

Stresses in Cast Metal Inlays Restored Molars

Sandu L., Topală F., and Porojan S.

Abstract—Cast metal inlays can be used on molars requiring a class II restoration instead amalgam and offer a durable alternative. Because it is known that class II inlays may increase the susceptibility to fracture, 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. The aim of the study was to investigate the influence of preparation design on stress distribution in molars with different class II preparations and in cast metal inlays. The first step of the study was to achieve 3D models in order to analyze teeth and cast metal class II inlays. The geometry of the intact tooth was obtained by 3D scanning using a manufactured device. With a NURBS modeling program the preparations and the appropriately inlays were designed. 3D models of first upper molars of the same shape and size were created. Inlay cavities designs were created using literature data. The geometrical model was exported and the mesh structure of the solid 3D model was created for structural simulations. Stresses were located around the occlusal contact areas. For the studied cases, the stress values were not significant influenced by the taper of the preparation. It was demonstrated stresses are higher in the cast metal restorations and therefore the strength of the teeth is not affected.

Keywords—cast metal inlays, class II restoration, molars, 3D models, structural simulations.

I. INTRODUCTION

TO reduce loss of tooth tissue and to improve biomechanical results, inlay restorations are good treatment choices for cavities in posterior teeth. Metallic inlays simply replaces missing tooth structure, without doing anything to reinforce the remaining structures. Stress concentrations can manifest themselves in various forms of failures [1, 2, 3, 4].

Cast metal inlays can be used on molars requiring a class II restoration instead amalgam and offer a durable alternative. Because it is known that class II inlays may increase the susceptibility to fracture, 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 [3].

Finite element analysis (FEA) has been widely employed in many researches to investigate the impact and effect of dental materials and restorative techniques on stress distribution. FEA is deemed as an effective tool to evaluate the biomechanical characteristics of these dental restorative

materials and systems, whereby the results carry significant clinical implications [5,6].

Little information is available on the stress analysis of cast metallic inlays. Modern design and valuation in order to obtain an adequate framework strength involves numerical simulations.

II. OBJECTIVE

The aim of the study was to investigate the influence of preparation design on stress distribution in molars with different class II preparations and in cast metal inlays.

III. MATERIALS AND METHODS

The first step of the study was to achieve 3D models in order to analyze teeth and cast metal class II inlays. The geometry of the intact tooth was obtained by 3D scanning using a manufactured device. The collected data were used to construct three dimensional models using Rhinoceros (McNeel North America) NURBS (Nonuniform Rational B-Splines) modeling program. These points were used to extrapolate the shape of the object, a process called reconstruction. Reconstruction involves finding and connecting adjacent points in order to create continuous surfaces. Nonuniform rational B-spline (NURBS) is a mathematical model commonly used in computer aided design, manufacturing and engineering. CAD is mainly used for detailed 3D models. With Rhinoceros modeling program the preparations and the appropriately inlays were designed.

3D models of first upper molars of the same shape and size were created: one intact tooth, eleven unrestored teeth with class II preparations with different tapers (between 0 and 10 degree); the same teeth restored with metallic inlays (Fig. 1-5). Inlay cavities designs were created using literature data.

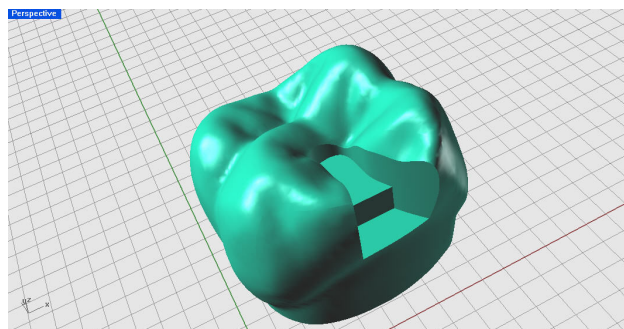


Fig. 1 Unrestored molar with class II preparation

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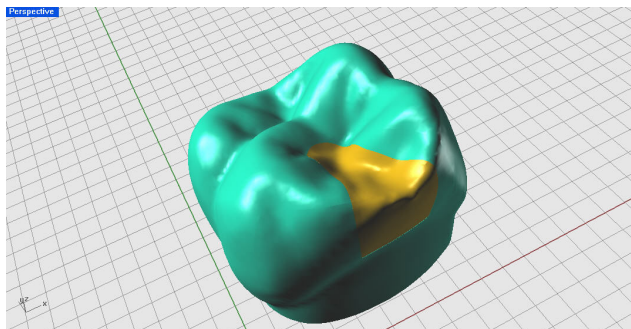


