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ORIGINAL ARTICLE

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Cuspal deflection of directly or indirectly restored teeth

Deflexão cuspídea de dentes restaurados direta ou indiretamente

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ABSTRACT

Objective: The aim of this study was to evaluate the cuspal deflection of teeth restored directly and indirectly. **Material and Methods:** Forty sound maxillary premolar teeth were restored with composite and different base materials. Wide mesial-occlusal-distal cavity preparations were performed, with isthmus width of one third of the distance between the cuspal tips, 3 mm occlusal and a 5 mm interproximal preparation height. The teeth were divided into 4 groups (n = 10), according to the restoration type: G1) GIC-DCR (1 mm glass ionomer cement base and direct restoration using nanoparticulate composite); G2) FL-DCR (1 mm base of flowable composite resin and direct restoration using nanoparticulate composite); G3) GIC-ICR (1 mm glass ionomer cement base and indirect restoration using nanoparticulate composite GIC base); G4) FL-ICR (1 mm base of flowable composite resin and indirect restoration using nanoparticulate composite). The specimens were submitted to compressive load of 50 N on the buccal and lingual cusps, in a universal testing machine. The lingual cusp microstrain ($\mu\varepsilon$) measurements were executed by strain gauges. **Results:** The Kruskal-Wallis (5%) test was used and showed there were no significant differences among the microstrain values for the four study groups (G1 = 1250; G2 = 1075; G3 = 1279; G4 = 937). **Conclusion:** It could be concluded that the restorative techniques and the bases employed did not show any influences in cuspal deflection.

KEYWORDS

Base materials; Cuspal defection; Composite resin; Direct restoration, Indirect restoration.

RESUMO

Objetivo: O objetivo deste trabalho foi avaliar, por meio de medidores de tensão, a deflexão cuspídea sofrida por dentes restaurados, direta e indiretamente, com resinas compostas e diferentes materiais de base. **Material e Métodos:** Para o preparo dos corpos-de-prova (CP) foram utilizados 28 dentes pré-molares humanos íntegros, extraídos por razões ortodônticas que tiveram suas raízes embutidas em poliuretano de densidade semelhante a do osso e suas raízes recobertas por um espaçador visando simular o espaço referente ao ligamento periodontal. Na etapa seguinte os dentes receberam preparos cavitários do tipo mésio-ocluso-distais amplos e então restaurados direta e indiretamente com resina composta e dois diferentes materiais de base/forramento, resina flow e cimento de ionômero de vidro. Para a realização das medidas de deflexão das cúspides foram utilizados extensômetros lineares elétricos colados à face lingual de cada dente e submetidos a uma carga de 50 N aplicada por uma ponta romba de diâmetro de 3,0 mm, que promoveu compressão simultânea nas vertentes triturantes das cúspides vestibular e lingual, numa máquina universal de ensaios. **Resultados:** Foi realizado o teste de Kruskall-Wallis (5%) de significância e não foram encontradas diferenças estatísticamente significantes entre os grupos (G1 – 1250; G2 = 1075; G3 = 1279; G4 = 937). **Conclusão:** Pode-se concluir que o tipo de restauração bem como o tipo de base empregados nesse estudo não alteram a deflexão cuspídea dos dentes com restaurações amplas.

PALAVRAS-CHAVE

Resina composta; Cimentos de ionômero de vidro; Deflexão cuspídea; Restaurações diretas; Restaurações indiretas.

INTRODUCTION

Adhesive restorations enable more conservative preparations, the remaining structures can be reinforced and the tooth-restoration margin can be sealed. Crown fractures, caused by masticatory stress, hardly occur in intact teeth, but loss of structure due to restorative process increases fracture risk. Fractures are more common in weakened cusps, in teeth with wide and deep restorations. Besides this fracture risk, a cuspal deflection can happen and consequently, tooth-restoration adhesive interface can fail, causing postoperative sensibility, microinfiltration and secondary decay [1-4].

