. By classifying AP radiographs according to the criteria mentioned above can we be able to determine the superolateral coverage of the implanted acetabular cup in every case? Should we be prepared for graft implantation?

Material and methods

We examined the data of treated hip dysplasia patients at the UDMHSC, Department of Orthopaedics. We selected those cases where complete radiograph and CT documentation was available. 21 hips of 16 patients were examined.

On the horizontal slices of CT scans we measured the largest distance between the anterior and the posterior walls of the acetabulum this way we could roughly judge the size of the cup needed.

We classified the AP pelvic radiograph according to both Hartofilakidis and Crowe. In borderline cases we used frontal scans from the CT to decide which group to classify it in. A number of authors[12,27,28] deal with the determination of the primary rotational center of the hip. In our case we used the method popularized by Fessy[12] *(Figure 4)*.

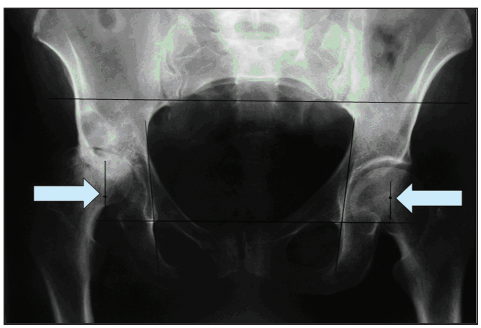

Figure 4. The determination of the primary rotational center of the hip according to Fessy

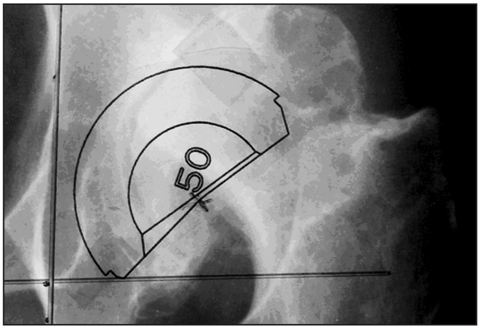

Figure 5. Placing the proper sized template as determined by the CT on the rotational center of the hip

By using the template of the proper size cup as determined from the CT we placed it on the rotational center of the hip on the radiograph and took digital pictures of it *(Figure 5)*.

With the aid of a graphics program we edited the digital pictures to determine the degree of the cup that is not covered by acetabular bone, and with this we determined the percentage of the cup left uncovered compared to the total circumference *(Figure 6)*.

We made graphs of the obtained data and examined the relationship between the classifications and the coverage of the implanted cup.

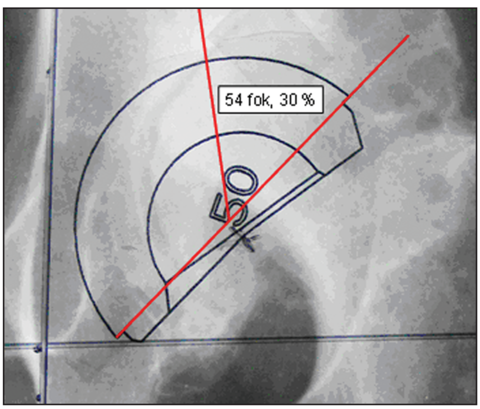

Figure 6. The determination of the uncovered part of the acetabulum in degrees and percentage

Results

In our examination we discarded those cases with high dislocations (Hartofilakidis III, Crowe IV), because it is obvious that in order to implant a prosthesis if at all possible would require bone grafting.

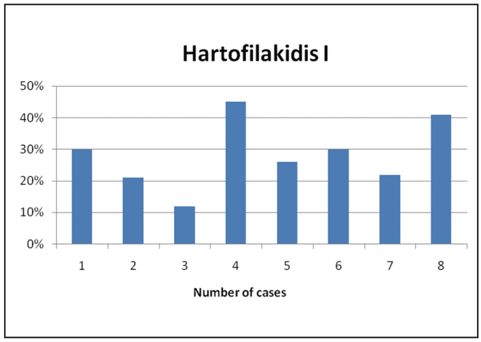

Table 1. The uncovered percentage of the implanted cup in Hartofilakidis group I

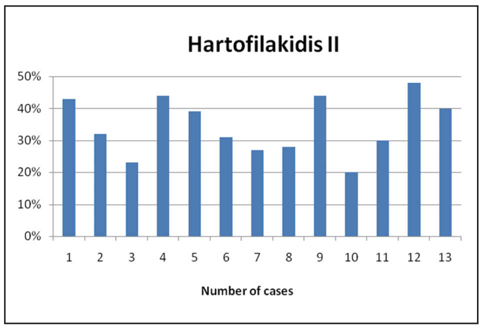

Table 2. The uncovered percentage of the implanted cup in Hartofilakidis group II

Due to the small number of cases we did not perform statistical analysis, but a few conclusions can never the less be drawn from the graph.

