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A 3D FINITE ELEMENT MODEL OF THE RADIUS, WITH THE RADIAL COMPONENT OF MAESTRO PROTHESIS, UNDER A MAXIMAL GRIP LOADING CONDITION

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SUMMARY
The main goal of this study was to achieve a native and an arthroplastic model of the radius, with the Maestro prosthesis, in order to be able to simulate and analyze how a maximal grip loading can alter the mechanical behavior of the bone.

INTRODUCTION
Joint replacement surgery in the wrist is less common but can be an option if you have painful arthritis that does not respond to other treatments.
Wrist arthroplasty has shown that it allows to preserve a range of motion, but it's currently not considered to be universally safe and effective, due to traditionally high complication rates [1].Nowadays total wrist arthroplasty still fails due to serious problems that occur, like imbalance, loosening, instability or infection [2]. However, according to reports published [3, 4], the major reason that artificial joints eventually fail can be associated with the risk of aseptic loosening. Loosening can be associated to the presence of abnormally high levels of tension in the bone around the prosthesis.
The main goal of this work was to study and compare the biomechanical behavior of the radius in its native and arthroplastic state, with the radius component of the Maestro prosthesis, in a maximal grip loading condition. In this context, numerical models were developed and used to determine and analyze the biomechanical behavior of the structures attached to the component.

METHODS
For this study a native and an arthroplastic finite element (FE) models of the radius were considered. According to this, the radius structure were modelled, as well as the radius component of the Maestro prosthesis, the native model and the arthroplastic model can be seen in the Figure 1.
The models considered were constrained on the diaphysis of the radius and all the interfaces between the components were fastened.
The loading condition used was representative of a maximal grip [5]. The load-case applied was used to access the principal strains at the cancellous bone of radius, before and after arthroplasty, in the frontal aspect.

Figure 1: Native model (left) and arthroplastic model (right).

RESULTS AND DISCUSSION
In the 2 and 3, it can be see the patterns of the principal strains at the cancellous bone of radius.

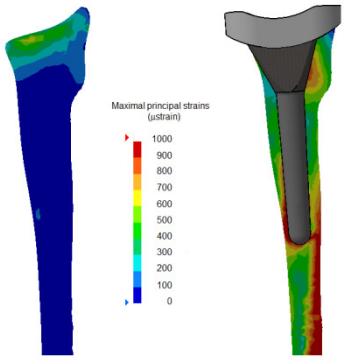

Figure 2: Maximal principal strains in cancelous bone of native (left) and arthroplastic (right) states.

Comparing the principal strains of the arthroplastic model, near the radius component, with the native model, it can be observed that the introduction of the Maestro prothesis leads to an increase of the bone strains along the implant length, in the metaphyseal region, with peak strains observed at the implant tip.
The increase of maximal principal strains was 8,7 times higher (97 to 940 μstrain) in the arthroplastic state when compared with the native state.
Relatively to the minimal principal strains, the arthroplastic state showed values 9,9 times higher (-90 to -980 μstrain) than the native state.

However, in the maximal principal stains it also occurs an increase of the deformations along the lateral aspect.
However, in the minimal principal strains it can be seen that the increase occurs in the opposite side, i.e. in the medial aspect.

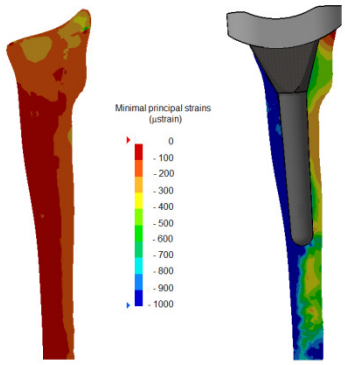

Figure 3: Minimal principal strains in cancelous bone of native (left) and arthroplastic (right) states.

CONCLUSIONS

The main goal of this study was to compare the biomechanical behavior of the radius in its native and arthroplastic state, with the radius component of the Maestro prosthesis, in an extreme activity.
The numerical results show that the introduction of the component in the radius significantly alters the mechanical behaviour of the cancellous bone when compared with the native state. In fact, the introduction of the component caused an increase in mechanical stress, thus enhancing its fatigue failure.

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