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# Molars Fracture Resistance with Class II Cavities Restored with Different Resin - Based Materials

# Resistência à Fratura de Molares com Cavidades Classe II Restauradas com Diferentes Materiais à Base de Resina

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**Abstract**

The teeth weakening due to the preparation of class II mesio-occluso-distal cavities is a challenge for the clinician. The objective of this study was to evaluate the molars fracture resistance with class II mesio-occluso-distal cavities restored with different restorative techniques and materials. Forty extracted molars were divided into 5 groups: Group 1 – intact healthy teeth (positive control); Group 2 – unrestored teeth with mesio-occluso-distal class II cavities (negative control); Groups 3 to 5 – restored teeth with standardized dimensions. In groups 3 to 5, the cavities were restored with flow resin only, flow resin coated with a nano-hybrid resin, and nano-hybrid resin only, respectively. All specimens were tested for resistance to fracture using an axial compressive load, a metallic sphere measuring 8 mm in diameter on a universal testing machine EMIC DL-2000. A 10 kN load cell operated at a speed of 5 mm/min until the tooth fracture. Data were subjected to analysis of variance and Tukey's tests ($\alpha = 0.05$). Group 3 showed higher fracture strength (2243.1 ± 473.7N) when compared to groups 2, 4 and 5. This difference was statistically significant ($p<0.05$). The fracture strength of teeth restored with flow mesio-occluso-distal restorations was similar to that of intact natural teeth.

**Keywords:** Compressive Strength. Composite Resins. Dental Cavity Preparation.

**Resumo**

*O enfraquecimento dos dentes devido às preparações de cavidades mesio-ocluso-distal é um desafio para o clínico. O objetivo deste estudo foi avaliar a resistência à fratura de molares com cavidades mesio-ocluso-distais classe II restauradas com diferentes técnicas e materiais restauradores. Quarenta molares extraídos foram divididos em 5 grupos: Grupo 1 – dentes saudáveis intactos (controle positivo); Grupo 2 – dentes não restaurados com cavidades mesio-occluso-distais classe II (controle negativo); Grupos 3 a 5 – dentes restaurados com dimensões padronizadas. Nos grupos 3 a 5, as cavidades foram restauradas apenas com resina flow, resina flow recoberta com uma resina nano-híbrida e somente resina nano-híbrida, respectivamente. Todas as amostras foram testadas quanto à resistência à fratura usando uma carga compressiva axial, usando uma esfera metálica medindo 8 mm de diâmetro em uma máquina de teste universal EMIC DL-2000. Uma célula de carga de 10 kN operava a uma velocidade de 5 mm/min até a fratura do dente. Os dados foram submetidos à análise de variância e testes de Tukey ($\alpha = 0,05$). O grupo 3 apresentou maior resistência à fratura (2243,1 ± 473,7N) quando comparado aos grupos 2, 4 e 5. Essa diferença foi estatisticamente significante ($p <0,05$). A resistência à fratura dos dentes restaurados com resina flow foi semelhante à dos dentes naturais intactos.*

**Keywords:** *Força Compressiva. Resinas Compostas. Preparo da Cavidade Dentária.*

## 1 Introduction

Since the introduction of the acid etching technique by Buonocore[1] new techniques have emerged with regarding the restoration of dental function and aesthetics. In addition, the idea of dental tissues conservation has emerged in the last few years.[2]

According to Mehta and Banerji[3] the current adhesive restorative materials and techniques makes it possible to aesthetically treat posterior teeth with a reasonable predictability of success. However, all the resin materials undergo an inherent shrinkage during the polymerization reaction, especially in deep cavities. Furthermore, a high cavity configuration factor (C-factor) can amplify the problems associated with composite resin restorations due to shrinkage.[4,5] Two types of problems related to polymerization can be observed: gaps can form if the composite is weakly attached to the dental tissues; if the bond strength exceeds the shrinkage stress, the restoration maintains an internal tension that pulls the tooth walls.[6] Some of the effects of these processes may be perceived clinically: postoperative pain and degradation of the tooth-restoration interface, which in turn can lead to marginal staining, secondary caries, and pulp inflammation.[6,7]