Fig. 2 Restored molar with class II metallic inlay

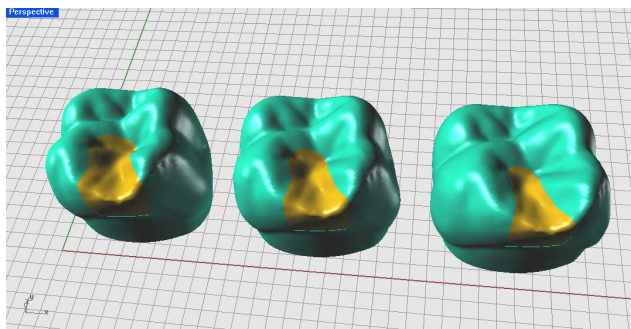


Fig. 3 Restored molars with class II metallic inlays (taper of 10, 6, and 0 degree)

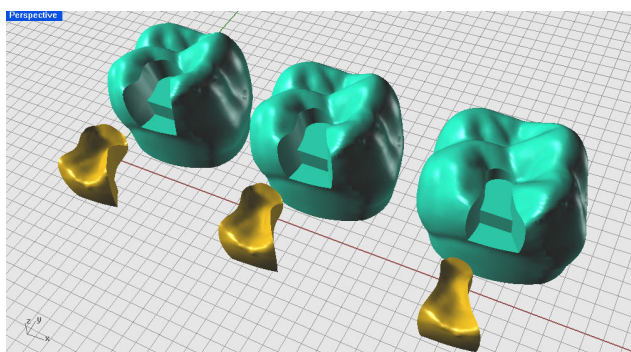


Fig. 4 Prepared molars and class II metallic inlays (taper of 10, 6, and 0 degree)

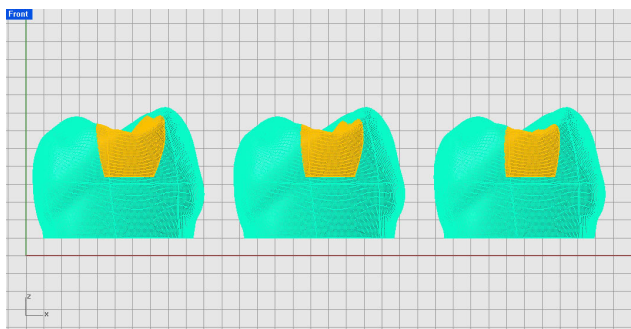


Fig. 5 Restored molars with class II metallic inlays (taper of 10, 6, and 0 degree) - mesial aspect

The geometrical model (Fig. 6) was exported and the mesh structure of the solid 3D model was created using the computational simulation of Ansys finite element analysis software (Fig. 7). These were used for structural simulations.

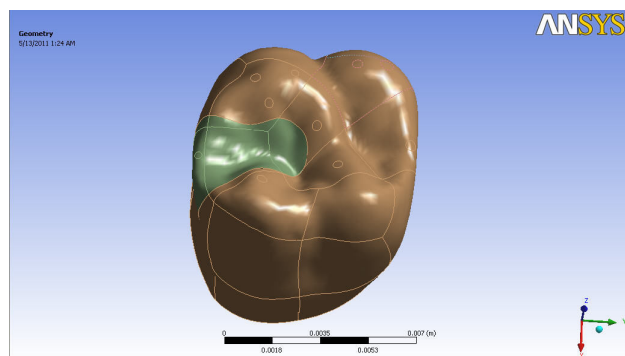


Fig. 6 Geometrical model of the molar

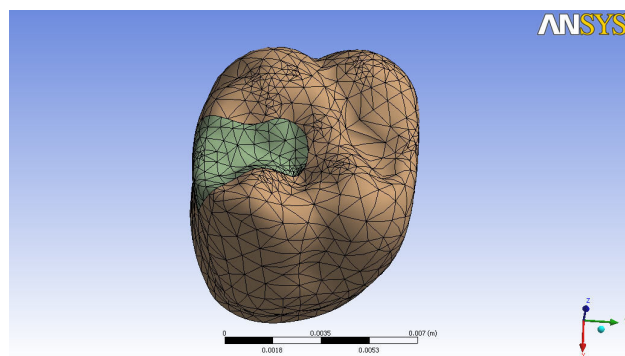


Fig. 7 Mesh structure of the molar

An occlusal load of 200 N was conducted, and stresses occurring in the inlays, teeth structures, and total stresses were calculated.

