This is why it was necessary to consider two types of loads upon the composite material molar model: centric compression and eccentric compression using forces compatible to the normal human bite force.

If the load is applied at the center of the molar, which is an ideal situation, corresponding to a perfect symmetry of the anagonist teeth during occlusion, the values and distribution of the principal stress is shown in figure 2.

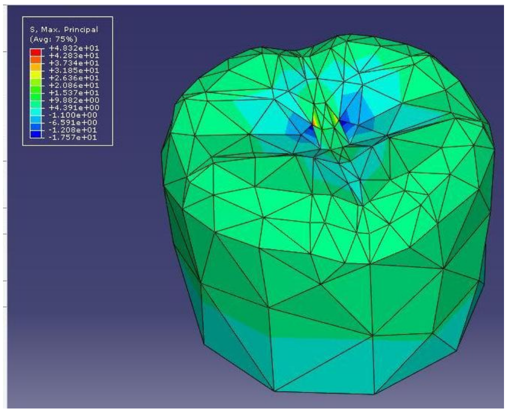

Figure 2: Principal Stress Distribution for a Centric Compression

For the second situation, which is also more encountered due to the imperfections in the occlusion of antagonist teeth, the principal stress distribution is presented in figure 3.

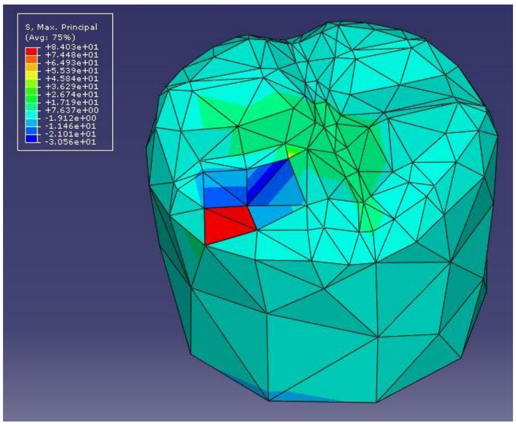

Figure 3: Principal Stress Distribution for an Eccentric Compression

The performed analytical study gives clues upon the stress distribution and values, deformations values in dental structures subjected to a known load and allows the choice of the optimum material and geometrical shape of the dental prosthetic works, according to real requirements.

Thus, the representation of the two types of strains clearly shows that the centric compression is uniformly distributed upon the tooth surface, leading to an almost uniform stress distribution, while the second type of strain, leads to a dangerous increase of the stress in the force action area, though the rest of the tooth remains in a comfortable strain zone.

For comparison we also performed models for other type of materials, usually used in dental prosthetics in order to estimate the opportunity of using composite materials, from mechanical point of view. The figure 4 presents the results obtained for an acrylate tooth subjected to an eccentric compression, which is obviously more likely to produce stress.

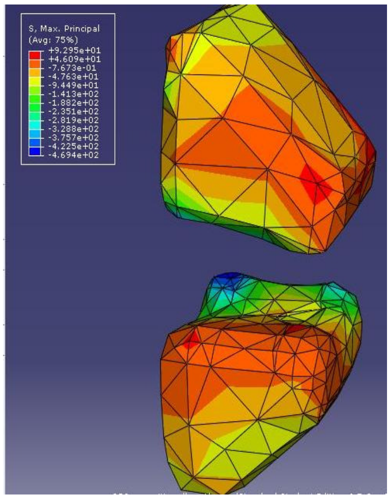

Figure 4: Principal Stress Distribution for an Acrylate Tooth Subjected to Eccentric Compression

The representations above confirm again that the stress is much higher in the area where the eccentric forces are acting and also the fact that the stress is considerably smaller and more uniform in the models designed of fibre reinforced composite materials.

We also were able to obtain the diagrams representing the force-displacement variation for both types of compression: centric (figure 5) and eccentric (figure 6).

Analyzing the diagrams we observe that the centric load leads to an almost uniform increase of the displacement with the force, while the eccentric one presents abrupt variations.