In direct adhesive Class II restorations, methods such as incremental techniques, the use of ceramic inserts or application of a base have been proposed to reduce the composite polymerization shrinkage.[8] However, these techniques are not considered sufficiently effective when applied to large class II restorations.[9] Moreover, the resin insertion becomes more difficult when the cavity is too deep.[5] Due to these factors, it may be difficult to obtain a good marginal adaptation in broad and deep cavities. The restorative material adaptation to the cavity margins is a crucial factor in the long-term restorations performance.[10] For this reason, low shrinking stress flowable composites are a focus of research in the field of posterior restorations.[11]

A restorative material for posterior teeth with improved characteristics regarding the polymerization shrinkage is SureFil SDR™ (Stress Decreasing Resin) (Dentsply Caulk, Milford, Delaware). According to the manufacturer, it was developed from a unique technology which led to a flow composite with very low residual polymerization shrinkage.[12] The technology employed in the SDR™ optimizes the polymer network formed during cure, reducing the polymerization stress caused by polymers that are extremely stiff. Using this technique, a more relaxed polymer network compared to conventional photo activation isformed, which results in the contraction stress reduction by up to 60%. This is achieved by utilization of a polymerization modulator that is chemically incorporated into the structure of the organic matrix of the SDR™ resin monomer. According to the manufacturer, the SDR™ polymerization modulator reduces the stress build-up without reduction in the polymerization or conversion rate.

Sound teeth rarely fracture under normal masticatory function. Several studies have emphasized the importance of maintaining the tooth structure to preserve the remaining tooth strength.[13-15,16] Teeth weakening due to MOD preparations and the contribution of restorative materials to improve the remaining dental tissues strength have been studied by several groups since 1956.[17-19] Although in vitro studies are not a reproduction of a typical real mastication force, they represent an important source of information. Compression testing is the most used methodology to compare the fracture resistance of teeth receiving restorative material.

Within this context, this study aimed to compare the fracture resistance of healthy teeth with class II MOD cavities restored with SureFil SDR™ flow. The null hypothesis tested was that the fracture resistance of teeth restored with the new bulk-fill flow resin is not significantly different from that of healthy teeth.

## 2 Material and Methods

Forty sound human third-molars with similar dimensions were selected for the study. The teeth were subjected to cleaning and visual inspection with a magnifying glass, making sure of the absence of cracks, cavities or any defect. The teeth dimensios were as follows, as verified by a digital caliper: 9.0±1.0 mm bucco-lingually and 7.0±1.0 mm mesio-distally. Tooth disinfection was performed with a 0.1% thymol solution. Subsequently, the teeth were stored in distilled water at 4 °C until use. The teeth roots were subsequently placed at the center of the plastic cylindrical trays (20 mm in diameter and height) and embedded with epoxy resin until a distance of 2 mm of the cement-enamel junction was reached. Care was taken to maintain the occlusal surface of the teeth parallel to the base of the cylinder, since in the fracture resistance tests, the compressive force is applied parallel to the teeth long axis. The teeth were randomly assigned to five equal groups (Table 1).

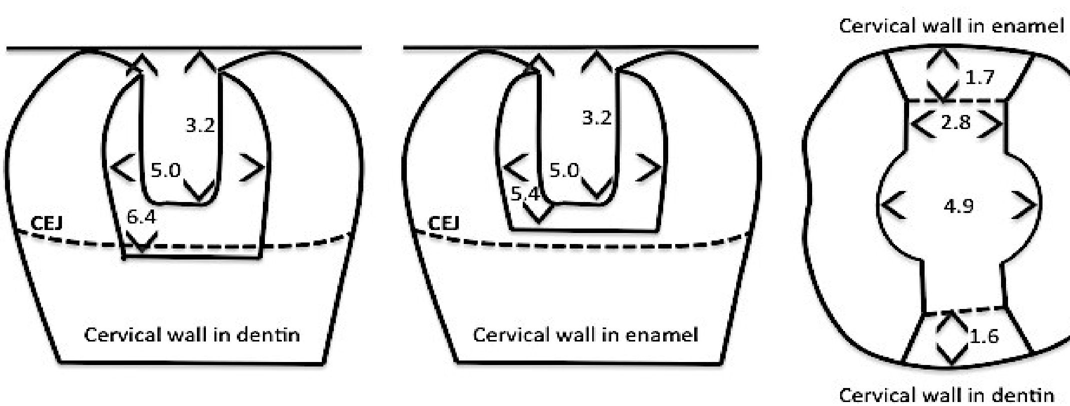
**Table 1 -** Treatment Groups

| Group | Cavity | Type of restoration |
|---|---|---|
| 1 | Intact | Intact teeth |
| 2 | MOD | Non-restored |
| 3 | MOD | Completely filled with SDR™ |
| 4 | MOD | Filled with SDR™ + Esthet-X HD |
| 5 | MOD | Completely filled with Esthet-X HD |