According to González-López et al.[5], the dental structure progressive loss in depth, with the marginal crests removal, as it occurs in MOD (mesial-occlusal-distal) cavities, associated with the oclusal loads increase, have contributed for the cuspal deflection augmentation. Highest deflection values have been registered for MOD cavities [6]. Tantbirojna et al. [7] and Lee et al. [8] have correlated the cuspal deflection increase with the tooth cavity size and shape. Adhesive restorations performed with the incremental method, or indirect restorations might reduce cusp deformation [8]. Equally, the combination of glass ionomer cement and composite resin might reduce the deformation by reinforcing the dental structure [9] and decreasing the deflection. This technique consisted of using GIC as a dentin substitute and other dental materials (e.g. composite resin, amalgam) as an enamel substitute, lessening the composite resin total volume without altering the restoration final resistance [9,10].

Several studies have demonstrated variations in cuspal deflection, following the method used. Shimizu et al. [2] have found a smaller deformation in teeth restored with combination of composite resin and flowable resin, in comparison to other restorative materials. Palin et al. [11] have compared two trademarks of methacrylate composite resin and an experimental oxiran composite resin, and have found a smaller cusp deflection in the experimental material. Cara et al. [12] and Alomari et al. [13] verified that there was a significant reduction in the cuspal deflection of teeth restored directly with composite resin and intermediate flowable composite layer. In a study, where two composite resins (Marathon and P-50) were compared to amalgam in class II restorations, it has been found that Marathon significantly let the teeth more rigid than prepared and non restored teeth. However, P-50 and amalgam did not show this difference [14].

The strain gauge method has been a cuspal deflection measurement method found in the literature, and it has been based on the use of a small sensor – the strain-gauge. Deformation, experienced by the cusp, led to variations of electric resistance. Thus, this variation was sent to the data acquisition board and transformed into digital signs, which enabled the readings through specific software [15].

Controversies observed in literature have motivated the execution of this research. So, the main objective was to evaluate, through strain gauges, the cuspal deflection of teeth restored directly or indirectly with composite resin and different base materials, which were submitted to oclusal load after different restorations.

MATERIAL AND METHODS

For the specimen (Sp) preparation, 40 sound human premolar teeth were used. The teeth were extracted due to orthodontic reasons and obtained through donation of private dental. The teeth collection and usage was evaluated and consented by the Research Ethics Committee of São José dos Campos Dental School (Sao Paulo State University). Teeth were examined with a stereoscopic magnifying glass in order to discard those that previously showed cracks or/and fractures.

Teeth roots were embedded in a polyurethane base presenting similar density to human bone (F-16 AXSON. Cergy, France), and were covered by a film of relief wax (about

0.3 mm) in order to simulate the periodontal ligament width. This space was later filled out with light body condensation silicone (Xantopren, Hareaus Kulzer, Germany), so that, the entire coronal portion and the first two millimeters below the cementum-enamel junction were exposed.

In the following stage, teeth received mesial-occlusal-distal cavity preparations, with isthmus width of one third of the distance between the cusps tips, a 3 mm oclusal preparation height, and 5 mm interproximal preparation height, using a diamond bur (N° 3131 – RG Sorensen, EUA). The 40 teeth were divided into four groups according to the restoration type:

Group 1: GIC-DCR – MOD cavities directly restored using Z-350 nanoparticulate composite resin (3M-ESPE) on a 1 mm base of Vidrion F (SS White) glass ionomer liner (SS White) (10 Sp);

Group 2: FL-DCR - MOD cavities directly restored using Z-350 nanoparticulate composite resin (3M-ESPE), with a resin base - Filtek Flowable Restorative (3M, ESPE) (10 Sp);

Group 3: GIC-ICR - MOD cavities indirectly restored using Z-350 nanoparticulate composite resin (3M-ESPE), with a base of Vidrion F (SS White) glass ionomer liner (SS White) (10 Sp)

Group 4 FL-ICR – MOD cavities indirectly restored using Z-350 composite resin (3M-ESPE), with a base of Filtek Flowable Restorative (3M, ESPE) (10 Sp).

