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Investigation of the preparation design on stresses resulted in ceramic inlays restored premolars

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Introduction

Ceramic inlays can be used on premolars requiring a class II restoration instead posterior composite resins, amalgam or gold inlays and offer a durable and aesthetic alternative. MOD inlays may increase the susceptibility to fracture. Therefore it is important to ensure optimal performance in selection of the adequate preparation design to reduce stresses in teeth structures and also in the restorations [1-3]. The aim of the study was to investigate the effect of preparation design on stress distribution in premolars with different class II and MOD cavity preparations restored with ceramic inlays.

Material and Methods

The study was performed on an upper first premolar, using a finite element analysis. Enlarged plaster teeth (scale 2:1) were scanned using a manufactured device . For most situations, a single scan will not produce a complete model of the object. Multiple scans, from many different directions are usually required to obtain information about all sides of the object .Files were imported in LeiosMesh (Enhanced Geometry Solutions Corporations, Italy), where the point clouds from the teeth surfaces were cleaned and assembled. These scans were brought in a common reference system, a process that is usually called alignment, and then merged to create a complete model (Fig. 1).

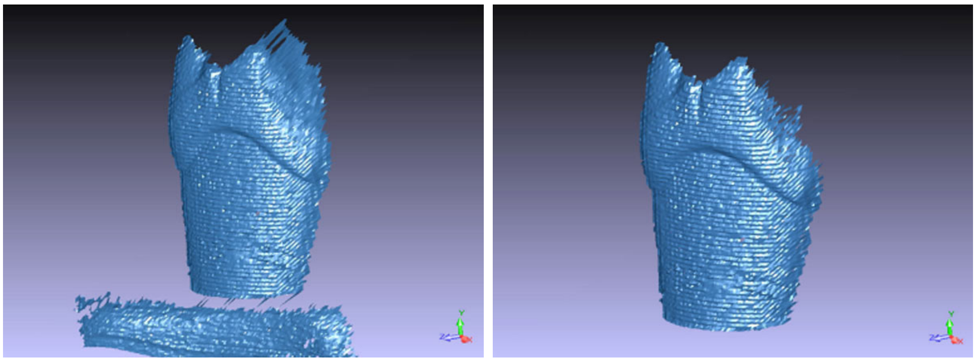

Fig. 1a-b: Multiple meshes, cleaned from unnecessary triangles and used to obtain information about all sides of the tooth

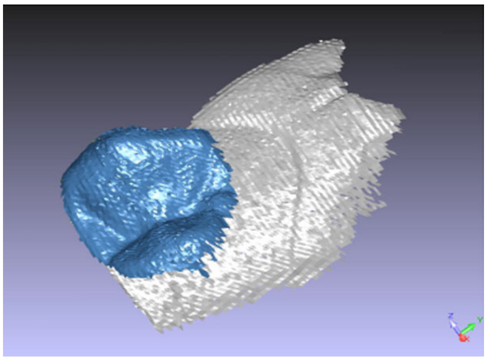

Fig. 1c: Multiple meshes, cleaned from unnecessary triangles and used to obtain information about all sides of the tooth

The assembled meshes were scale down at the natural size of the tooth and rotate to gain an anatomic position. On this mesh were build NURBS surfaces which were imported in Rhinoceros (McNeel North America) NURBS (Nonuniform Rational B-Splines) modeling program. (Fig. 2)

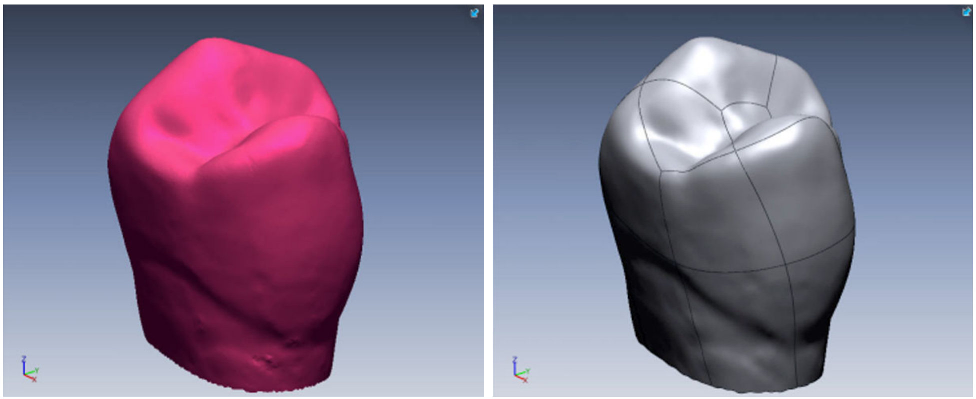

Fig. 2a-b: The final mesh, the NURBS surfaces on the mesh, NURBS surfaces imported in RHINO, the premolar volume