An oblique loading of 200 N was applied in 10 points, according to the contact points with the antagonists (Fig. 8).

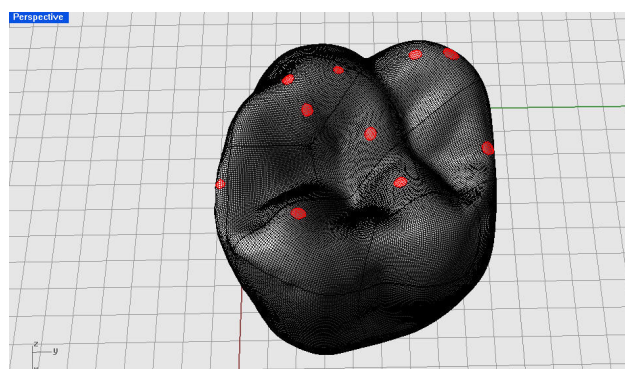


Fig. 8 Points selected for loading on the restored molar

At each selected loading point, an oblique loading of 20 N was applied (Fig. 9).

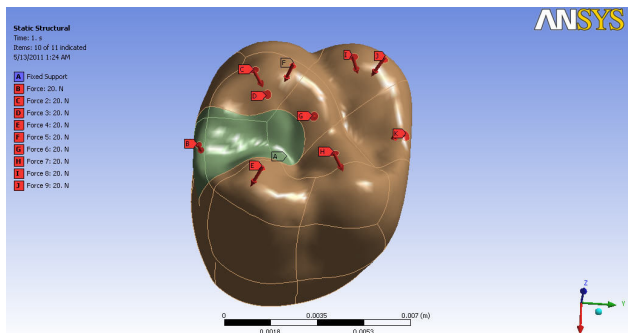


Fig. 9 Loading of the restored molar

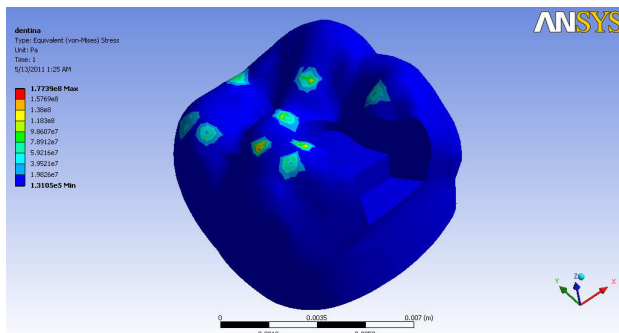


Fig. 9 Stress distribution in the prepared tooth.

IV. RESULTS AND DISCUSSIONS

For all cavity designs (sample 1-11), stresses in the restoration, and tooth were evaluated separately (Table I, Fig. 8).

TABLE I
VON MISES EQUIVALENT STRESS VALUES IN THE RESTORATIONS AND IN THE INLAY RESTORED MOLARS FOR TAPERS BETWEEN 0 AND 11 DEGREE

Sample	Taper [degree]	Von Mises equivalent stress [Pa]	
		Restoration	Tooth
1	0	2.35E+08	1.89E+08
2	1	2.68E+08	2.38E+08
3	2	2.49E+08	1.54E+08
4	3	2.55E+08	1.88E+08
5	4	2.69E+08	1.69E+08
6	5	2.26E+08	1.77E+08
7	6	2.79E+08	1.67E+08
8	7	2.48E+08	1.55E+08
9	8	2.56E+08	1.83E+08
10	9	2.57E+08	2.00E+08
11	10	2.47E+08	1.93E+08

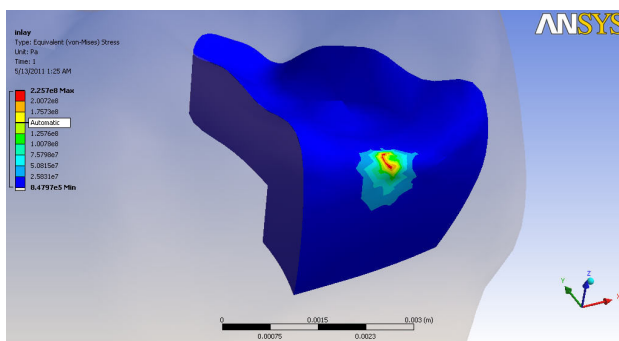


Fig. 10 Stress distribution in the inlay.

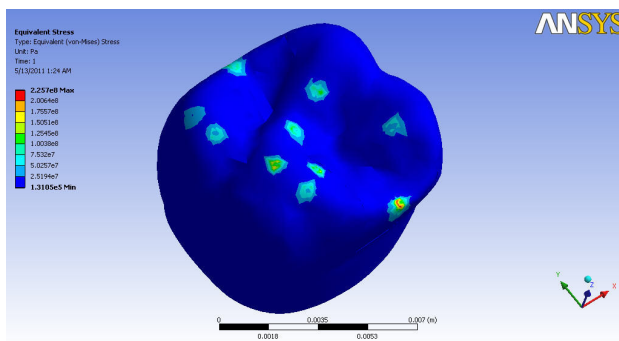


Fig. 11 Stress distribution in the restored molar.

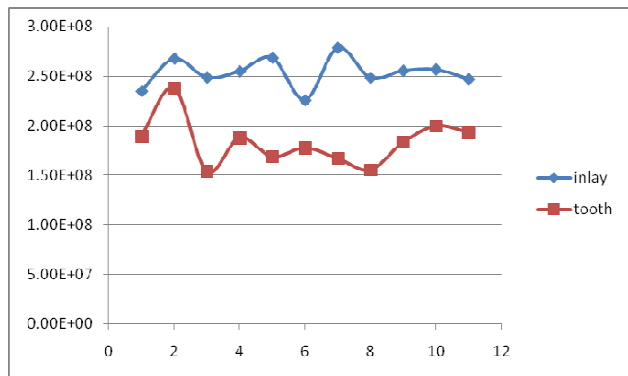


Fig. 8 Von Mises equivalent stress values in the inlay restored molar

Stresses were located around the occlusal contact areas (Fig. 9, 10).

For the studied cases, the stress values were not significant influenced by the taper of the preparation.

In the teeth restored with cast metal inlays, the von Mises equivalent stress values were similar to those in the intact tooth.

V. CONCLUSIONS

Numerical simulations provide a biomechanical explanation for stress distribution in inlays restored teeth. Within the limitations of the study, it was demonstrated stresses are higher in the cast metal restorations and therefore the strength of the teeth is not affected. A taper between 0 and 10 degree of the preparation is not decisive for the stress values.

ACKNOWLEDGMENT

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REFERENCES

[1] Fonseca, R.B.; Fernandes-Neto, A.J.; Correr-Sobrinho, L. & Soares, C.J. (2007). The influence of cavity preparation design on fracture strength

- and mode of fracture of laboratory-processed composite resin restorations. J Prosthet Dent. 98:277-284, ISSN 0022-3913.
- [2] Dejak, B.; Mlotkowski, A. & Romanowicz, M. (2003). Finite element analysis of stresses in molars during clenching and mastication. J Prosthet Dent. 90:591-7, ISSN 0022-3913.
- [3] Shillingburg, H.T. (1997). Fundamentals of fixed prosthodontics. 3rd ed. Chicago: Quintessence. p.171-9, ISBN 0-86715-201-X.
- [4] Dejak, B.; Mlotkowski, A. & Romanowicz, M. (2007). Strength estimation of different designs of ceramic inlays and onlays in molars based on the Tsai-Wu failure criterion. J Prosthet Dent.98: 89-100, ISSN 0022-3913.
- [5] Yamanel, K.; Caglar, A.; Gulsahi, K. & Ozden, U.A. (2009). Effects of different ceramic and composite materials on stress distribution in inlay and onlay cavities: 3-D finite element analysis. Dental Materials Journal. 28(6): 661-670, ISSN 0109-5641.
- [6] Dejak, B. & Mlotkowski, A. (2008). Three-dimensional finite element analysis of strength and adhesion of composite resin *versus* ceramic inlays in molars. J Prosthet Dent. 99: 131-140, ISSN 0022-3913.