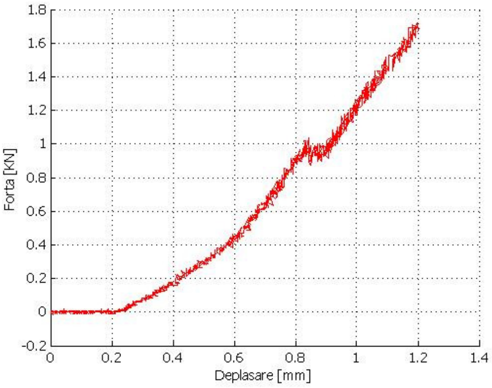

Figure 5: Force-Displacement Diagram for Centric Compression

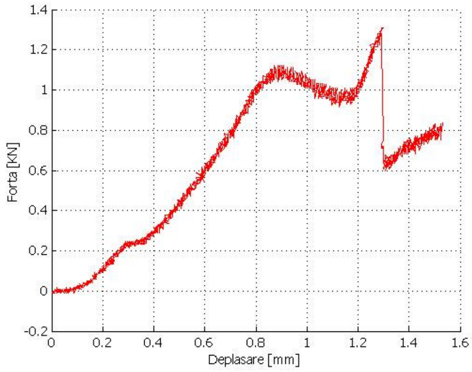

Figure 6: Force-Displacement Diagram for Eccentric Compression

EXPERIMENTAL RESULTS

The compression tests were performed using a Multipurpose Servohydraulic Universal Testing Machine, type LFV 50-HM. The maximum load force is ±50kN and the maximum stroke of the working head is up to 400mm.

The first tests were made for a centric compression as shown in figure 7.

Figure 7: Centric compression of the composite material tooth sample

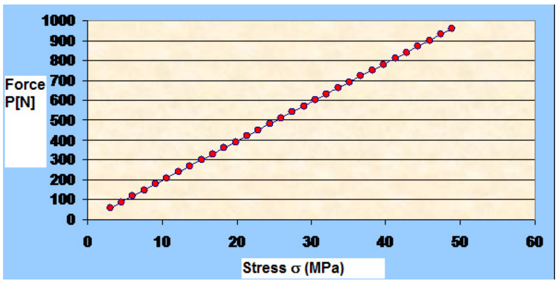

Figure 8: Value of stress depending on the applied centric compression force

Considering the compression force P, between 0 and 960N, the diagram in figure 8 was obtained for the corresponding stress during the experiment.

Further on the samples were subjected to an eccentric force placed as shown in figure 9.

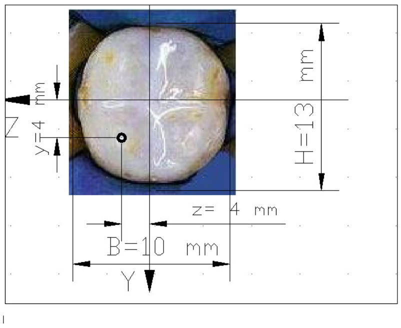

Figure 9: Location of the force point of application during the eccentric compression

Considering P between 300N and 990N to cover all the possibilities of bite forces, we are able to obtain the diagram of the stress depending on the force value, as shown in figure 10.

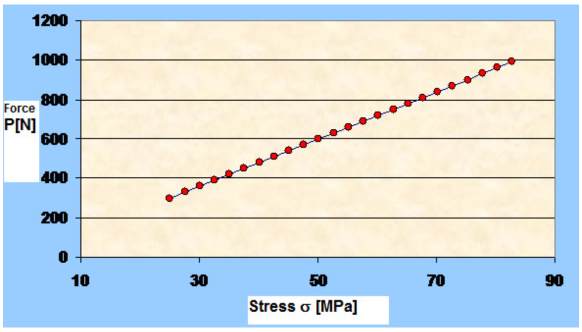

Figure 10: Value of stress depending on the applied eccentric compression force

Up to a certain value of the unit load the material behaves elastic, then it goes into plastic domain becoming unable to return to the initial size and shape. When the unit loading increases over the breaking strain value, the material deformation concentrates, a crack occurs leading to the sample break.

The experiments proved that the samples do not break up to 990N which is much higher than the bite force exerted by a human being.

CONCLUSIONS

The finite element analysis allows visualizing the areas where the principal stress appears in dental structures subjected to certain loads and creates the possibility of an accurate intervention in order to eliminate them.

Analyzing the principal stress, deformation and safety factors, we found that edges are most exposed so using corresponding methods to smooth surfaces becomes necessary.

The finite element analysis allows us to obtain enough data to determine the optimal shape and size of the dental prosthetic structures.

It will be also necessary to consider the fact that a small cross-section of the tooth (e.g. incisive or canine), leads to a bending tendency in horizontal plane so the rupture takes place horizontally.

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