Group 1 and 2 specimens were restored by incremental technique. After the liner/base insertion with 1 mm thickness, the increments, with thickness of 2 mm, were inserted and light-cured with a halogen light-curing unit (Optilight Plus, Gnatus, Brazil), for 20 s each.

For the indirect restorations execution (groups 3 and 4), the prepared teeth with the respective liner/base material were impressed with Optosil/Xantopren (Hareaus Kulzer, Germany) condensation silicone, first with the heavy body, and secondly with the light body material.

Guided and centralized crown insertion into trays was done by a bench parallelometer, enabling the standardization of the light body impression material thickness of all groups' impressions. Impressions were poured with type IV dental stone (Durone, DENTSPLY, USA) and stone dyes were obtained, on which the indirect composite resin restorations were made by incremental technique, as described for the direct restorations group. These indirect restorations were cemented onto the prepared teeth with a dual cure resin luting cement, Bistite II DC (Bisco), through a device specially elaborated to standardize the cementation load in 750 g. After the luting excess removal, the oclusal surface was exposed to halogen light curing unit, for 40 s (Optilight Plus, Gnatus, Brazil).

Twenty-four hours after the restorations conclusion, the specimens were submitted to 50 N load applied by a 3.0 mm diameter rhombus tip, which promoted a compression on the buccal and lingual cusps triturating slopes, in a universal testing machine (EMIC, Sao José dos Pinhais – Paraná – Brazil).

Measurements of cuspal deflection were performed by electrical linear sensors (strain gauge) – PA-06-062AB-120L model (Excel Sensors Ltd., Sao Paulo, Brazil), fixed with cianoacrilate to the lingual surface of each tooth (Loctite Super Bonder® - 3M, EUA).

Measurements were executed according to a protocol described by Vasconcellos16 (2005), in which the strain gauges were connected to electrical signs amplifying device, through electrical cables (26 AWG 0.14 mm – Muticabo – Sao Paulo – Brazil). The two sensors data were amplified and transferred by a sign amplifier (ADS 2000IP – Lynxx – Sao Paulo, Brazil). Electrical variations were registered and later transformed in microstrain ($\mu\varepsilon$) units by

AqDados (Lynxx – Sao Paulo, Brazil), special data acquisition software. Magnitude deformation ($\mu\varepsilon$) in each extensometer was equal to its length divided by its original length (1.52 mm) and multiplied by 10-6. The apparatus was balanced and calibrated, between each measure (± 10 $\mu\varepsilon$), in order to eliminate previous readings remainders.

Each specimen was monitored for 1 minute, to a 10 Hz frequency, resulting in 600 microstrain values per specimen. Microstrain mean values for each specimen were provided by the AqDAnalysis software (Lynxx – Sao Paulo, Brazil). Statistical analysis was performed by MINITAB 14 software (Release 14 – 2004 – Minitab Inc.). As data have not presented a normal distribution, the Kruskal-Wallis non-parametric test, at 5% significance level, was used for comparison among the averages

RESULTS

Microstrain values found for the possible combinations between base/liner materials (GIC or flowable resin) and restorations techniques (direct or indirect) are described in Table 1 and are shown in Figure 1. It could be observed that values showed a great numeric variability, which could be considered as an inherent characteristic of the strain gauge method. Such variation had probably been responsible for the non-normal data distribution. This way, the median values better expressed the cuspal deflection tendency (microstrain) in relation to the research variables.

