Fracture Resistance of Pulpotomized Primary Molars Restored with Extensive Class II Amalgam Restorations

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Abstract:
Objective: The aim of the present study was to evaluate fracture resistance of pulpotomized primary molar teeth restored with extensive multisurface amalgam restorations.

Materials and Methods: Eighty extracted carious human primary molar teeth were selected for the present study. Teeth were divided into eight groups of ten. Mesio- or disto-occlusal and Mesio-occluso-distal cavities with different cavity wall thickness (1.5 or 2.5 mm) were prepared in both first and second primary molar teeth. After restoring teeth with amalgam, all specimens were stored in distilled water at 37°C for 7 days. Then samples were thermocycled for 1000 cycles from 5°C to 55°C. The specimens then were subjected to a compressive load in a universal testing machine at a crosshead speed of 0.5 mm min⁻¹. ANOVA and t-test were used for statistical analysis.

Results: Mean fracture resistance of first and second molar teeth were 975.5 N (SD=368.8) and 1049.2 N (SD=540.1) respectively. In the first molar group, fracture resistance of two-surface cavities was significantly more than three-surface cavities (P<0.001), however this difference was not statistically significant in the second molar group. In both first and second molar group, fracture resistance in cavities with 2.5 mm wall thickness, was significantly more than the group with 1.5 mm wall thickness.

Conclusion: The mean fracture resistance in pulpotomized primary molar restored with amalgam restorations was higher than reported maximum bite force in primary teeth even in extensive multi-surface restorations. Therefore, the teeth with large proximal carious lesions in schoolchildren could be restored with amalgam.

Key Words: Compressive Strength; Pulpotomy; Tooth, Deciduous; Molar; Dental Amalgam

INTRODUCTION
Loss of tooth structure due to dental caries and cavity preparation can reduce fracture resistance [1,2], especially in endodontically treated teeth restored with extensive (mesio-occlusal-distal; MOD) restorations [3-5]. Loss of marginal ridge has been shown to weaken teeth and increase susceptibility to fracture [3,5]. In the preschool children, with large proximal caries lesions, treatment with stainless steel crowns is more favorable than amalgam because of their durability. Similar-sized lesions in teeth that are within 2-3 years of exfoliation could be restored with amalgam because the anticipated lifespan is short [6]. However, studies revealed that teeth restored with amalgam are significantly weaker than intact teeth and non-bonded amalgam pro-
duced negligible increase in cuspal fracture resistance [7,8]. In order to prevent tooth fracture because of occlusal forces, tooth structure must be saved as much as possible during cavity preparation [1]. Currently, there is no report in the literatures about the minimum thickness of cavity walls in primary teeth restored with amalgam, which can resist masticatory forces. The purpose of this study was to evaluate fracture resistance of pulpotomized primary molar restored with extensive multi-surface amalgam restorations.

MATERIALS AND METHODS
Eighty extracted first (FMT) and second primary molar teeth (SMT), 40 of each group, were collected. Each tooth was cleaned and examined using a fiber-optic light and teeth with cracks or other visible defects and extensive carries that prevent standardized cavity preparation, were excluded. All teeth disinfected with thymol 0.2% and then stored in normal saline solution no more than three months. Teeth were kept in humid conditions in and at no stage in the study, teeth were allowed to dehydrate.

The teeth were mounted vertically in acrylic resin two millimeters below the CEJ, approximately at the level of the alveolar bone in a healthy tooth, and cusps were aligned in the same plane in all teeth to ensure an equal distribution of the load during the test procedure. After pulpotomizing the teeth, they were divided into eight groups.

In order to minimize the influence of size and shape variations on the results, primary teeth were divided into FMT and SMT groups. Each group subsequently divided into two subgroups according to the type of cavity (two- or three-surface cavities). Then, each subgroup subdivided into two groups according to their cavity wall thickness (1.5 mm or 2.5 mm). Teeth with the similar crown size were selected for each group (FMT or SMT). Cavitated carious lesions in children usually take place in distal of FMT and mesial of SMT molar. Therefore, MO cavities were prepared in SMT group and DO cavities in FMT group. Considering the fact that the thickness of enamel in primary teeth is 1 mm, the cavity-wall thickness was selected to be 1.5 mm, so that a minimal amount of 0.5 mm of the dentin remained.