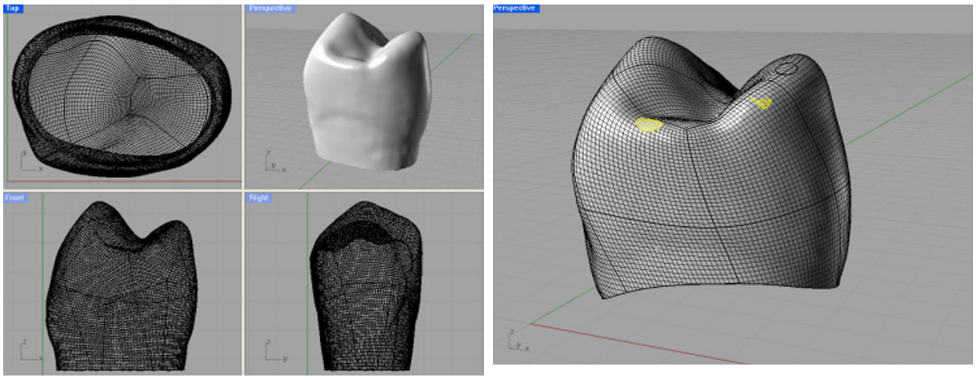

Fig. 2c-d: The final mesh, the NURBS surfaces on the mesh, NURBS surfaces imported in RHINO, the premolar volume

This 3D model were used as a support for inlay modeling (Fig. 3).
These were exported in Ansys finite element analysis software to be used for structural simulations. Twenty-two 3D models of maxillary first premolars, with the following designs of class II and MOD ceramic restorations were generated: eleven class II inlays with butt joint margins, eleven MOD inlays with butt joint margins, both with different tapers (between 0 and 10 degree). The model of the prepared tooth structure for class II was divided into 22568 elements connected at 36935 nodes, and the inlay into 4615 elements connected at 8378 nodes. For the MOD restored tooth, it was divided into 21337 solid elements connected at 35214 nodes, and the inlay into 5990 elements connected at 10809 nodes. Computational simulation of an occlusal load of 200 N was conducted, and stresses occurring in the ceramic restorations, and teeth structures were calculated using Ansys finite element analysis software.

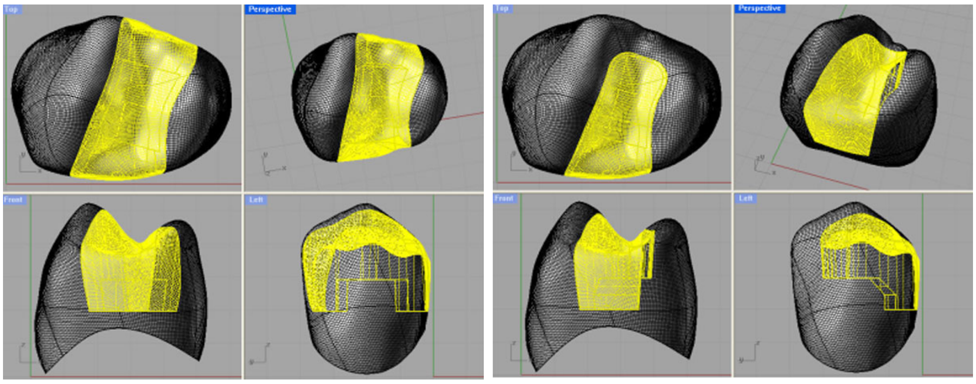

Fig. 3a-b: The MOD and MO inlays modelled in Rhinocers

Results

Occlusal load on inlays restored teeth produces stress surrounding the contact areas. In the teeth restored with ceramic class II inlays, the von Mises equivalent stress values were similar to those the intact tooth. In the teeth restored with ceramic MOD inlays, the von Mises equivalent stress values were higher than in the intact tooth. For the studied cases, the stress values were not significant influenced by the taper of the preparation (Fig.4, Table I, II).