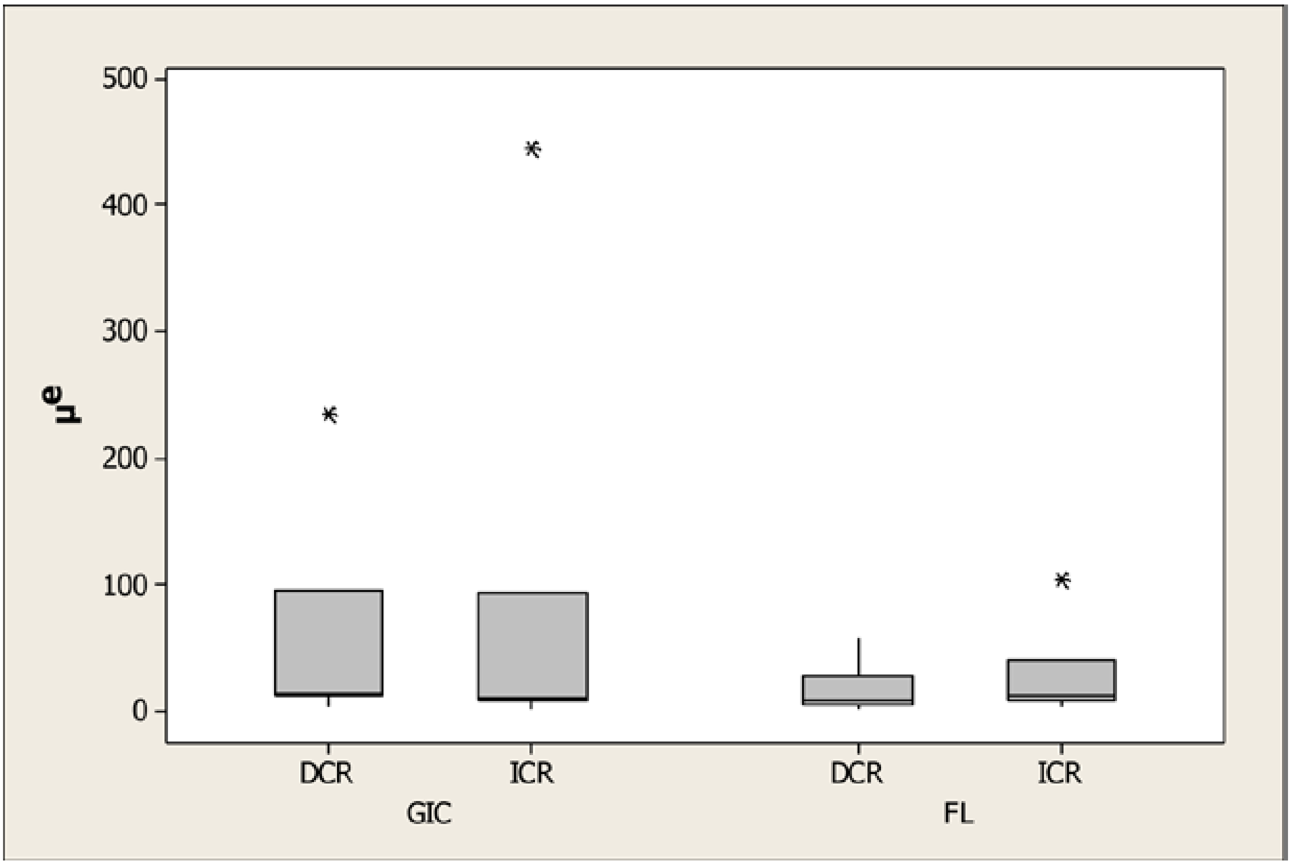

Figure 1 – Microstrain (με) results distribution according to base material and restorative technique (interquartile values).

Table 1 – Microstrain (με) mean, maximum values, minimum values and median description for the different combinations between base material and restorative technique

Groups	Mean	Standard deviation	Minimum	Maximum	Median
GIC-DCR	57.9	84.2	2.69	234.9	12.9
GIC-ICR	84.7	162.2	1.52	445.5	9.85
FL-DCR	16.59	20.22	1.97	58.24	7.88
FL-ICR	27.6	35.7	2.98	103.7	11.7

For comparison among median values, there were no significant differences among base materials or among restorative techniques as showed in tables 2 and 3 (Kruskal-Wallis 5%).

