International Journal Dental and Medical Sciences Research
Volume 5, Issue 4, July-Aug 2023 pp 549-554 www.ijdmsrjournal.com ISSN: 2582-6018

Structural Integrity of Biomimetic Restorations in Pulpotomized Primary Molars: An Invitro Study

Eslam Abdulhamid Haj Ali[1], Salwa Mohamed Awad[2] and Hossam El-Sherbiny Hammoud[3]

[1]*MSc student, Departement of Pediatric Dentistry, Faculty of Dentistry, Mansoura University,Egypt*
[2]*Professor, Department of Pediatric Dentistry, Faculty of Dentistry, Mansoura University, Egypt.*
[3]*Lecturer, Department of Pediatric Dentistry, Faculty of Dentistry, Mansoura University, Egypt*

Date of Submission: 20-08-2023 Date of Acceptance: 31-08-2023

ABSTRACT: The selection of proper restorative material is essential in pulpotomized treating primary teeth to maintain the remaining tooth structure and protect the teeth against masticatory force. The study aimed to evaluate the structural integrity of biomimetic restorations in 40 pulpotomized primary molars restored with amalgam, resin-modified glass ionomer.Structural integrity test was recorded using a universal testing machine. Result show force at maximum compressive stress was statistically significantly higher among RMGIC group as compared to amalgam group. So RMGIC restoration showed higher structural integrity than amalgam.

KEYWORDS: Biomimetic restoration, Structural integrity.

I. INTRODUCTION

Primary teeth are essential for maintaining space and aesthetics, protecting the integrity of the dental arch, and preventing malocclusion. Therefore, teeth with pulpal disease and pulpal exposure should be treated and preserved as long as possible until replacement with the successors. Pulpotomy is the treatment of choice for pulp exposure in a vital tooth due to caries or trauma. It is indicated when the radicular pulp tissue is intact or capable of healing after removing the affected or infected coronal part of the dental pulp from deciduous teeth. [1]

Various materials and restorative techniques are suggested to improve the structural integrity of teeth with severe coronal loss. Adhesive restorations transmit and distribute stresses across the bonding interface to the tooth; consequently, occlusal forces can be distributed over a large surface area due to micromechanical adhesion, thereby reinforcing a weakened tooth structure.[2]

Stainless steel crowns are highly suggested to prevent the fracture of weakened cavity walls and to reduce the possibility of pulpotomized tooth marginal leakage.[3] The Stainless steel crowns notable drawback is aesthetics due to the metallic appearance, which patients and parents dislike, also requiring tooth preparation. [4]

New restorative protocols have been proposed over the last two decades to properly use modern adhesive systems while preserving the remaining sound tooth structure.[5]

Restorative dentistry uses biomimetics to restore teeth's functional, mechanical, and aesthetic requirements as naturally as possible. Essentially, it aims to replace the damaged portion of teeth far more conservatively than traditional tooth preparation, which involves extensive and invasive preparations to facilitate retention and resistance forms.[6]

In clinical dentistry, biomimetics refers to the repair of damaged dentition by mimicking the appearance, biomechanical, and functional characteristics of natural teeth.[7]

Structural integrity is the ability of a structure to tolerate the force without having failed due to fracture, deformation, or fatigue,[8] as well as the ability of the restorative material to tolerate functional pressures determines its long-term performance.[9]

Therefore, because of challenges in restoring the pulpotomized teeth and the need for this study, it is worthy to evaluate structural integrity of different traditional restorations in extracted primary molars teeth using universal testing machine.

II. MATERIALS AND METHODS

Study design:

This study was designed as an invitro study to alleviate the structural integrity of biomimetic restorations in pulpotomized primary molars restored using amalgam, resin-modified glass ionomer. This invitro study was conducted at the Department of Pediatric Dentistry at Mansoura

International Journal Dental and Medical Sciences Research
Volume 5, Issue 4, July-Aug 2023 pp 549-554 www.ijdmsrjournal.com ISSN: 2582-6018

University.Approval of this study was obtained from ethical committee of scientific research of Faculty of Dentistry, Mansoura University with the code number: M14060722

Sample size calculation:

The calculated sample size of the study was 13 specimens in each group at 5% level of significance and 95% power of the study, using G*Power 3 sample size calculator.Sample size calculated based on mean fracture resistance in Newton among the studied group (516.9) , SD (151.8) and mean (811.9) , SD (238.5) among control group (Luthria, et al, 2012).[10]
The sample size was increased to 20 specimens in each group (total 40) to compensate for incomplete data and to increase the study power.

