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Fracture Resistance of Teeth with Different Cavity Designs for Proximal Lesions with Different Restorative Materials.

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ABSTRACT

Background: Many diseases and conditions weaken the strength of tooth making it to fracture. Many cavity designs and materials are used to restore the tooth to bring about the normal function. The present study was done to determine which one of the three class II cavity design offer the best fracture resistance to the teeth when used with different restorative materials. **Methods**: 165 molars (150 intact and 15 carious) were collected and preserved in hydrogen peroxide. These teeth were divided into five groups and restored with silver amalgam, compomer (Dyract AP) and metal modified ionomer cement (Miracle mix). The restored teeth were subjected to a compressive load using Universal Testing Machine by flat and metallic die. **Results**: Conventional designs with amalgam restoration seemed to withstand more load when it was imparted through a flat surface (741 kg ±158 SD) compared to the box or slot designs. However, when the load was imparted through a metallic die, the slot design with compomer restoration gave the maximum value (SD) of 472 (±88) kg. When analyzed statistically on the difference in the fracture resistance among the different restoration materials and the different cavity designs, statistically significant values were found between certain combinations. **Conclusion**: The study concluded that in the case of silver amalgam material, the test conducted by flat surface gives the best strength for the conventional design which is 3% and 23% better than that of box type and slot type respectively. However, when tested with a metallic die, slot type takes 8.3% more load than the conventional type. Among the various restoration materials tested for, amalgam provides more strength followed by compomer and miracle mix.

Keywords: Silver amalgam, compomer (Dyract AP), metal modified ionomer cement (Miracle mix), fracture resistance, Slot preparation, box preparation.

INTRODUCTION

Like any other tissue in the human body teeth are subjected to different diseases and conditions such as caries, wear, trauma and developmental defects which may weaken its strength leading to loss of tooth or fracture. So as to bring about or restore back the normal functions and integrity they have to be replaced by a material compatible enough in all respects to the natural tooth. For this purpose silver amalgam was developed and deployed first for filling decayed teeth. Yet, there were controversies among practitioners/researchers about whether the decayed teeth were to be prepared or not and whether the decay should be removed or not.[1]

In the middle of the 19th Century, Dr. G.V. Black first established the principles of cavity preparations, set up nomenclatures and identified the attributes of the restorative materials.[2] His wisdom remained for more than half a century. Since then, improvised approaches for approximal cavity preparation like internal or tunnel preparation for treatment of class II lesion as described by Mclean and Hunt by using GI cements, micro-chip cavity preparation, mini box cavity preparation and full box preparation have been deployed.[3] Slot box preparation which involves only the interproximal box without opening of the occlusal fissure, if the later is not affected by caries has also been added to the list.[4] Meanwhile, many dental amalgam alternatives have also been developed.

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Aims

The present study was done primarily to determine which one of the three class II designs (conventional, mini box and slot) offers the best fracture resistance to the teeth. The study also aimed to test which restorative material out of the three in vogue viz. silver amalgam, compomer (Dyract AP) and metal modified ionomer cement (Miracle mix) gives the best strength to the teeth with the different designs already mentioned above and also to compare the strength of the restored teeth between intact and carious teeth.

MATERIALS AND METHODS

A prospective study was done in 2010 in the Department of Dentistry, JN Institute of Medical Sciences in which 165 freshly extracted human molars (150 intact and 15 carious) were collected and preserved in hydrogen peroxide. These teeth were divided into five groups as Group 1 (45 nos.), Group II (45 nos.), Group III (45 nos.), Group IV (15 nos.) and Group V (15 nos.) for different designs of conventional, box, slot, intact and carious respectively.

All the 45 teeth in the conventional design (Group I) were subjected to cavity preparation in the same manner. Using high speed air-water spray, the pit near one proximal surface was entered with a punch-cut using a No. 245 bur. By maintaining a depth of 0.2-0.5 mm into dentin and bur axis oriented parallel to the long axis of the tooth, the bur was moved to extend the outline to include the occlusal fissure and the opposite pit. The isthmus space was restricted to 1/4th of the intercuspal space. A proximal ditch-cut was made by allowing the bur-end to cut a ditch gingivally along the dentinoenamel junction, two-thirds at the expense of dentin and one-third at the expense of the enamel. All the unsupported enamel and marginal irregularities were removed and a 900 cavo-surface angle was made.

The 45 teeth in the Box-design group (Group II) was prepared without an occlusal preparation as recommended by Almquist TC et al.[5] Similarly, cavity preparation for the Slot design group (Group III) was done by using the procedure adopted by Oddera M.[4]

Since the tests were to be conducted for the three different designs with three different restorative materials, all the teeth in each of the aforementioned groups (Group I, II and III) were divided in to three subgroups viz. Amalgam, Miracle mix and Dyract AP sub-groups thereby giving 45 teeth in each of the sub-groups. Teeth in the amalgam group were restored with high copper silver amalgam (silver-48%, tin-30% and copper-22%). The teeth in miracle mix subgroup were restored by using metal-modified GIC (powder-15gm, liquid-8ml, alloy-17gm). The cavities in the Dyract AP subgroup were restored with compomer (polymerizable resins and TCP resin).

All the restored teeth as well as the non-restored teeth (intact and carious) were then mounted individually on a self-cutting acrylic base. Then, they were subjected to a compressive load in a Universal testing Machine by using two methods. One method was subjection to a compressive load applied by a flat surface and the second method was subjection to a compressive load by a metallic die. 10 teeth from each of the subgroups, 10 from intact group (Group IV) and 10 of the carious teeth (Group V) were subjected to compressive load applied by the flat surface whereas the remaining teeth were subjected to compressive load applied by metallic die until complete fracture occurred.

The results obtained from both the compressive tests were compared. T-test was used for comparison of the mean ultimate weights applied before complete fracture took place. A p-value of less than 0.05 was considered as statistically significant.

RESULTS

The teeth used for the study belonged to people of different ages, sexes and villages/wards and can be considered as a representative sample

Table 1: Fracture resistance by different cavity designs and restorative materials

Cavity designs	Loads applied in kg (SD)					
	By a flat surface			By a metallic die		
	Amalgam	Compomer	Miracle mix	Amalgam	Compomer	Miracle mix
Conventional	741 (±158)	562 (±163)	521 (±201)	396 (±91)	428 (±266)	359 (±228)
Box	642 (±88)	523 (±134)	515 (±168)	347 (±129)	529 (±220)	399 (±142)
Slot	564 (±132)	439 (±439)	392 (±165)	429 (±152)	472 (±88)	308 (±51)

It was observed that in a few cases, high spots or points of the tooth got chipped off at a much lesser load, but it still continued to take more load before getting finally crushed. In a few more cases, the material got displaced and then complete fracture took place. Having observed these phenomena, any load-value falling outside ± 3 standard deviation was considered as outliers and was excluded from the analysis.

[Table 1] shows the load in kg which could be resisted before complete fracture took place for the different cavity designs and the different restorative materials used. Conventional designs with amalgam restoration seemed to withstand more

load when it was imparted through a flat surface (741 kg ±158 SD) compared to the box or slot designs. However, when the load was imparted through a metallic die, the slot design with compomer restoration gave the maximum value (SD) of 472 (±88) kg.

Table 2: Comparison of fracture resistance among different restoration materials and cavity designs.

		Load applied by flat surface		Lot applied by metallic die	
Material	**Cavity design**	**t-value**	**Conclusion**	**t-value**	**Conclusion**
Amalgam	Conventional & box	1.64	Not significant	0.931	Not significant
	Conventional & slot	2.10	Significant	0.558	Not significant
	Conventional & intact	2.64	Significant	3.604	Significant
	Conventional & carious	6.46	Significant	4.577	Significant
Compomer	Conventional & box	0.55	Not significant	0.13	Not significant
	Conventional & slot	1.70	Not significant	0.47	Not significant
	Conventional & intact	0.51	Not significant	1.90	Significant
	Conventional & carious	3.41	Significant	1.90	Significant
Miracle mix	Conventional & box	0.67	Not significant	0.44	Not significant
	Conventional & slot	1.49	Not significant	0.65	Not significant
	Conventional & intact	0.03	Not significant	1.33	Significant
	Conventional & carious	2.30	Significant	1.32	Significant