The cavity preparations were standardized according to the following procedures. In three-surface cavities, proximal boxes were extended mesio-distally up to 1 mm to adjacent cusp tips. The extension of the prepared boxes were up to the point that 2/3 of the mesiodistal width of the teeth in both buccal and lingual surfaces remained intact, and the remaining width of the marginal ridge was the same as that of a bur 256 (0.8 mm). Proximal boxes were located at the cemento-enamel junction (CEJ) in all cavities. The attempt was made to allow the same thickness of tooth structure within each group and thickness of cavity walls were standardized with the aid of an orthometer gauge (Korkhaus Orthometer Kit, 75228 Ispringen, Denstaurm, Germany).

A new high-speed water spray bur was used for each preparation. Pulp chambers were filled using zinc oxide eugenol (Dorident, Switzerland) and zincphosphate cements (Harvard, Germani) and teeth subsequently were restored with amalgam (Cinaluy, Dr Faghihi

<table>
<thead>
<tr>
<th>Table 1. Mean and SD of resistance to fracture force (N) for two- and three-surface cavities in FMT.</th>
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<tbody>
<tr>
<td><strong>Type of cavity</strong></td>
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<td>-------------------</td>
</tr>
<tr>
<td>Two-Surface</td>
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<tr>
<td>Three-Surface</td>
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</table>

SD= Standard Deviation; FMT=First primary-Molar Teeth
Dental Co) using a matrix retainer (Tofflemire matrix retainer, Teledyne Dental products, Saratoga, Ca, USA). All specimens were stored in distilled water at 37°C for seven days and thermocycled between 5°C and 55°C with a dwell time of 30 seconds for 1000 cycles. Fracture resistance of specimens was measured using a universal testing machine (Instron, Attleboro, MA, USA) at a crosshead speed of 0.5 mm/min. Test procedure was performed using a steel ball with the dimension, which allowed contacting the inclined planes of the occlusal surfaces of the teeth, and not the restorations. Type of failure and the place of fracture line in cavity walls were recorded. The collected data were analyzed using ANOVA and t-student tests. A level of significance of 0.5% was accepted.

RESULTS
Regardless of type of cavity and cavity wall thickness, the mean fracture resistance of FMT and SMT were 975.5 N (SD=368.8) and 1049.2 N (SD=540.1) respectively. There was no significant difference in fracture resistance of FMT and SMT groups (P=0.47). Since there was a reciprocal effect between the tooth type and the cavity wall thickness (P=0.01), the FMT and SMT groups were analyzed separately by two-way ANOVA.

In the FMT group (Table 1), the mean fracture resistance of two-surface cavities was significantly more than the three-surface cavities (F=31.01, P<0.001). Also fracture resistance in the group with the cavity wall thickness of 2.5 mm was significantly more than the group with 1.5 mm thickness (F=5.06, P=0.03).

In the SMT (Table 2), the mean value of fracture resistance in three-surface cavities was more than two-surface cavities however; the difference was not statistically significant. (F=1.5, P<0.22). Moreover, the fracture resistance of cavities with 2.5 mm remaining wall was more than the group with 1.5 mm thickness of cavity walls. (F=228.3, P<0.001).

Most of fractures occurred in cavity walls (Fig. 1) which took place apical to the CEJ (Fig 2).

DISCUSSION
Regardless of type of cavity and thickness of cavity wall, SMTs showed higher fracture resistance than FMTs; however, the difference was not statistically significant. This may be due to this fact that the larger teeth might have higher fracture resistance compare to smaller teeth [9].

In the FMT group, fracture resistance of two-surface cavities was almost twice as three-surface cavities; regardless of cavity wall thickness. Loss of marginal ridge integrity has been reported as the greatest contributing factor for the loss of tooth strength; therefore, in order to maintain tooth strength, the marginal ridges should be preserved, whenever it is possible [10-12]. This is especially important in FMT, which is smaller than SMT. Panaitvisai, and Messer [4] studied cuspal deflection in endodontically treated molars with MO or MOD restorations. They have concluded that access cavity preparation in MOD group weakened the tooth structure significantly more than teeth, which restored with MO restorations. Preserving the marginal ridge decrease, the cuspal deflection, and increasing the tooth stiffness even when the marginal ridge is not adjacent to the cusp that is under

Table 2. Mean and SD of resistance to fracture force (N) for two- and three-surface cavities in SMT.

