Statistical models can help diagnose children with hip disorders

Hannicka Sahlstedt
Department of Biomedical Engineering, Lund University

February 27, 2018

Early diagnosis of diseases of the hip in children can spare them pain and prevent them from getting osteoarthritis in young adult life. To diagnose diseases in the hip of children you must first know what a normal child's anatomy looks like. This can be studied with statistical models.

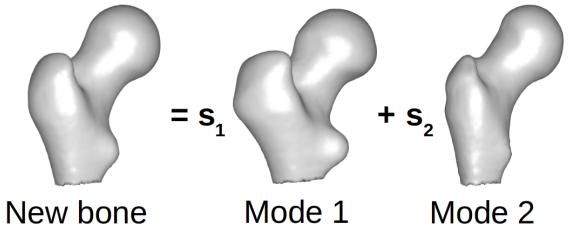
There are a number of diseases that affect the hip of children. A few examples of such diseases are epiphysiolysis, where the growth plate in the head of the thigh bone slides back or down, hip dysplasia that makes the hip unstable and Perthes disease (see the image below), where the head of the thigh bone stops growing and becomes deformed. All these diseases lead to increased risks of osteoarthritis in young adult life. However, if they can be diagnosed and corrected in an early stage, osteoarthritis can be delayed or prevented. But to diagnose them you have to know what the normal development of the bone looks like.

A radiograph of the hip of a child showing a case of Perthes disease in the thigh bone to the left in the image. *Image by James Heilman, Licensed under CC BY-SA 4.0, URL: https://commons.wikimedia.org/wiki/File:LCPdisease2015.png. 2015.*

The normal development can be captured by models called statistical shape models or SSMs. To create a SSM of the thigh bone for children, first you need to know the anatomy of the bone of a group of children. Once the SSM has been created, it contains all the anatomical differences of the children's bones.

So, if you want a SSM to study the anatomy, but need the anatomy to create it, what's the point of creating the model? Well, you only need a smaller set of bones to create the model. From it you can then create new bones, with shapes that were not used to create the SSM.

When you create a SSM it captures the anatomical differences in so called modes, like the ones in the image below. Each mode is related to a different variation in bone shape. By combining the modes in different ways, new bones are created. In the figure below you see an example of how thigh bones corresponding to different modes are added together to form a new bone.



A new bone created by adding the modes from the SSM together. s_1 and s_2 are numbers and by changing their values different bones can be created.

SSMs were created and used to look at anatomical differences for different groups of children. When looking at how the models described children from three different age groups (7-10 y, 12-15 y and 16-17 y) difference in the shape of their bones were found. The differences between their bones were not only due to the size of the bone, naturally the bone grows with age, but also due to other differences in their shapes. This means that if you want to define what the normal hip looks like you need to have different definitions for e.g children that are 7 years old and children that are 12 years old. When boys and and girls were compared to each other, no differences in the anatomy of their thigh bones were found.

The full anatomy is needed to make reliable diagnoses. Usually, it is obtained by scans which impose much higher radiation doses than regular radiographs. In the future, the SSMs that have been created could be used to create full reconstructions of the thigh bone from regular 2D radiographs, like the one in the image to the left. By using the SSM, the full anatomy of the thigh bone can be obtained without exposing children to the larger amount of dangerous radiation.