1. In case of Hartofilakidis I and II *(Table 1, 2)* it can be seen that there is wide dispersion in the coverage of the implanted cup. This means that both groups contain cases that from a surgical point of view should belong to a less or more severe group.

2. It can also be seen that if we draw the line at 20% of uncoverage than both groups contain mostly cases where bone grafting would be necessary.

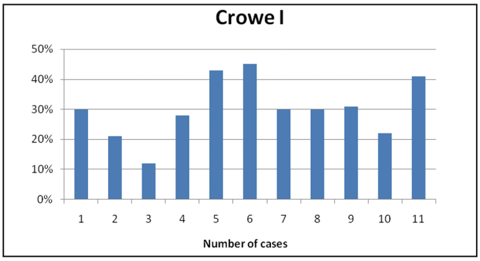

Table 3. The uncovered percentage of the implanted cup in Crowe group I

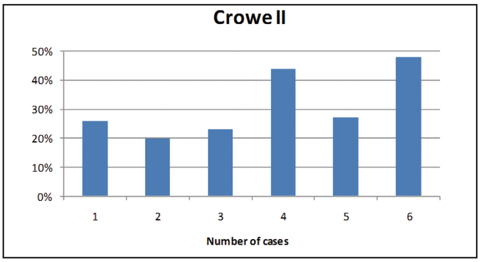

Table 4. The uncovered percentage of the implanted cup in Crowe group II

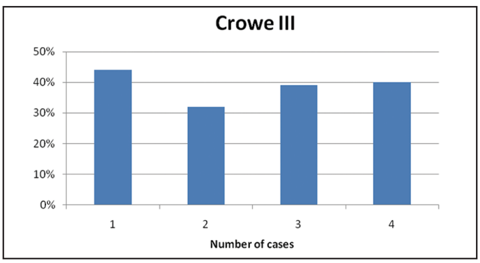

Table 5. The uncovered percentage of the implanted cup in Crowe group III

1. When examining according to the Crowe classification *(Table 3. 4. 5.)* the result are still scattered although within each group they are more homogeneous. The most likely reason for this is, that unlike the Hartofilakidis classification, here there are 3 subgroups.
2. In this case it is also true that if we allow only 20% of the cup to be uncovered than in all the groups almost every acetabulum would require augmentation.

Discussion

According to our results we can state that the degree of cranial migration of the femoral head, which both classifications are aimed at determining, is in direct connection with the superolateral coverage of the acetabulum, but the connection is not so close. We have to assume that these two parameters are influenced by other components.

1. In the introduction we discussed the characteristic deformities of the dysplastic acetabulum. During surgery we often see that deformities due to the pathological development of the acetabulum are very diverse. Therefore we also should not expect untreated cases to be homogenous.
2. In the treatment if hip dysplasia the femoral head and the acetabulum have a mutual remodeling effect on each other which can be worsened by improper treatment. Even nowadays we can see avascular necrosis causing distortion of the femoral head which in turn causes acetabular deformities due to late and rough conservative treatment.
3. During surgical treatment the complete, nowadays incomplete pelvic osteotomies also cause a whole individual variation of deformities.

Our article mainly focuses on raising a problem. Due to the small amount of cases our results can not be statistically analyzed. We would although note that the articles cited by us also have few usually under 100 cases. The reason for this most likely is the high specificity of the topic.

If we examine the true goal of our article only than the low number of cases does not necessarily affect the result. Our question was that are the above discussed classifications alone suitable for determining the superolateral coverage of the acetabular cup in every case. If extreme cases are categorized in the individual groups, which occurred in both classifications, than we have to answer our question with no, even though on the average the classifications give a good approach.

Summarizing we can state that the superolateral coverage of the implanted acetabular cup in hip dysplasia is influenced by a number of factors. For meticulous surgical planning the classification based on an AP X-ray alone does not offer enough information. In difficult cases we recommend the use of 3D CT scans and if possible based on this, with the rapid prototype technology the making of a 3D model.

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