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Evaluation of Fracture Resistance of Three Different Restorative Materials in Teeth Restored with Tunnel Preparation - An *In Vitro* Study

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Abstract

Background: The tunnel concept accesses proximal dentinal carious lesions from the occlusal surface. This concept aims to preserve the marginal ridge and to minimize the loss of healthy tooth structure, thus saving clinical time as well as conserve the strength of tooth.

The aim of the study was to investigate the fracture resistance of three different restorative materials in teeth with tunnel preparations.

Methods and Materials: Fifty fully formed human maxillary premolars were selected for this *in vitro* study and divided into four main groups (N=10) Group 1: Biodentine, Group 2: Bioglass R, Group 3: Fiber reinforced composite, Group 4: Glass Ionomer Cement and Group 5: Control. Tunnel preparation was done using a round bur and fracture resistance was checked using a Universal Testing Machine (UTM).

Results: The mean comparison of values between the groups was found to be statistically significant (F=3722.01, P value <0.05). To find out the pair wise comparisons, post-hoc Turkey test was applied and mean difference of all the comparisons was found to be statistically significant (P value <0.05).

Conclusion: Considering the materials chosen to restore the tunnel prepared teeth, fiber reinforced composite proved to be superior in demonstrating good fracture resistance followed by Biodentine, Bioglass R and conventional glass ionomer cement.

Keywords: Biodentine; Bioglass R; Conventional glass ionomer cement; Fiber reinforced composite; Tunnel restoration

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Introduction

There is a constant evolution and change in the field of dentistry and this change is very much evident in the field of conservative dentistry as well where in, the tooth preparation designs have been modified since Blacks concept of the "extension for prevention" to "prevention for extension" [1]. These changes have been extensively supported by the introduction of minimal invasive designs as well the improvement in oral hygiene and extensive fluoridation program. All these factors have lowered the incidence and prevalence of dental caries. A change in the pattern of dental disease, dental materials and technology and an understanding of the limitations of restorative procedures, continue to alter concepts of cavity preparation [2,3].

Caries is a common oral disease which affects all age group sowing to the demineralization of tooth structure, which is caused by acid producing bacteria in the presence of fermentable carbohydrates. Caries which occurs in the proximal areas extending into dentin traditionally requires removal of the intact marginal ridge to gain access to the carious lesion beneath. In recent years the trend in restorative dentistry has been towards conservative cavity designs. The tunnel preparation is one of these, first described in 1963 for the restoration of distal approximal surfaces of deciduous second molars [4,5].

In this preparation the proximal caries was approached from the occlusal aspect leaving the marginal ridge intact. The concept of tunnel preparation was reintroduced by Hunt and Knight in 1980 and promoted it as a more conservative procedure than a conventional Class II cavity [6,7].

Tunnel preparation accesses proximal dentinal caries through an occlusal pit and is designed to preserve the overlying proximal marginal ridge and maintain greater tooth integrity. According to the preparation technique, the tunnel preparations are mostly classified as 'total tunnels' when the proximal enamel is perforated and 'partial tunnels' in case of non-perforated proximal enamel [8,9].

Glass ionomer cement could be a material of choice for tunnel preparation as it bonds to the enamel and dentine, in addition to releasing fluoride. However, it may not be strong enough to withstand the occlusal biting force, and many clinicians have hesitations using it as permanent restoration in adult dentition. In previous studies composites and amalgam have also been used for tunnel restoration [10,11]. This *in vitro* study aims to evaluate restorative materials like Bioglass R, Biodentine and fiber reinforced composite in improving the fracture resistance of tunnel-restored teeth.

Methods

Fifty fully formed human maxillary premolars were selected for this *in vitro* study which was extracted due to periodontal and orthodontic reasons. Carious, cracked, fractured and calcified teeth were excluded.

Teeth were cleaned with 5.25% sodium hypochlorite solution (Neelkanth health care, Boranada, India) for 60 min and prophylaxis of the same was done. For standardization purpose the mesiodistal and buccolingual width was considered at 7 ± 1 mm and 9 ± 1 mm respectively.

They were stored in thymol (The good scents company, Oak Creek, USA) solution till the procedure. All the teeth were divided into four experimental and one control group. Group 1 (n=10) Biodentine (Septodent, France), Group 2 (n=10) Bioglass R (Biodinamica, Brazil), Group 3 (n=10) Fiber Reinforced Composite (FRC) (Everx posterior, GC, Japan), Group 4 (n=10) conventional Glass Ionomer Cement (GIC) (Ketac Molar) and Group 5 (n=10) intact teeth.

