DESIGN AND DEVELOPMENT OF AN INNOVATIVE TEMPOROMANDIBULAR JOINT PROSTHESIS.
BIOMECHANICAL CHARACTERIZATION - RESEARCH OF CONCEPT

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ABSTRACT
When designing a medical device, the primary objective is to improve the patient's conditions. Therefore, there must be a strong focus on continuous interaction with the human element. The procedure that has been devised and the biomechanical characterization studies that result when applying value analysis to the search for concepts of an innovative temporomandibular joint (TMJ) prosthesis are presented (Mesnard, 2013).

Keywords: articular displacements, slope angle.

INTRODUCTION
When characterizing the biomechanics of the TMJ, specific metrology techniques were used for the experimental quantification of the displacements and actions (Coutant, 2008). TMJ articular displacements were described and quantified by stereo photogrammetry while muscle efforts were evaluated by electromyography and magnetic resonance imaging (Fig.1). The protocol was subjected to a repeatability study.

The search for concepts was based on functional analysis and elaboration of behavioral models of the joint in its natural state and equipped with the prosthesis. Finite element models of the jaw and joint were created and validated to determine stresses and strains on the surface of the bone (Ramos, 2014). The characterization study produced the input data to choose the muscular actions and the boundary conditions.

These models can be used for biomechanical analyses, to predict the performance of implants and to compare behaviors of the healthy and implanted structures. Then the influence of geometry, the links between implant and bone tissues could be considered to guide the decisions when creating innovative technical solutions.

RESULTS AND CONCLUSIONS
For a healthy volunteer, three to five readings were always taken in order to evaluate the influence of changes in behavior and establish significant values. Then, for a representative sample (32 volunteers) of the population, Figure 1, the values of the geometrical characteristics followed normal distributions (Mesnard, 2012).

Three groups were isolated relatively to three kinematic models presenting weak inter-individual variations in relation to the collective values (definition from the mean value by the standard deviation). The correlation between the kinematic characters and the disc-condyle
trajectories along the temporal facet provided the value of the temporal slope angle for each group.

Fig. 1 - Characterization of the condyle displacements and slope angle among 32 volunteers

The intra- and inter-individual variability of the slope angle may result from a range of causes: temporal, pathological, behavioral... Inter-individual variability is linked only to anatomical-physiological factors such as geometry, local distribution of tissues...

Elaborating concepts, the aim cannot be to control these variations and then, the limited use in addition to difficulties in producing a custom-made prosthesis guide the designer to manage and integrate anatomical variations.

Every year, the implantation of a TMJ prosthesis concerns fewer than five thousand patients. These results are useful for the design and tend to guide the designer towards a modular component for the temporal side. By providing the surgeon with a range of three (to five) modules, the component angle will be chosen using a pre-operative scan image.

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REFERENCES

[1]-M. Mesnard and A. Ramos, 2013, Towards a rigorous approach to designing a temporomandibular joint prosthesis. From clinical challenge to numerical prototype, Procedia CIRP, 5, p.141-146.