When the load was applied by a flat surface, intact teeth were found to have statistically significant fracture resistance compared to carious teeth (t value=2.312) whereas no significant difference could be detected between the two types of teeth when the load was given through a metallic die (t value=0.219)

When analyzed statistically on the difference in the fracture resistance among the different restoration materials and the different cavity designs, statistically significant values were found between certain combinations [Table 2].

When the force was applied by a flat surface the conventional and the box cavity restoration designs had similar load carrying capacity when the restoration material used was amalgam. But, significant difference was seen between the conventional design and slot design. For both intact and carious teeth, the difference was statistically significant. When the force was applied through a metallic die, significant differences were detected both in the intact and carious teeth.

When compomer was used as the restoration material, significant difference could be seen only between the conventional and the carious teeth when load was given by a flat surface. But when the load was applied through metallic die, it was significantly increased both for the intact and carious teeth.

With miracle mix, significant difference could be detected only with the conventional design and the carious teeth whereas, when for load applied through metallic die, the difference in load carrying capacity was significantly increased for both the intact and carious teeth.

DISCUSSION

The observation that the conventional cavity preparation could withstand more when the load was applied by a flat force uniformly over the whole tooth is in contrast to previous study proceedings in which the load was applied either on the isthmus area or using a spherical or pointed tool,[1,10] the load being concentrated on a specific point or by using a specially made loading steel device with a rounded thin end and the tooth subjected to uniaxial compressive loading in a Universal testing machine.[6,7] Jagadish S et al tested the compressive force by using the universal testing machine in which they used two metal roads each measuring 2mm in diameter instead of one metal rod with the points of contact flattened with a fine diamond to prevent the metal rods from slipping.[8] Their study results were less than the ones obtained in the present study. Caplan DJ et al also measured the fracture resistance of teeth with approximal retention grooves and restored with silver amalgam and composite resin.[9,11] Their study also showed lesser values compared to the present one. The probable reason might be that, they used 5000 Kg compression load cell. Also the instrument was calibrated electronically and the center of the probe with a 5X1 mm rectangular surface was placed above the center of the restored marginal ridge and a double thickness lead-foil was placed between the probe and the restoration in order to minimize chipping of the restoration.

It was also seen that when the load was applied by a flat surface, the strength of the intact teeth is more than that of the carious teeth.[12] However, when the load is applied by a metallic die both the types of teeth give almost the same strength. This may be because of the fact that the degree of decay in some of the carious teeth was not very advanced or in spite of the presence of caries, the remaining tooth-structure might be still strong.

CONCLUSION

In the case of silver amalgam material, the test conducted by flat surface gives the best strength for the conventional design which is 3% and 23% better than that of box type and slot type respectively. However, when tested with a metallic die, slot type takes 8.3% more load than the

conventional type. It can be concluded that slot type design can be advocated in order to preserve maximum tooth structure. In the case of compomer, the load carrying capacity when force is applied by a flat surface or by a metallic die, there was no statistically significant difference among the various designs. Hence, even in the case of compomer, slot type design can be advocated. The same result was seen for the miracle mix. Hence, in case of miracle mix also, slot type design may be preferred.

Among the various restoration materials tested for, amalgam provides more strength followed by compomer and miracle mix.

The actual load coming on teeth is not gradually applied. Most of the time, it is an impact load e.g. on biting a hard object which is mixed with food accidentally/unknowingly, it is known that the impact strength is much lower. Also, the teeth inside a patient's mouth experiences repeated loading and hence may become fatigue. It is known that fatigue strength is also much lower than the static (gradually applied load) strength. Hence, the tooth will actually fracture at much lower loads than obtained in the present study. Still the present study gives a qualitative comparison of the different types of designs and materials. However, there is need to verify the current study findings by doing case-studies of patients.

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