Specimens' selection:

Forty extracted second (upper and lower) primary molars were collected for this study from dental clinics at Mansoura city and nearby cities, Faculty of Dentistry, Mansoura University for the reasons of anatomical defects, crack, extensive carious lesions or infection. The forty teeth were selected randomly for this study: (20) upper teeth and (20) lower teeth. The selection based on the following inclusion criteria: Teeth with class Ⅱ cavities, no or minimal (less than one third) root resorption, no external or internal root resorption, teeth without previous restorations.

Specimens grouping:

All the teeth were divided randomly into two groups of 20 each. Then each group were divided into two subgroups of 10 upper teeth and 10 lower teeth, and each sample take a number consist of 2 digits (the number of group, number of sample from 1 -10).

Preparation of the cavity:

Standardized class Ⅱ access cavities dimensions and depth were be conducted. Then pulpotomy done by filling the pulp chamber with a layer of zinc phosphate.

Restorations:

A universal metal matrix band/retainer will be placed around each prepared tooth[11]. Then, the restorative materials will be placed in the prepared class Ⅱ cavities according to each group as follow:

Group 1: Amalgam(SDI, Victoria, Australia)

Amalgam powder and liquid will be mixed in a mechanical amalgamator for 10 seconds to achieve a homogeneous consistency and the triturated amalgam will be condensed into the prepared cavity. Finally, carving will be done to reproduce the proper tooth anatomy and then burnishing to smoothen the rough margins and surface of the restoration.[12]

Group 2: RMGIC(FUJI Ⅱ light cured Capsule, GC corporation , Tokyo, Japan)

Firstly, conditioning of the cavity was be done by 37% phosphoric acid for 5 sec, rinsed away with a water spray and excess moisture was drying. Then, teeth were restored using fujiⅡ LC resin modified glass ionomer using capsule applier after triturating for 10 sec at 4300 (cpm),Then,apply of the material without voids in the cavity of the tooth and light cured for 20 seconds.[13]

Static structural integrity testing will be recorded using a universal testing machine (Instron,UK).A stainless steel metal ball ended cylindrical tip size 4mm, the tip fixed parallel to the long axis of the tooth and focalized on the center of the tooth until the tip just touched the occlusal surface. Compressive loading of the teeth operated at a crosshead speed of 1mm/min, and the force necessary to fracture each tooth recorded in Newton (N) with the computer software.[1]

Statistical analysis:

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 24). The normality of data was first tested with one-sample Kolmogorov-Smirnov test.

Qualitative data were described using number and percent. Continuous variables were presented as mean ± SD (standard deviation) for normally distributed data. The following tests were used; Monte carlo test was used to compare qualitative variables when expected cell count less than 5 while ANOVA test was used to compare more than two quantitative variables (parametric).

For all above mentioned statistical tests done, the threshold of significance is fixed at 5% level.The results was considered significant when $p \leq 0.05$. The smaller the p-value obtained, the more significant are the results.

III. RESULT

Forty extracted second primary pulpotomized molars carried out to evaluate the structural integrity of biomimetic restorations in pulpotomized primary molars using amalgam, resin-modified glass ionomer.

Table 1 show mean force at maximum compressive stress (structural integrity test) was statistically significantly higher among

International Journal Dental and Medical Sciences Research
Volume 5, Issue 4, July-Aug 2023 pp 549-554 www.ijdmsrjournal.com ISSN: 2582-6018

RMGICgroup than amalgam group. p value ≤0.05.the mean ±SD force at maximum compressive stress inRMGIC group showed the highest resistance against fracture (986.02 ±144.1), and amalgam group (563.93 ± 194.48).
Min-Max force in amalgam group (304.62- 967.41), in RMGIC group (714.88 - 1120.63).