<table>
<thead>
<tr>
<th>Type of cavity</th>
<th>Thickness (mm)</th>
<th>Number</th>
<th>Mean</th>
<th>SD</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-Surface</td>
<td>1.5</td>
<td>10</td>
<td>803.7</td>
<td>311.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>10</td>
<td>1261.9</td>
<td>500.5</td>
<td>F=1.5</td>
</tr>
<tr>
<td>Three-Surface</td>
<td>1.5</td>
<td>10</td>
<td>803.7</td>
<td>311.4</td>
<td>P&lt;0.22</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>10</td>
<td>1261.9</td>
<td>500.5</td>
<td></td>
</tr>
</tbody>
</table>

SD= Standard Deviation; SMT=Second primary-Molar Teeth
load [4]. Hence, it could be expected that in present study three-surface cavities showed lower resistance to fracture than the two-surface cavities.

Despite the type of cavity, the mean fracture resistance of teeth with 2.5 mm wall thickness was higher than the teeth with 1.5 mm wall thickness. These finding could imply that in FMT, preserving tooth structure especially both marginal ridges are important in order to increase the tooth strength and fracture resistance.

In the SMT group, the mean fracture resistance value of two-surface cavities was higher than three-surface cavities; however, the difference was not statistically significant. Comparing this result with the findings obtained from FMT group revealed that loss of marginal ridge in the former is less important than the later. It has also shown that weakening effects of loss of marginal ridges in molars are much less compare to premolars [12]. This higher resistant to fracture in larger teeth might be attributable to the bulkier tooth structure which can lead to higher strength in teeth.

The mean fracture resistance in 2.5 mm thick cavity walls was significantly higher than 1.5 mm thick cavity walls, regardless of cavity type. This might be as a result of preserving more tooth structure particularly dentin in the thicker cavity wall group. Previous investigators have shown that preservation of tooth structure is important in order to improve the fracture resistance under occlusal loads and to increase survival rate in restored teeth. They have also demonstrated that the main factor endangering the survival of pulless teeth is the loss of dentin [5,13,14]. According to the findings of the present study, in SMT group, thickness of cavity wall had more impact on fracture resistance than the type of cavity (two- or three-surface).

Studies regarding occlusal forces have shown a great variability. Many factors can influence the bite force value, especially in children, including: facial structure, general muscular force and sex differences, location of the bite force recording device within the dental arch, mental state during the experiment, state of dentition, malocclusions and temporomandibular dysfunction, the extent of the vertical separation of the teeth and the jaws due to bite fork [15-17]. However, the mean value of maximum bite force has been reported between 151.9 to 374.4 N in different studies [18-21]. In this study the mean fracture resistance were 975.5 N (SD=368.8) and 1049.2 (SD=540.1) N in FMT and SMT respectively which were much higher than the maximum bite force values reported in the literatures.
Evaluating types of failure in study groups revealed that the most common failure was cavity wall fracture (77%). In most cases, fracture line was below the CEJ (55%) and the distance between fracture line and CEJ was approximately one millimeter in almost half of those cases. When these circumstances occur in clinic, two-surface cavities could be restored using a retentive cavity, however, in the cases that fracture line is positioned more than one millimeter under CEJ and when preparing a retentive cavity is not possible, the tooth must be considered for extraction.

CONCLUSION
In FMT, preserving more tooth structure especially marginal ridges are important in order to increase tooth strength, similarly, in SMT, just preserving more tooth structure at cavity walls plays a significant role in increasing tooth strength. The fracture resistance in pulpotomized primary molar restored with amalgam was higher than maximum bite force in primary teeth even in extensive multi-surface restorations. Therefore, the teeth with large proximal carious lesions in schoolchildren could be restored with amalgam.

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REFERENCES
14-Assif D, Gorfil C. Biomechanical considera-