**Source:** Research data.

Class II box-shaped (MOD) cavities were prepared with parallel walls and enamel margins were bevelled, with cervical margins located 1.0 mm below (mesial) and above (distal) the cement-enamel junction. Figure 1 illustrates the cavities dimensions. The cavities were prepared using cylindrical flat-end coarse-grained diamond burs under abundant water spray. The finishing procedures were performed with fine-grained burs of the same shape. The dimensions of the preparations were monitored by using a caliper and a periodontal probe.

**Figure 1 -** Cavities dimensions




**Source**: The authors.

Teeth were allocated in 5 groups with the following restorative procedures: group 1 - intact teeth; group 2 - MOD cavities prepared but not restored; group 3 - cavities were cleaned with a water spray and dried with absorbent paper, leaving the dentin slightly moistened. Next, self-etching one-bottle adhesive Xeno® V (Dentsply Caulk, Milford, Delaware) was applied according to the manufacturer's instructions and light cured for 20 s. The restorative material SureFil® SDR™ *flow* was applied directly into the cavity preparation using a Centrix® syringe (Centrix System, DFL, Jacarepaguá, Rio de Janeiro) with a slow and steady pressure. The filling took place from the deepest cavity portion up to the cavosurface edge angle in 4-mm height increments of up to 4 mm in height. The resin tip was withdrawn progressively as the cavity was filled. The increments were photo cured using the LED-based curing unit Bluephase G2 (Ivoclar Vivadent, Schaan, Liechtenstein), with a power density of approximately 1100 mW/cm$^2$. The finishing procedures were performed using fine-grained burs.

The same procedures as mentioned above for group 3 were performed in group 4 until the adhesive system application. Subsequently, SDR™ *flow* was placed directly into the cavity using a Centrix® syringe with a slow and steady pressure. The insertion occurred from the deepest cavity portion up to 2mm below the cavosurface edge angle . This increment was then light-cured, and the occlusal cavity portion (2mm) was filled with the nano- hybrid composite EsthetX™ (Dentsply Caulk, Milford, Delaware), followed by curing of this resin according to the manufacturer's instructions. The finishing procedures were performed using fine-grained burs.

Group 5 received the same procedures mentioned above. Subsequently, the cavities were filled with oblique increments of approximately 2-mm thickness with Esthet-X™ HD following the manufacturer's instructions. Each increment was light-cured separately. The finishing procedures were performed using fine-grained burs.

After restoration, all of the groups were stored in distilled water at 37 ˚C and protected from light. After one week, all the specimens were removed from the storage conditions and tested for fracture resistance by means of an axial compressive load, a metallic sphere measuring 8 mm in diameter. This sphere was attached to a universal testing machine EMIC DL-2000 (São José dos Pinhais, PR, Brazil) with a load cell of 10 kN, which was driven at a speed of 5 mm/min until the tooth fracture. The force necessary to fracture each tooth was recorded in Newtons (N) and the data were analyzed using analysis of variance and Tukey's test for the five experimental conditions.

## 3 Results and Discussion

The mean values of fracture resistance (N) and standard deviations for each of the five experimental conditions are shown in Table 2. The fracture resistance of group 3 was significantly higher than the other groups ($p<0.05$), except for group 1, which showed no significant difference ($p=0.65$). Teeth restored with SDR™, SDR™ + nano-hybrid resin, nano-hybrid resin only, and intact teeth (groups 3, 4, 5 and 1, respectively) showed a significantly higher fracture resistance when compared to the prepared/non-restored teeth (group 2; $p<0.05$). There were no statistically significant differences between groups 1 and 3 ($p=0.20$), between groups 1 and 4 ($p=0.76$) and between groups 4 and 5 ($p=0.19$).