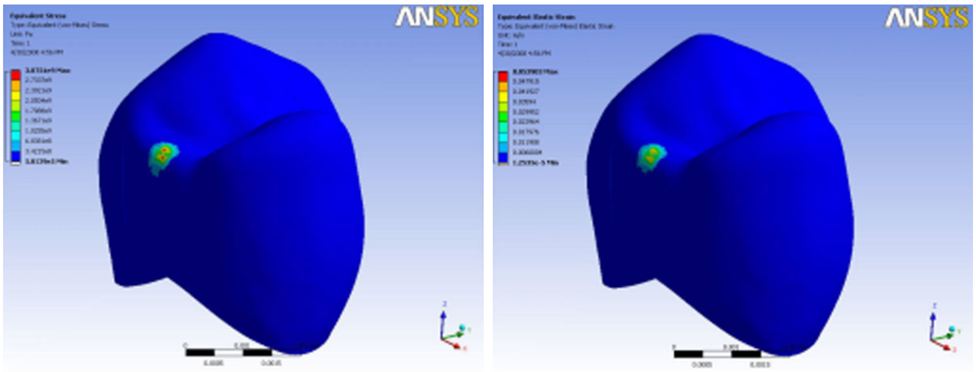

Fig. 4a-b: Stress distribution in MO, MOD inlays and prepared teeth structures

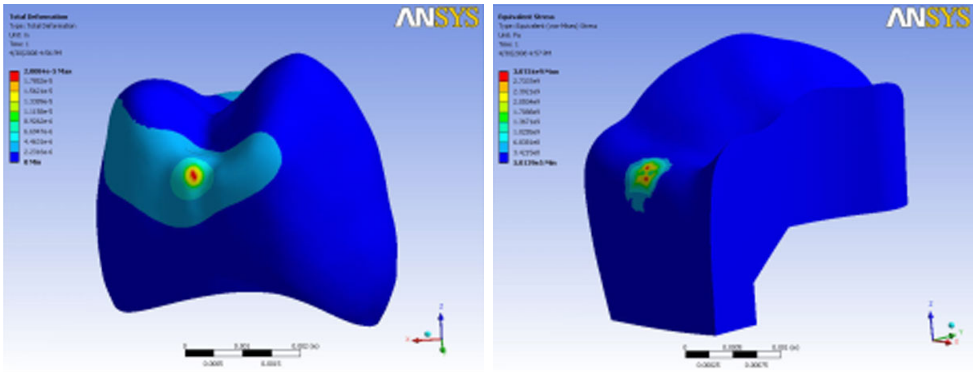

Fig. 4c-d: Stress distribution in MO, MOD inlays and prepared teeth structures

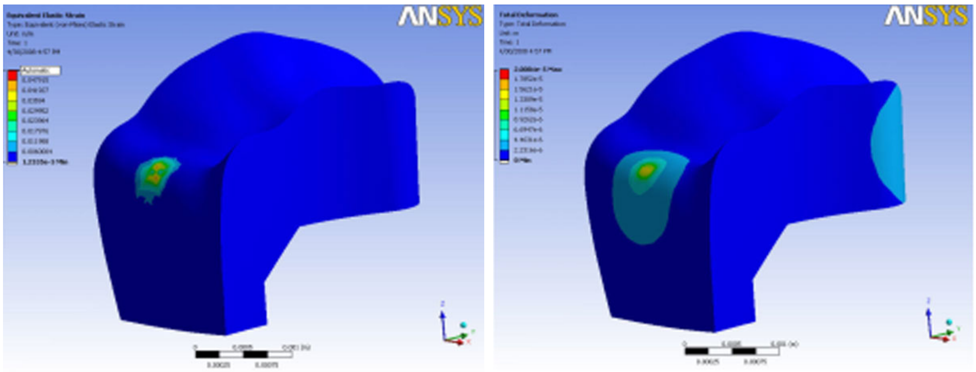

Fig. 4e-f: Stress distribution in MO, MOD inlays and prepared teeth structures

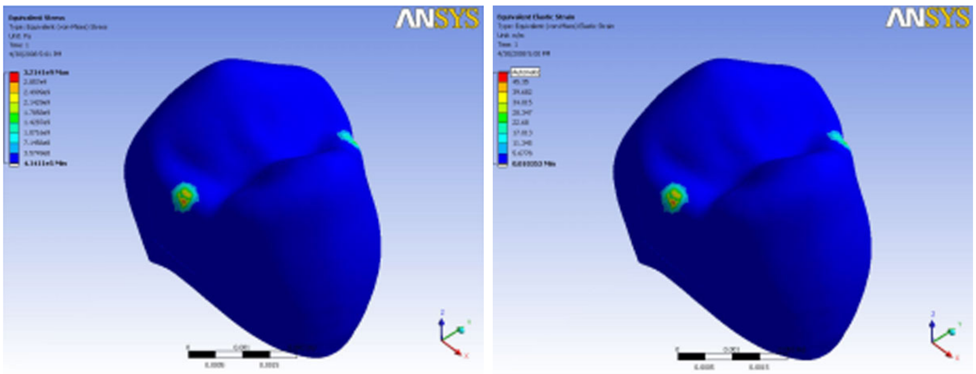

Fig. 4g-h: Stress distribution in MO, MOD inlays and prepared teeth structures

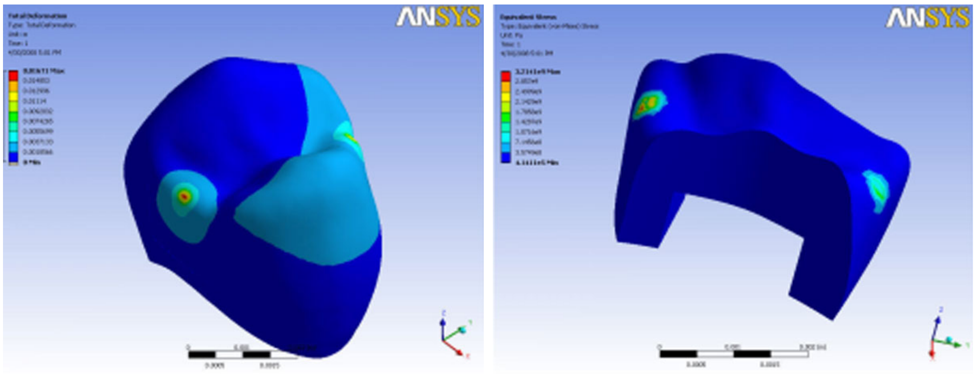

Fig. 4i-j: Stress distribution in MO, MOD inlays and prepared teeth structures

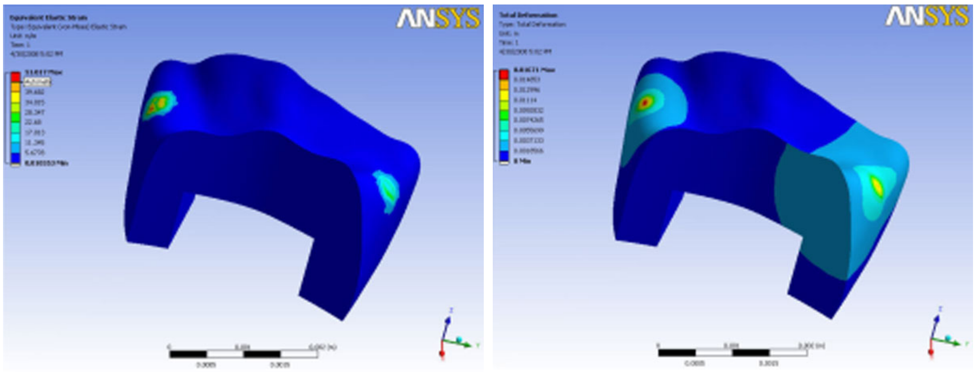

Fig. 4k-l: Stress distribution in MO, MOD inlays and prepared teeth structures

Taper [degree]	Von Mises stress min [Pa]	Von Mises stress max [Pa]	Displacement [mm]
00	0.31315	3599.6	1.96E-08
01	5.43E+05	3.73E+09	2.00E-05
02	5.08E+05	3.65E+09	2.02E-05
03	5.01E+05	3.08E+09	2.01E-05
04	4.39E+05	3.55E+09	1.98E-05
05	6.05E+05	3.72E+09	2.00E-05
06	7.06E+05	3.32E+09	2.00E-05
07	7.96E+05	3.78E+09	2.00E-05
08	8.10E+05	3.23E+09	1.98E-05
09	7.16E+05	4.07E+09	1.95E-05

Tab. 1: Stresses and displacements for the MOD inlay

Taper [degree]	Von Mises stress min [Pa]	Von Mises stress max [Pa]	Displacement [mm]
00	4.06E+05	3.21E+09	1.62E-05
01	4.38E+05	3.73E+09	1.59E-05
02	4.74E+05	3.73E+09	1.58E-05
03	5.78E+05	3.19E+09	1.51E-05
04	5.67E+05	3.92E+09	1.56E-05
05	6.79E+05	3.76E+09	1.57E-05
06	7.39E+05	3.92E+09	1.53E-05
07	4.42E+05	3.45E+09	1.51E-05
08	5.30E+05	3.40E+09	1.58E-05
09	6.55E+05	3.79E+09	1.57E-05

Tab. 2: Stresses and displacements for the MO inlay

Conclusions

Within the limitations of the study, it was demonstrated that ceramic inlays on premolars prevent failure and produce a low stress values, even if MOD restorations are used. A taper between 0 and 10 degree of the preparation is not decisive for the stress values.

Acknowledgements

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Literature

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Poster Faksimile: