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Shape and biomechanical models for population specific design of anatomical peri-articular implants

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Main Industrial Partner: Christian Lutz, Stryker Trauma AG **Starting Date: 1.1.2006**

Name Other Industrial Partners **Duration: 3 years**

Project description

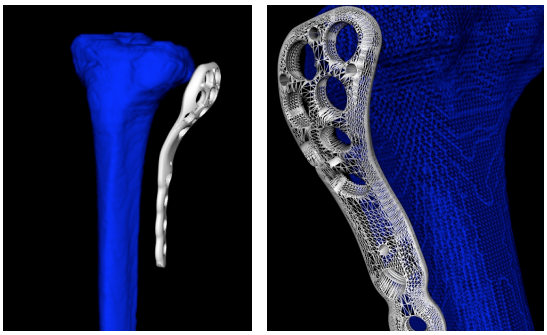
Current design processes for orthopedic implants rely on very limited information about the shape of the target bone. Such information may be in the form of a small set of shape parameters (eg lengths and angles) derived from the existing literature, which fails to capture the complexity of real anatomical shapes. Alternatively, tests on cadaver bones can be performed. However, extrapolating the findings reached by such tests to the whole target population can lead to implants that may fit some patients, but not others.

Scientific/technical/business objectives

For this reason, the current project uses novel population-based design methods to develop market-specific trauma implants. Our technology allows a compact model that represents the range of shape variation encountered in a set of different bones to be automatically built. The model is based on large collections of CT scans. Statistical analysis techniques are employed to determine the average bone shape in a given population, as well as the shape distribution around this average in the form of principal components of shape variation. Once the model is built, it allows generating as many bone instances as required to accurately represent the population. Finite element calculations are used to evaluate the biomechanical properties of the generated bone instances. This method enables to reconstruct the statistical distribution of bone biomechanical properties across the population.

Results

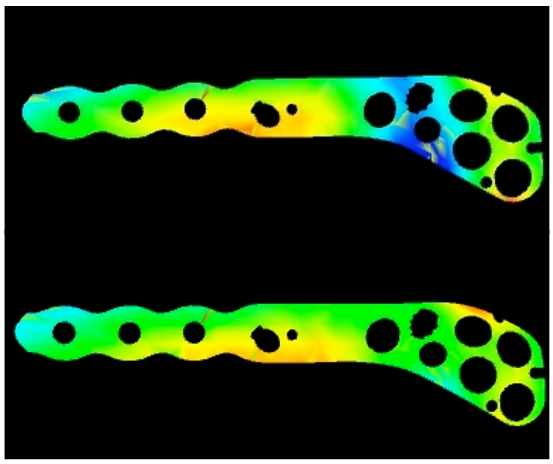
The proposed population based method was first applied to evaluate the fitting of a proximal reconstruction plate for the tibia and determine whether the current plate design fitted Asiatic population or if a new plate needed to be developed for this specific market.



Automatic algorithm was develop to find the best surface fitting between an implant shape and the bone surface.

Statistical shape models for the Asiatic and Caucasian population were built with a database of 67 tibias for each ethnic group. An automatic fitting algorithm was developed to find the optimal position of the implant on the bones. The problem can be cast as a rigid registration including constrains on the possible position and orientation of the implant on the tibia. Virtual bone instances representing the statistical bone shape variability in the population were generated with the previously constructed models. On each of these bones, the plate was automatically fitted and the distance between the bone and the plate was calculated for each point of the plate

The statistical variation in the distance for each ethnic group was computed and graphically represented (Figure).



Average distance from the plate to the bone for the asiatic population (top) and the caucasian population (bottom). Blue color indicates a large distance (hence a poor fit) and red indicates small distances. The fitting of the plate on the asiatic population was less good than for the caucasian population.

The new methodology, applied here to compare plate design for different ethnic groups, enabled Stryker to decide if a new design was required for the Asiatic market.

Implementation stage/perspectives

We believe that, in the future, evidence-based orthopedic implant design will replace most of the cadaver testing. Further, being able to study the whole range of bone shapes and densities of the target population will lead to better fitting implants, as well as a considerable cost reduction in the design process. In order to assess the qualities of an implant, further developments will enable the testing of different scenarios concerning implant position, fixation techniques or mechanical properties.