Table 2 – Microstrain (με) median values and P-value obtained by Kruskall-Wallis test for comparison among the base materials used in the study

Base Materials	Median	P-value
GIC	12.79	0.232 (p > 0.05)
FL	9.37	

Table 3 – Microstrain (με) median values and significance level obtained by Kruskall-Wallis test for comparison among restorative the techniques used in the study

Restorative techniques	Median	P-value
DCR	12.50	0.927 (p > 0.05)
ICR	10.75	

DISCUSSION

The cuspal strain study related to different materials and restorative techniques can provide guides regarding the restorative procedures effects on dental structures protection and longevity. If great deformations occurred in restored teeth, the emergence of cracks and fractures would be possible, especially when dental structure is weakened. Besides, if the restorative material allowed a significant cuspal movement, postoperative sensibility or even microinfiltration in tooth-restoration interface would also occur.

In this study, differences were not observed among the base materials studied (glass ionomer cement and flowable composite resin) referring to the microdeformation caused by maxillary premolar cuspal deflection.

Cuspal deflection reduction due to polymerization contraction was verified when an intermediate layer of flowing resin was used between the dental adhesive layer and the composite resin layer [12,13]. According to Cara et al. [12] (2007), this reduction has occurred due to the presence of a more elastic material layer, which would have absorbed the stress generated by the subsequent material's polymerization contraction.

Dental structure loss replaced by adhesive restorations has resulted in reinforcement of dental structure and consequently in a smaller cuspal deflection [17,18]. The application of a non-adhesive restorative material have neither reinforced the remaining structure and nor avoided the largest cuspal deflection [19]. In the present study, there were no differences among the intermediate materials used as restoration base (GIC and flowing resin). This could be explained by the fact that both materials had adhesive properties. Although, there were no differences among the base materials, it could be observed in Figure 1.

Shimizu et al [2] have verified a decrease in deformation of composite resin restored teeth, when a flowable composite resin was used previously to composite resin application.

Jagadish and Yogesh [1] have compared the fracture resistance of premolars with MOD cavities preparations and restored with amalgam, cermet and composite resins. It was noticed that after compressive tests, composite resin restored teeth presented the largest resistance values, compared to the others.

The strain gauge method was used instead of the fotoelasticity and finite element analysis because it could provide quantitative and qualitative data regarding to the microdeformation suffered by the experimental body-of-proof. The great variation of the microdeformation results might have happened due to the influence of a great number of factors that could have interfered in the passage of the current through the system (strain gauges orientation, thermal oscillations and information loss in the path between the extensometers and the data acquisition device entrance).

A hypothesis has been cogitated that the use of another test might have resulted a smaller oscillation in the results (less susceptible to variations). In this case, the cuspal deformation difference between teeth with GIC and flowing resin bases restored cavities could have become present. According to Jantarat et al.[20], other possible tests to evaluate the cuspal deformation would be “Linear Variable Differencial Transformers” (LVDTs) e “Direct Current Differencial Transformers” (DCDTs). Despite the fact that Strain gauges would be less sensitive to detect deformations than the two methods mentioned above, they were easier for experimental use, requiring a smaller number of adjustments.

Comparing the composite resin restoration technique (direct and indirect), there were no differences between them, related to the microdeformation produced by the cuspal deflection of the restored teeth.

Fleming et al [21] and Palin et al. [11] have verified a smaller cuspal movement, thus smaller was the polymerization contraction of the restorative material. It has been expected that indirectly made restorations resulted in the polymerization contraction effect being reduced, due to resin cement layer thickness. However, if this effect occurred, it would not be reflected by a smaller cuspal deformation during the load application.

In a study performed by Lee et al.[8], comparing the direct techniques with single increment, direct incremental technique and indirect technique for MOD cavities composite resin restorations, a larger cuspal deflection has been found, due to the polymerization contraction in the single increment technique. The incremental and indirect techniques have resulted in smaller and similar deformations amongst each other, corroborating with our results, where just these latter techniques were compared.

CONCLUSSION

Restoration techniques and base material showed no influence in cuspal deflection behavior.

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