INFLUENCE OF BIOMIMETIC CONDITIONING PRE ENDODONTIC TREATMENT ON THE FRACTURE RESISTANCE OF ENDODONTICALLY TREATED MOLARS

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ABSTRACT

The objective of the study was to evaluate the influence of biomimetic conditioning (BC) (prior endodontic sealing associated with deep margin elevation and restoration of cavities) of the tooth prior to root canal treatment on the fracture resistance, mode of failure, and stresses and deformations of molars with extensive MOD cavities restored with provisional restorative material. Four groups were obtained and analyzed using the three-dimensional finite element method (in silico) and also in vitro: G1- Inlay; G2– Onlay; G3– CB inlay; and G4- CB onlay. A load of 100N was applied to the occlusal surface of the crown and the maximum principal stress (σmax), shear stress (tmax), and maximum principal displacement (umax) were checked for all the involved structures. For the in vitro study, a spherical tip with a diameter of 6 mm was centrally positioned on the occlusal surface of the tooth, and a compressive load was applied (1 mm/min) until fracture. The models with CB showed a reduction in stress and strain values compared to the models without CB, which had the stresses concentrated at the bases of the cusps. The inlay group showed the lowest fracture load values (879.9 N ±192.92), followed by the onlay group (1201.2 ±136.83), inlay+CB (1390.8 ±195.18), and the highest value was found in the onlay+CB group (1631.3 ±211.54). There was no statistical difference (p=0.123) between the onlay group and the inlay+CB group. The Biomimetic Conditioning pre-endodontic treatment increased the fracture resistance of endodontically treated molars.

Keywords: endodontically treated teeth, fracture resistance, three-dimensional finite elements.

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INTRODUCTION

The rehabilitation of endodontically treated teeth (ETT) is still considered a challenge in Restorative Dentistry. After the treatment of the root canals, the structure of the tooth is modified due to the removal of dental tissue, access, and instrumentation of the root canal (Dietschi et al., 2008).

Teeth that require root canal treatment are often found to be partially fractured (missing one or more walls/cusps) or restored and require proper timing during endodontic treatment, in addition to being commonly associated with extensive coronal destruction and often requiring indirect restorations (Biacchi et al., 2013).

In biomimetic restorative dentistry, adhesive procedures are not only linked to aesthetic purposes but also to the possible biomechanical strengthening of the tooth using materials that mimic dental structure. In this way, it preserves healthy dental structure without the need for further wear and represents a paradigm shift in traditional dentistry (Bazos, 2014). Thus, the biomimetic restorative conditioning of the tooth prior to root canal treatment can aid in the prognosis of the tooth. This innovative biomimetic proposal was developed by combining techniques previously described in the literature, such as preliminary endodontic sealing (De Rose et al., 2015), deep margin elevation (Magne and Spreafico, 2012a), and the filling of enamel cavitations with composite resin restorations.

The objective of this study was to evaluate the influence of biomimetic conditioning (prior endodontic sealing associated with deep margin elevation) of the tooth before root canal treatment on the fracture resistance, failure mode, stress concentrations, and deformations of extracted permanent human molars restored with provisional restorative material.

METHODOLOGY

The present work is registered under Opinion 4.785.325 of CAAE: 46378320.8.0000.5076. In vitro analyses and three-dimensional finite element method analyses were conducted. Using the SolidWorks graphic design program (SOLIDWORKS 2018, SOLIDWORKS CORPORATION, MA, USA) and images from a computed tomography scan of a healthy tooth, a three-dimensional model of a first lower molar with an MOD-type cavity and endodontic treatment was created (Camargos et al., 2020).

The crowns of the teeth were prepared to simulate a coronal destruction in a borderline situation between a direct and an indirect restoration. The occlusal box was prepared so that the buccal and lingual walls have a thickness between 1.5 and 2mm. The proximal box was made up to 1.5mm away from the amelodentinal junction. The models were exported to the finite element software Ansys Workbench 14.0 (Swanson Analysis Inc., Houston, PA, USA) for numerical analysis. The mechanical properties of

all the structures are those available in the specific literature. The finite element mesh was determined using tetrahedral elements of size 0.3 mm. All the structures were assumed to be bonded. The models were defined by fixing the external surfaces of the cylindrical mounting base in all directions. The loading was applied axially at the center of the crown with a magnitude of 300N (Borges et al., 2021). The response variables were the maximum principal stress (σmax), minimum principal stress (σmin), Von Mises stress, shear stress (tmax), and maximum principal displacement (umax) for all the structures studied.

For the in vitro study, 40 lower third molars were used, which were cleaned and stored in a 0.1% thymol solution. The roots were immersed up to 3 mm below the cement-enamel junction using self-curing acrylic resin and mounted in a special positioning device. The teeth were then randomly distributed into 4 groups (n = 10): G1 – MOD without cusp coverage; G2 – MOD with cusp coverage; G3 – MOD + prior endodontic sealing and deep margin elevation without cusp coverage; and G4 - MOD + prior endodontic sealing and deep margin elevation with cusp coverage. The crowns of the teeth were all prepared to simulate a coronal destruction of a borderline condition between a direct and an indirect restoration. The occlusal box was prepared so that the buccal and lingual walls had a thickness between 1.5 and 2mm using a diamond bur no. 2135. For the simulation of the deep proximal box and concavities in the remaining walls, a diamond bur 1016 was used. The amount of wear was determined by the diameter of the tip to wear the tooth until the tip's shaft touches the cusp of the tooth. The coronal opening was also performed with the diamond tip 1016.7

