Abstract-

Aim:

To evaluate the fracture resistance and microleakage of endodontically treated teeth with simulated cervical cavities restored with different restorative materials namely Glass Ionomer Cement (GIC), Resin Modified Glass Ionomer Cement (RMGIC), Flowable Composite (FC), Compomer, Giomer and SDR Flow.

Materials and Method

One hundred twenty-eight extracted human permanent incisor teeth were assigned to eight groups. All the groups were subjected to endodontic treatment. Samples were equally divided based on materials used Group I (resorptive cavities were not prepared) and Group II (resorptive cavities were prepared and left unrestored), Group III (GIC), Group IV (RMGIC), Group V (FC), Group VI (Compomer), Group VII (Giomer), Group VIII (SDR Flow). Resorption cavities were prepared (3mm diameter and 2mm depth) labially in the specimens belonging to Group II to Group VIII and restored with respective restorative materials. Compressive load was calculated under Universal Testing Machine and microleakage was tested using Confocal Laser Scanning Microscope.

Statistical Analysis:

Statistical analysis was done using one-way ANOVA and Tukey's multiple comparison test and $P < 0.05$ was considered statistically significant.

Results:

Multiple comparisons revealed that group VI (compomer) had significantly highest fracture resistance with non-significant p value ($p>0.05$) when compared among all the experimental groups and showed lowest microleakage values among all the experimental groups with significant p value ($p<0.05$).

Conclusion:

None of the restorative material eliminated the fracture resistance and micro leakage. However, group VI (Compomer) showed promising results in providing maximum of fracture resistance and minimum micro leakage with respect to other groups.

Keywords- Invasive cervical resorption, SDR flow, Compomer, Fracture resistance, Microleakage, Confocal Microscope.

Introduction

External root resorption is the aggressive activity of odontoclasts leading to reversible or irreversible loss of cementum, dentin and bone.[1,2] Invasive cervical root resorption (ICR) is more virulent form of external root resorption that can occur in both vital and non-vital teeth. The etiology can be physiological or pathological.[1] Clinically an obvious pinkish color is seen in the cervical region, due to resorption of coronal enamel and dentine. This is due to translucent remaining enamel revealing underlying highly vascular resorptive tissue.[3] The factors responsible for ICR are abnormal orthodontic forces, dental trauma, intra-coronal bleaching, surgery involving cementoenamel junction (CEJ), delayed eruption, bruxism, developmental defects, and deep root scaling.[4]

Radiographically an irregular radiolucency with ragged margins or moth-eaten appearance is seen.[5]` In early stages tracing of root canal outline is possible on radiograph as pulp is not involved.[6] The fundamental treatment approach is thorough extirpation of resorptive tissue using trichloro-acetic acid (TCA). TCA causes coagulation necrosis of granulation tissue and deactivate tissue present in infiltrative channels and recesses. If access to the coronal 1/3rd of the root is difficult surgical or combination of surgical and nonsurgical approach can be adopted. However preferred treatment option is nonsurgical approach. To restore cervical resorption numerous materials available are- amalgam, various glass ionomer cements, variety of composites, mineral trioxide aggregate (MTA), and biodentine, etc.[7]

But, microleakage is a major issue around dental restorative materials in clinical dentistry. Which might lead to hypersensitivity of restored teeth especially in Class 1 and Class 2 resorptive lesions. Even there is rapid degradation of some restorative materials which can lead to discoloration, recurrent caries, pulpal injuries.

That's why this study aims to compare the fracture resistance and microleakage of endodontically treated teeth with simulated invasive cervical resorptive cavities restored with different adhesive restorative materials.

METHOD:

A total of 128 caries-free single rooted extracted teeth were included in this study. Access cavities of all the samples were prepared and working length was determined which was set to be 1 mm shorter to reach the level of the minor apical foramen and biomechanical preparation was done with rotary Pro Taper Universal system (Dentsply Sirona, Ballaigues, Switzerland) and canals were obturated with Gutta-percha and AH Plus Sealer (Dentsply, India Pvt. Ltd).

Invasive cervical resorptive cavities were prepared at the point of intersection of the long axis of the tooth and CEJ of all samples using round diamond point (Mani Inc, Japan) of 3mm diameter and 2mm depth.

DIVISION OF GROUPS:

After following conventional root canal procedures, all samples were assigned to two control and six experimental groups. Each group contained n=16 samples which were further subdivided into n=8 samples for testing fracture resistance and microleakage respectively.

Group I (Negative control): resorptive cavities were not prepared.

Group II (Positive control): resorptive cavities were prepared and left unrestored.

Samples from group III to VIII: resorptive cavities were prepared and restored with respective restorative materials.

Group III: Restorative Glass Ionomer Cement (GC Gold Label II)

Cavities were conditioned with GC cavity conditioner and followed by placement of restorative glass ionomer cement in the cavities.

Group IV: Resin Modified Glass Ionomer Cement (GC Gold Label II LC)

Cavities were conditioned with GC cavity conditioner and additional step of priming the tooth surface was done in which primer (Prime Dental Products Pvt Ltd) was applied in a thin coat and light cured for 20 sec followed by placement of RMGIC in the cavities. After placement of material in cavities curing was done for 20 sec by light curing unit (WoodPecker LED unit).

Cavity walls of samples from group V to group VIII were etched for 15 s and rinsed for 10 s. Followed by blot drying, two successive coats of adhesive (Adper Single Bond 2) were applied for 15 s and cured for 20 s by light curing unit (WoodPecker LED unit) followed by placement of different variety of composite materials. Materials are listed as follows -

Group V: Flowable Composite (Filtek Z350 XT) shade A3, was placed with Teflon coated instrument and cured for 30 sec by light curing unit.

Group VI: Compomer (Dyract, Dentsply) dispensed directly into the cavity preparation and cured for 40 s.

Group VII: Giomer (Beautibond, Shofu), shade A3 was placed and cured for 20 s.

Group VIII: SDR Flow (Dentsply), was placed in a single increment of 4mm and cured for 20 s.

After restoration all the samples were subjected for testing fracture resistance (n=64) and microleakage (n=64).

For fracture resistance samples were mounted in acrylic block at the center with CEJ 2mm coronal to the resin surface with dimensions 30mm height and 25mm diameter. All specimens were tested for fracture resistance subjected under compressive loading in

Universal Testing Machine (AIM-653-1, Amil Ltd, India) and values were obtained in Newtons.

To fulfil another objective 64 samples were submitted for microleakage. Samples were stored in Rhodamine B dye for 24 hrs. Samples were removed and washed thoroughly to remove the superficial dye. Samples were then sectioned through the center of the restoration in bucco-lingual plane using a diamond disc (Denstply Maillefer, Ballaigues, Switzerland) under water spray and dye penetration was assessed using LSM image browser software under a Confocal laser scanning microscope.

The scoring criteria used for microleakage was as follows:

0º = no leakage

1º = less than or up to one-half of the depth of the cavity preparation

2º = more than one-half of the cavity preparation involved, but not up to the junction of the axial and occlusal or cervical wall

3º =dye penetration up to the junction of the axial and occlusal or cervical wall, but not including the axial wall

4º = dye penetration including the axial wall

The data was collected, tabulated, and statistically analyzed using SPSS 19 (SPSS Inc., Chicago, IL, USA).

Statistical analysis:

The statistical analysis was done using SPSS (Statistical Package for Social Sciences, Version 19. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.). Analysis of variance (ANOVA) followed by Tukey’s post-hoc test was carried out among various study groups to compare fracture resistance and microleakage. The level of significance for the study was set at a P-value of less than 0.05.

Results:

Table 1 indicates comparative and SD values of mean fracture resistance among all the groups. Group VI (Compomer) showed highest mean fracture resistance values among experimental groups followed by those of Groups VII, V, IV, III, VIII and II, as demonstrated in Table 1 and Graph 1. In pair wise test (Table 2) the fracture resistance statistically non-significant $\{p = > 0.05\}$.

Score values were mentioned in Table 3. Table 4 showed the comparison of microleakage scores among the various groups. Group VI (Compomer) showed least microleakage among experimental groups as demonstrated in Table 4 and Graph 2. Table 5 revealed Pair wise comparison showed statistically significant difference when Group VI (Compomer) was compared with other experimental groups $\{p = < 0.05\}$ except Group V (flowable composite) and Group IV (RMGIC) where p value was non-significant $\{p = > 0.05\}$.

Discussion:

In permanent tooth due to trauma, cervical root resorption occurs, which can lead to loss of tooth structure. Selection of appropriate restorative material for ICR cavities is crucial because fracture resistance and microleakage are two important issues to be considered in material selection. The restorative material should have such kind of qualities that strengthen the tooth and surrounding tissues.

The main goal of treating ICR cavities is to disable entire resorbing tissues and restoring it with suitable restorative material following nonsurgical or surgical approach.[8] Properties of different restorative materials vary like polymerization shrinkage, coefficient of thermal expansion, adhesive properties, and modulus of elasticity, these differences can influence their ability to resist fractures and prevent microleakage.

One of the reasons for poor performance of restorative material is its placement in cavities located both in dentin/ or cementum.[9] because of the organic content in dentin, partial elimination of the smear layer, orientation of dentin tubule at the cervical wall and absence of hybrid layer in the dentinal margins are few important causes of leakage.

In the present study negative control group showed maximum fracture resistance and no microleakage whereas positive control group showed minimum fracture resistance and 100% microleakage indicating that cervical resorption weekends the tooth. Among the restored samples Compomer showed maximum fracture resistance (1.59 KN) and minimum microleakage of 50% samples with **score 0**. Because compomer is mainly a single component containing the properties of both glass-ionomer materials and composite consisting of acid-modified di-methacrylate reinforced with silanized (calcium-, barium-, strontium-, and aluminum-fluorosilicate) glass particles. The structure of compomer consist of two polymerizable methacrylic residues and acid groups, which improves its physical properties and clinical handling. Besides low compressive and flexural strength, it showed high mechanical properties, a very low effect of salivary contamination while setting, no polymerization shrinkage, and improved adhesion to tooth structure. These improved properties are due to its resin portion which provide a micromechanical bond through hybrid layer and resin tag formation.

Giomer showed more fracture resistance (1.30 KN) after Compomer but the p value was non-significant ($p>0.05$). This might be because of unique S-PRG technology of Giomer which is composed of a stable phase of glass-ionomer suspended in resin matrix in accordance with the study done by Boli et al (2020)[18]. But it showed microleakage in 62.5% samples with **score 3**. This might be because of gap formation around the tooth restoration interface which led to reduced marginal adaptation and hygroscopic expansion (caused marginal deterioration) in accordance with the study done by Karim et al (2014).[10]

Other restorative materials also showed fracture resistance and microleakage. As flowable composite showed fracture resistance (1.23 KN) and microleakage in 37.5% samples with

Score 0 (i.e. no microleakage). This might be because of low modulus of elasticity and low filler content, which provide an elastic buffer that absorbs pressure and diminishes surface tension might be the reason for better results in flowable composite.[11]

RMGIC and GIC showed fracture resistance (1.18 KN and 1.06 KN) but p values were statistically non-significant ($p>0.05$). When microleakage was compared 12.5 % of RMGIC samples showed Score 0 (i.e. no microleakage) but in GIC 100% samples showed microleakage with different values and p values were statistically significant. As GIC bond to tooth structure through chemical adhesion leading to poor bond between the tooth restoration interface.[12] This might be because of various air inclusions which acted as stress points, leading to a higher chance of fractures which is in accordance with the study done by Burrow et al.[13]

SDR Flow when compared with other groups showed least fracture resistance (0.98 KN) but p value was statistically non-significant and microleakage extended till **score 4 (**dye penetration including the axial wall) but p value was statistically significant. Low fracture strength of SDR was due to low amount of filler loading in the composition (68 % by wt, 45% by vol.) which leads to low strength values for both flexural and compressive tests along with high polymerisation shrinkage might be the reason for poor fracture resistance and microleakage of SDR in the present study.[14]

Root canal treated teeth with cervical cavities led to tooth fracture which is a common clinical failure which leads to tooth loss. Vertical root fracture (VRF) accounts for 13.4% in endodontically treated teeth.[15] In some conditions full coverage crown is difficult to acquire, as labial ferrule cannot be placed. So, teeth need to be adequately reinforced. This study was done to investigate the fracture resistance and microleakage of different restorative materials (GIC, RMGIC, Flowable composite, Compomer, Giomer, SDR Flow). Since the current investigation was carried out in vitro, future research should concentrate on in vivo settings to assess the clinical performance of the examined restorative materials. As teeth were not subjected to any mechanical stress and sealing ability of these restorative materials should also be examined through other complex methods like bacterial penetration and with the use of fluid transport model. Hence, direct application of these results to clinical situations must be implemented cautiously.

Conclusion-

None of the restorative material eliminated the fracture resistance and micro leakage. However, Compomer showed promising results in providing maximum of fracture resistance and minimum micro leakage with respect to other groups. Even though, Compomer showed promising results, the clinical performance of any material cannot be predicted solely based on an in-vitro study these results should be confirmed by long term clinical observations to determine a suitable material for ICR cavities.

REFERENCES

1. **Bergmans L, Van CJ, Verbeken E, Wevers M, Van Meerbeek B, Lambrechts P.** Cervical external root resorption in vital teeth. J Clin Periodontol. 2002;29(6):580–85.
2. **Kandalgaonkar SGL, Tupsakhare S, Gabhane M.** Invasive Cervical Resorption: A Review. J Int Oral Health. 2013;5(6):124–30.
3. **Afkhami F, Akbari S, Chiniforush N.** Entrococcus faecalis Elimination in Root Canals Using Silver Nanoparticles, Photodynamic Therapy, Diode Laser, or Laser-activated Nanoparticles: An In Vitro Study. J Endod. 2017;43(2):279–82.
4. **Heithersay GS.** Invasive cervical resorption: An analysis of potential predisposing factors. Quintessence Int. 1999;30:83–95.
5. **Heithersay GS.** Invasive cervical resorption. Endod Top. 2004;7:73–92.
6. **Patel S, Kanagasingam S, Pitt FT.** External cervical resorption: A review. J Endod. 2009;35:616–25.
7. **Karunakar P, Soloman RV, Anusha B, et al.** Endodontic management of invasive cervical resorption: report of two cases. J Conserv Dent 2018;21(5):578–81.
8. **Heithersay GS.** Management of tooth resorption. Aust Dent J. 2007;52:S105–21.
9. **Litonjua LA, Andreana S, Bush PJ, Tobias TS, Cohen RE.** Noncarious cervical lesions and abfractions: a re-evaluation. *J Am Dent Assoc* 2003; 134: 845–50.
10. **Karim UM, Eraky ME, Etman WM.** Three year clinical evaluation of two nanohybrid giomer restorative composites Tanta Med J. 2014;11: 213-22.
11. **Rani P, Dakshita J, Sinha P, Sharma N, Sharma I, Singh D, Mehra.** Resistance to Fracture of Endodontically-treated Teeth with Simulated Cervical Resorption Cavities

Restored with Different Restorative Materials: An In Vitro Study. World Journal of Dentistry, 2023;14(10):844-50.

12. **Moodley DS, Grobler SR.** Compomers: Adhesion and setting reaction. journal of the South African Dental Association 2003; 58(1):21, 24-8.

13. **Burrow MF, Nopnakeepong U, Phrukkanon S.** A comparison of microtensile bond strengths of several dentine bonding systems to primary and permanent dentine. *Dent Mater* 2002; 18: 239–245.

14. **Didem A, Gözde Y, Nurhan O.** Comparative Mechanical Properties of Bulk-Fill Resins Open Journal of Composite Materials 2014;4:117-21.

15. **Bolli RV, Margasahayam SV, Shenoy VU, Agarwal AM.** A comparative evaluation of the fracture resistance of endodontically treated teeth with simulated invasive cervical resorption cavities restored with different adhesive restorative materials: An in vitro study. J Conserv Dent. 2020;23(2):174–79.