After stratification for tooth size, a number 4 round burs were used for preparation of the tunnel restoration, The tunnel was prepared in the proximal fossa leaving 1.8 ± 0.3 mm width of marginal ridge and 2.5 ± 0.3 mm of marginal ridge height (Figure 1).

Experimental restorative materials were filled into the tunnel prepared teeth according to manufactures instructions. Teeth were arranged onto a flower arrangement sponge to prevent the dehydration. The samples were then mounted in acrylic block for fracture testing. The strength of the marginal ridge was tested in a universal testing machine (Dutt.x100, India) (Figure 2), using a stepwise dynamic loading procedure.

The tunnel restored teeth in the acrylic block were placed in the platform of UTM and the load was transferred to the marginal ridge by a steel rod. The tip of the roadways 1.0 mm and the contact point was 1.5 mm away from the marginal ridge. This distance was measured three times with a vernier caliper. The peak force was incrementally increased by 0.050 kN after every 500 cycles. This procedure was repeated until the marginal ridge fractured. The load level and the number of cycles were recorded at the time of fracture.

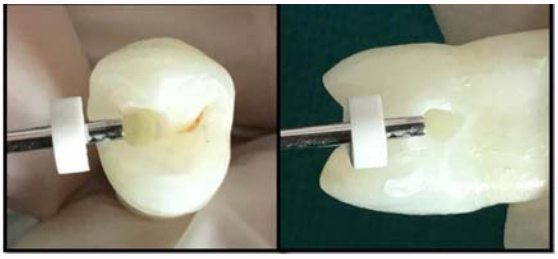

Figure 1: Standardization of tunnel preparation.

Figure 2: Fracture resistance of tunnel restored tooth using UTM.

Result

Statistical analysis was done using ANOVA and Post hoc turkey SPSS Version 16 (SPSS Inc., Chicago, IL, USA). A significant difference (P<0.0001) in the mean values of fracture resistance was observed among experimental groups as well as with the control group (Table 1).

Among all the groups the control group had the highest mean values of fracture strength. Fiber reinforced composite exhibited highest fracture strength among the experimental materials followed by Biodentin, Bioglass R and GIC (Table 2).

Discussion

Various advances in caries management protocols, restorative materials, instruments and diagnostic aids have encouraged clinicians to practice minimal invasive cavity designs to treat proximal caries in permanent posterior teeth. When proximal caries progresses extensively into dentin, traditional restoration requires removal of the intact marginal ridge to gain access to the carious lesion beneath. Current caries management involves minimally invasive cavity preparation design, which can be "slot" or "box-only," as well as "tunnel" and "saucer-shaped" preparations [5,12].

The tunnel restoration has been suggested as a conservative alternative to the conventional box preparation for treating proximal caries. The main advantage of tunnel restoration over the conventional box or slot preparation includes being more conservative and

Table 1: Mean values of the fracture resistance of the experimental and control group.

Group	N	Mean ± SD	F Value	P Value
I BIODENTINE	10	352.14 ± 3.35	3722.01	0.000 Significant
II BIOGLASS R	10	301.44 ± 1.16		
III FRC	10	382.32 ± 2.77		
IV GIC	10	274.81 ± 1.86		
V Total	10	402.27 ± 3.87		
Total	50			

Table 2: Pair wise comparison among experimental groups using post-hoc Tukey analysis.

Pairs	Mean Difference	P Value	Significance
I-II	50.69700*	0	Significant
I-III	-30.17700*	0	Significant
I-IV	77.33600*	0	Significant
I-V	-50.13000*	0	Significant
II-III	-80.874	0	Significant
II-IV	26.63900*	0	Significant
II-V	-100.82700*	0	Significant
III-IV	107.51300*	0	Significant
III-V	-19.95300*	0	Significant
IV-V	-127.46600*	0	Significant

increasing tooth integrity and strength by preserving the marginal ridge [12].

Various restorative materials were used in the past for tunnel restorations. Materials like glass ionomer, composite resin, and cermet were used for restoring tunnel preparation in various *in vivo* studies. Hassel rot et al conducted an *in vivo* study, restoring 224 patients with glass ionomer and composite restorations [13]. The success rate was 74% in permanent teeth and 10% in primary teeth after a follow up period of 3.5 years.

Wilkie et al. restored 86 glass cermet tunnel restorations of 26 adults and were followed up for 2 years. Filling defects, surface voids, and occlusal wear with surface crazing and cracking were found in 48% of the restorations [14]. Zenkner et al. restored 51 glass cermet restorations of tunnel type and were followed up for 2 years. The failures were marginal ridges fractured (4.2%), occlusal wear (4.2%), and white spots lesions (53.8%) [15].

Svanberg restored 18 adolescents with both glass ionomer tunnel restoration and Class II amalgam restoration and was followed up for 3 years. Less caries developed on the tooth adjacent to tunnel glass ionomer restoration than the amalgam restoration [16].

In the present *in vitro* study, the materials used to restore tunnel prepared teeth were FRC, Biodentine, Bioglass R and GIC.

Fiber reinforced composites was first described in the 1960's by Smith when glass fibers were used to reinforce polymethylmethacrylate. This group of material is very heterogeneous, depending on the nature of the fiber and the overlying of the resin which is used. FRC has randomly oriented short glass fiber as filler content in the composite. The short glass fiber acts as crack stopper.

Random fiber orientation has a significant role in mechanical properties. They might absorb some of the polymerization shrinkage stresses and increase the stress-relieving capacity of the matrix, and this could decrease the marginal microleakage and improve the adaptation of the material [17,18].

A study conducted by Chalker SA, Lumley revealed that tunnel restorations filled with posterior composites demonstrated better marginal adaptation than GIC, metal-reinforced glass-ionomer-cements or amalgam [19].

FRC mimics the supportive function of dentine during loading and acts as dentine replacing material. FRC exhibited the highest fracture resistance among all experimental group 382.32 ± 2.77 N.

Biodentine is also called a dentine substitute owing to the good chemical and mechanical properties. This shows improving interface between the dentine substitute Biodentine and the adjacent phosphate-rich hard tooth substance exhibiting good micromechanical adhesion. The product sheet of Biodentine states that a specific feature of Biodentine is its capacity to continue improving in terms of compressive strength with time until reaching a similar range with natural dentine [20].

Grech et al. [21] evaluated the micro hardness of the material using a diamond shaped indenter. Their results showed that Biodentine displayed superior values compared to bio aggregate and Intermediate Restorative Material (IRM).

Camilleri [22], in a study compared the physical properties of Biodentine with a conventional glass ionomer (Fuji IX) and a resin modified glass ionomer (Vitrebond). The study revealed that Biodentine exhibited higher surface microhardness compared to the other materials when unetched.

Hence considering the above properties Biodentine was chosen as one of the experimental materials to restore tunnel prepared teeth. The mean values of Biodentine group were 352.14 ± 3.35 N, and the material exhibited fracture strength of 352.14 N. Though the fracture strength values were inferior when compared to control and experimental group 1, it demonstrated statistically significant difference when compared with GIC and Bioglass R. GIC has certain drawbacks like poor mechanical and wear resistance.

The compressive strength can be examined by the setting reaction of GICs. Extensive moisture contamination especially within the first stages after cement mixing has been attributed as being responsible for reduced elastic modulus and fracture strength. Failure mechanisms such as void nucleation, crack propagation and detachment of particles or sudden, subcritical failure are common features of the low fracture resistance of Bioglass R [23,24].

Bioglass R exhibited significantly lower fracture resistance (301.44 ± 1.26) compared with FRC and Biodentine. GIC could be a material of choice for tunnel preparation because it bonds to enamel and dentine, in addition to releasing fluoride. However, it may not be strong enough to withstand the occlusal biting force, and many clinicians have reservations using it as permanent restoration in the adult dentition [25].

In the present *in vitro* study conventional GIC exhibited the least fracture resistance (274.81 ± 1.86) when compared to all the experimental and control groups.

Conclusion

Generally, tunnel restorations are a highly demanding technique. Therefore, preparation technique and accuracy of caries removal, as well as material characteristics of the restorative material and individual caries risk assessments, influence the clinical success. Considering the materials chosen to restore the tunnel prepared teeth, fiber reinforced composite proved to be superior in demonstrating good fracture resistance followed by Biodentine, Bioglass R and conventional glass ionomer cement.