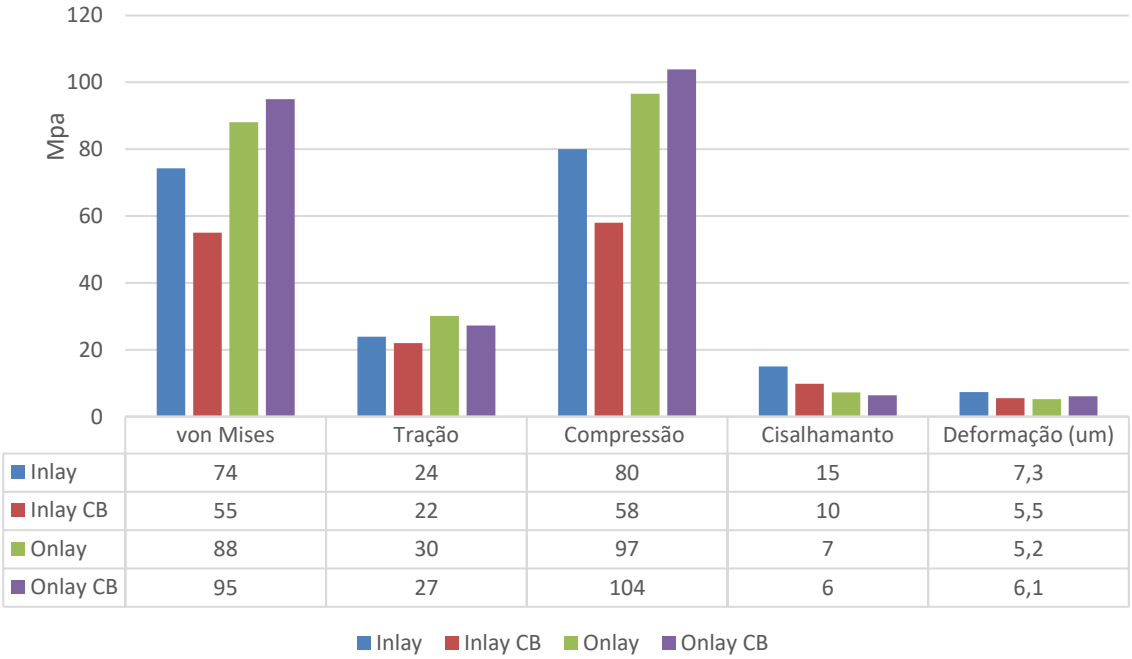
For the teeth treated with biomimetic conditioning, after cavity preparation, the preliminary endodontic sealing (PES) was performed on the freshly cut dentin of the MOD preparation walls and pulp chamber (excluding the floor, which was protected with Teflon tape) using a three-step adhesive system (Optibond FL; Kerr, Orange, CA, USA) according to a previously published protocol (MAGNE, 2006). The adhesive was polymerized for 20 seconds at 1000 mW/cm2 (VALO Curing Light, Ultradent Products, Inc., South Jordan, UT, USA) followed by an additional 10-second light polymerization under an air-blocking barrier (KY Jelly; Johnson & Johnson Inc, Montreal, QC, Canada). The proximal boxes were elevated 2 mm using photopolymerizable

composite resin. The enamel margins were redone with a fine spherical diamond bur (Brasseler) to eliminate excess adhesive. The teeth in groups 1 and 3 did not receive the biomimetic tooth conditioning treatment and will proceed to endodontic treatment after the preparation of the MOD cavity.

The teeth were then subjected to root canal treatment and the cavities were completely filled with temporary filling material (glass ionomer cement, Maxxion R - FGM). A universal testing machine (Instron Corp, Canton, MA) was used for the compressive strength test. A 6 mm diameter stainless steel spherical tip was axially positioned at the center, and a compressive load was applied vertically at a speed of 1 mm/min until fracture occurred. The maximum force required to fracture each sample was recorded in newtons (N).

RESULTS

The quantitative analysis demonstrated that the models with biomimetic conditioning with prior endodontic sealing showed a reduction in stress and strain values compared to the models without conditioning, except for compressive loads (Figure 1).



	von Mises	Tração	Compressão	Cisalhamanto	Deformação (um)
Inlay	74	24	80	15	7,3
Inlay CB	55	22	58	10	5,5
Onlay	88	30	97	7	5,2
Onlay CB	95	27	104	6	6,1

Figure 1. Quantitative analysis of the stresses and deformation of the four models. Von Mises, Tensile, Compressive, and Shear criteria presented in megapascals (MPa). Displacement Criterion presented in micrometers (μm)

*CB: biomimetic conditioning with prior endodontic sealing.

Fracture Resistance

The statistical analysis showed that the type of preparation [F(1,36) = 22.741; p<0.001] as well as the restorative approach [F(1,36) = 63.800; p<0.001] influenced the load-fracture outcome. There is no interaction effect of the factors on the fracture load outcome [F(1,36) = 0.470; p=0.497].

The inlay group showed the lowest fracture load values (879.9 N ±192.92), followed by the onlay group (1201.2 ±136.83), inlay + CB (1390.8 ±195.18), and the highest value was found in the onlay + CB group (1631.3 ±211.54). According to the Tukey HSD post hoc test, there was a statistical difference between all groups (p<0.05), except between the onlay group and the inlay + CB group (p=0.123).

CONCLUSION

Within the limitations of the study, it can be concluded that:

1. Biomimetic conditioning prior to endodontic treatment increased the fracture resistance of endodontically treated molars.
2. The highest fracture resistance values were found in the onlay and biomimetic conditioning group.
3. The groups with biomimetic conditioning showed lower values of stress and strain, in addition to exhibiting better stress distribution in the root dentin.

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