Total Hip Replacement as an Endpoint of Osteoarthritis Can Be Predicted by Analysis of Bone Shape
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Introduction: One of the problems that osteoarthritis (OA) research is faced with is the poor predictability of development and progression of the disease. Exemplary is the distinction between clinical OA and radiological OA. The pain and loss of function experienced by the patient is poorly related to Kellgren & Lawrence Scores as derived from x-ray images. Still assessment of radiological OA is standard diagnostic practice. Although radiological OA does not relate well to clinical OA, many studies have shown that changes in bone shape and density are related to progression of the disease, suggesting that current radiological scoring methods may not be specific or sensitive enough.

In this study we aim to find shape and density characteristics of the hip that relate to clinical OA and can be used as predictors of progression of osteoarthritis using so-called Statistical Appearance Models of the proximal femur.

Materials and Methods: Statistical Appearance Models (SAM) were created from contours around the proximal femur in DXA images of the hips (fig. 1). The method results in a set of independent modes that together quantitatively describe the total shape and density distribution, while each mode separately describes a specific characteristic of the shape or density.

The DXA images formed part of the GOAL cohort. In GOAL, 200 patients were included on their first visit to the physician with complaints of the hip. DXA images and x-rays were made at baseline and at two year follow-up. At both time points VAS pain and WOMAC questionnaires were taken to obtain clinical information on pain, stiffness and function. After two years 18 patients had received a total hip replacement (THR).

Progression of osteoarthritis was defined as having received a THR at follow-up.

Multivariate Stepwise regression using 4-fold cross-validation was used to predict the need for a THR at follow-up. Cross-validation ensured that stepwise regression did not result in over-fitting of the data.

Results: The model for prediction of THR at follow-up included VAS pain-score, the difference between JSW of the affected and non-affected side (dJSW), and the two shape modes. The total logistic model resulted in 96% correct classifications in the test sets, consisting of 99% correct classifications for the cases that did not get a THR, and 60% correct classifications for the cases that received a THR (fig. 2).

Models that excluded dJSW or the shape modes resulted in less correct classifications for the THR cases (40%, p<0.001). A model that used VAS combined with the traditional radiological measures JSW and K&L, scored even less (30%), of which K&L did not have any contribution to the prediction.

One shape mode reflected the transition from neck to head, a more gradual transition was associated with increased risk of THR. The other shape mode reflected differences in neck-length between affected and non-affected side. A shorter neck on the affected side associated with an increased risk for THR (fig. 3).

Discussion: This study shows that progression of OA is indeed related to bone shape of which the traditional measures of radiological OA are not the optimal surrogates. It is interesting that some of the parameters are better predictors when used as the difference between sides, rather than the measure itself. This could indicate progressive changes in the hip (dJSW) or indicate inherent left/right differences in geometry that stimulate development of OA.

In this study we did not find any mode with predictive power for THR that reflected the density distribution inside the femoral head.

Interestingly, the shape mode that reflected the transition between head and neck has been associated with receiving a THR before, in an independent population (1). The mode appears to indicate the sphericity of the femoral head. Deviations in the spherical shape can lead to impingement-like situations that have been associated with development of OA (2).

The second highlighted mode, the difference in neck length between affected and non-affected side could indicate a biomechanical difference between left and right that facilitates development of OA, or could be a sign of progressive changes in the femoral neck.

We showed that bone shape has strong additional power to predict progression of OA, which could prove invaluable for future OA related research.

2) Wagner et al, Osteoarthr Cart., 2003

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