**Table 2 -** Mean values of fracture resistance (N) and standard deviations for the groups

| Group | n | Type of restoration | Mean ± SD (N) |
|---|---|---|---|
| 1 | 8 | Intact teeth | 2243.1 ± 473.7$^{AB}$ |
| 2 | 8 | Non-restored | 708.4 ± 269.7$^{D}$ |
| 3 | 8 | Completely filled with SDR™ | 2849.3 ± 433.2$^{A}$ |
| 4 | 8 | Filled with SDR™ + Esthet-X™ HD | 1753.8 ± 512.3$^{BC}$ |
| 5 | 8 | Completely filled with Esthet-X™ HD | 1406.8 ± 428.5$^{C}$ |

*Same letters indicate statistically similar values – ANOVA and Tukey's tests (p >0,05).
**Source:** Research data.

The success of a restorative treatment depends on the correct selection of the restorative material and the use of an appropriate technique. Several studies have indicated that the fracture resistance of large cavity-prepared teeth is reduced due to loss of tooth structure.[17-19] Similarly, the results of this study also indicated that tooth resistance was reduced after the cavity preparation.

In the present study, it was observed that teeth restored with SureFil® SDR™ flow present improved fracture resistance when compared to teeth restored with a nano-hybrid composite. In addition, values similar to healthy teeth were noted. Therefore, the null hypothesis was accepted. Dentinstructural strength depends on the quality and integrity of a tooth anatomical form.[20] The preparation of an extensive MOD cavity may cause tooth cusps fracture if not restored.[21] The results of this study also showed that the restoration of a wide tooth cavity is important to achieve an increase of its resistance to fracture. Therefore, the reinforcement of a cavity with a suitable restorative material is needed to support the remaining tooth structure.

In a study by Jagadish and Yogesh[22] the authors suggested that composites when used in posterior teeth show great potential as a reinforcement material for cusps. Other studies have also demonstrated improved teeth fracture resistance after the use composite resins for MOD restorations.[21-24] However, the composites shrinkage during the polymerization reaction is one of the main limitations to the success of direct adhesive restorations. To minimize the polymerization shrinkage effects, the incremental insertion technique of composite resins has been used and is widely accepted in the dental community.[8] For this reason, the 2-mmincremental insertion technique was employed with the conventional composite in this study. As for the teeth restored with SDR™ flow, 4 mm increments in height were used, by filling most of the cavity in a single insertion/photo-activation. The groups of teeth restored with the new resin showed fracture resistance values similar to those of intact teeth. This finding may be due to the lower polymerization stress generated by the resin SDR™ flow. While teeth restored with conventional resin showed lower resistance than healthy teeth.

The group restored only with the resin SDR™ flow showed superior resistance when compared to the other groups of restored teeth. However, it is not clinically possible to use it in the entire cavity, i.e. without the 2-mm occlusal coating using the conventional composite. This occurs because the resin SDR™ flow, which is a fluid-consistency resin, does not allow proper sculpting and finishing of the occlusal surface and of the marginal ridges. In addition to the functional aspect, the aesthetic factor must also be considered, since the new resin is marketed in a single color and is also moderately translucent. Therefore, using the resin SDR™ flow according to the manufacturer's recommendations as a base material coated with a conventional resin, it is possible to obtain adequate fracture resistance, according to the present study.

The method of applying occlusal compressive load during the fracture test is another important factor. In this in vitro study, axial forces were applied at the center of the occlusal surface. Clinically, axial forces in addition to lateral forces and fatigue must be considered. Burke et al.[25] concluded that the best method to measure the premolars resistance to fracture is the use of a cylinder with a defined diameter. The use of a metal sphere 8 mm in diameter to test fracture resistance has been shown to be ideal for molars because it comes in contact with functional and non-functional cusps, and closely represents what is observed clinically.[24] That's why the teeth were subjected to a compressive load by means of a vertical steel sphere of 8 mm in diameter.

Regarding the clinical relevance of these findings, it should be considered that this study was performed in vitro and the mechanical test was performed 7 days after the restorations placement. Ideally, more reliable test methods must be developed in order to better reproduce the in vivo failure mechanisms that occur clinically with teeth and restorations. Further tests such as fatigue test and clinical investigations are also recommended to verify the results of this study.

## 4 Conclusion

Notwithstanding the limitations of this study, it can be concluded that teeth with MOD cavity preparations have decreased fracture resistance. Moreover, the use of SDR™ flow reversed the fracture resistance lost after the MOD cavity preparations.

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