References

1. Sigurjons H. "Extension for prevention": Historical development and current status of G.V Blacks concept. Oper Dent. 1983;8(2):57-63.

2. Ehrlich J, Yaffe A. A modified cavity preparation for restoring interproximal

caries. Compend Contin Educ Dent. 1987;8:62-5.

3. Elderton RJ. Marshall KJ, Hooper GR. Changing perceptions of the requirements of cavity preparations. Br Dent J. 1990;168(5):30-2.

4. Chu CH. Treatment of early childhood caries: A review and case report. Gen Dent. 2000;48(2):142-8.

5. Chu CH, Lo EC, You DS. Clinical diagnosis of fissure caries with conventional and laser-induced fluorescence techniques. Lasers Med Sci. 2010;25(3):355-62.

6. Howe LC. Minimal tooth preparation techniques for restorations with adhesive materials. Dent Update. 1989;16(10):418-20, 422-5.

7. Papa J, Wilson PR, Tyas MJ. Tunnel restorations: A review. J Esth. 1992;4 Suppl:4-9.

8. Hasselrot L. Tunnel restorations. A 3 1/2-year follow up study of Class I and II tunnel restorations in permanent and primary teeth. Swed Dent. J 1993;17:173-82.

9. Jones SE. The theory and practice of internal 'tunnel' restorations: A review of the literature and observations on clinical performance over eight years in practice. Prim Dent Care. 1999;6(3):93-100.

10. Chu CH, King NM, Lee AM, Yiu CK, Wei SH. A pilot study of the marginal adaptation and surface morphology of glass-cermet cements. Quintessence Int. 1996;27(7):493-501.

11. Lumley PJ, Fisher FJ. Tunnel restorations: A long-term pilot study over a minimum of five years. J Dent. 1995;23(4):213-5.

12. Mount GJ. Minimal intervention dentistry: Rationale of cavity design. Oper Dent. 2003;28(1):92-9.

13. Hasselrot L. Tunnel restorations in permanent teeth. A 7-year follow-up study. Swed Dent J. 1998;22(1-2):1-7.

14. Wilkie R, Lidums A, Smales R. Class II glass ionomer cermet tunnel, resin sandwich and amalgam restorations over 2 years. Am J Dent. 1993;6(4):181-4.

15. Zenkner JE, Baratieri LN, Monteiro SJ, de Andrada MA, Vieira LC. Clinical and radiographic evaluation of cermet tunnel restorations on primary molars. Quintessence Int. 1993;24(11):783-91.

16. Svanberg M. Class II amalgam restorations, glass-ionomer tunnel restorations, and caries development on adjacent tooth surfaces: A 3-year clinical study. Caries Res. 1992;26(4):315-8.

17. Garoushi S, Tanner J, Vallittu PK, Lassila L. Preliminary clinical evaluation of short fiber-reinforced composite resin in posterior teeth: 12-months report. Open Dent J. 2012;6:41-5.

18. Butterworth C, Ellakwa AE, Shortall A. Fibre-reinforced composites in restorative dentistry. Dent Update. 2003;30(6):300-6.

19. Chalker SA, Lumley PJ. An *in vitro* assessment of cavity margin finishing and marginal adaptation of tunnel restorations. Eur J Prosthodont Restor Dent. 1993;1(4):151-6.

20. Biodentine Active Biosilicate Technology Scientific File, Septodont, Paris, France.

21. Grech L, Mallia B, Camilleri J. Investigation of the physical properties of tricalcium silicate cement-based root-end filling materials. Dent Mater. 2013:29(2);e20-8.

22. Camilleri J. Investigation of Biodentine as dentine replacement material. J Dent. 2013:41(7);600-10.

23. Pontes DG, Guedes-Neto MV, Cabral MFC, Cohen-Carneiro F. Microleakage evaluation of class V restorations with conventional and resin-modified glass ionomer cements. Oral Health Dent Manag. 2014;13(3):642-6.

24. Cabral MFC, Martinho RLM, Neto1 MVG, Rebelo MAB, Pontes DG, Carneiro FC. Do conventional glass ionomer cements release more fluoride than resin-modified glass ionomer cements? Resto Dent Endod. 2015;40(3):209-15.

25. Chu CH, King NM, Lee AM, Yiu CK, Wei SH. A pilot study of the marginal adaptation and surface morphology of glass-cermet cements. Quintessence Int. 1996;27(7):493-501.