Force at maximum compressive stress	Amalgam group (n=20)	RMGIC group (n=20)	Test of significance
Mean ± SD	563.93 ±194.48	986.02 ±144.1	P≤0.001*
Min-Max	304.62- 967.41	714.88-1120.63	

Table (1): Force at maximum compressive stress (upper and lower) among the two studiedgroups

Table 2 Shows comparison of structural integrity between upper and lower subgroups for both restoration groups :The highest main value was observed in RMGIC in (upper teeth 1057.3±50.4 , lower teeth 914.76±144.1) , then amalgam group (lower teeth 581.82±227.78 and upper teeth 546.02±165) .So, There was no statistically significant difference between upper and lower teeth regarding maximum compressive stressfor two groups except in RMGIC group, it was higher in upper teeth.
P value of amalgam group 0.692, P value of RMGIC group 0.009.

Force at maximum compressive stress	Amalgam group	RMGIC group
Upper teeth	546.02±165	1057.3±50.4
Lower teeth	581.82±227.78	914.76±144.1
P value	0.692	0.009

Table (2): Comparison between upper and lower teeth regarding force at maximum compressive stress among the two studied groups

IV. DISCUSSION

The selection of an ideal restorative material for the restoration of pulpotomized teeth is among the goals of dental materials' research because these teeth are more susceptible to fracture due to the great loss of tooth structure.

Structural integrity of teeth depends on two main factors which are dimensions of the prepared cavity and the restorative material. Hence, the restorative material should have adequate strength and retention to protect the teeth against masticatory forces and preserve the remaining tooth structure. [14]

Tooth specimens in our study were exposed to structural integrity test because compressive strength like other mastication forces, is measured using a pressure force test to determine the material's resistance to chewing pressures and is frequently used as a performance criterion.[9]

Primary molars were chosen for this study because it is more susceptible to caries due to children consume more sweets in their diets.[15]. Also, Second Primary molars were using in this study because carious primary molars can significantly affect caries development in the adjacent permanent first molars, and a carious primary second molar has a significantly greater

effect than a carious primary first molar in this respect. [16]

Samples in this study was preserved on 0.1% thymol solution to avoid fungal or bacterial growth at room temperature prior to studywhich isimportant for the safety and prevention of infection spreadingand this was supported with Papadopoulos et al. (2019)[17]

Pulpotomy were done in this study because it is the most indicated and most common vital pulp procedure in primary molars with extensive caries [18] and selecting the optimum restorative modality to compensate for the loss of coronal tooth structure is considered the key to restorative success.

In the present study, amalgam had been chosen as it considered the most low-cost, simple-to-use material in restoring pulpotomized primary teeth.It has excellent durability and clinical properties, including low technique sensitivity and self-sealing capacity.[19] However, because it does not bond to the tooth structure, cavity preparations with retentive features are required.[20]

In our study, RMGIC used because it's able toimprove the mechanical properties of the teeth and it has a better wear resistance, higher moisture resistance, higher fracture toughness and a longer working time.[21]It can also remineralise, thereby inhibiting secondary caries at the restorative margins.[22]

Furthermore, RMGICs were created to combine the mechanical properties of composite resins with the anti-carious properties of GICs. However, they may not be acceptable in aesthetically critical areas of the mouth, as discoloration of resin-modified glass ionomer restorations was higher than discoloration of resin-based composite restorations.[23]

The current study used biomimetic aesthetics restorations because they are preferred by parents and children over stainless-steel crowns (SSC).Parents who care deeply about appearances are not welcomed by SSCs. The metallic look of SSCs is enough to turn off some parents. [24]

In this study the purpose of using biomimetic concepts is to conserve tooth structure and vitality, increase the longevity of restorative dental treatments, and eliminate future retreatment cycles. Biomimetic dental materials are inherently biocompatible with excellent physico-chemical properties. They have been successfully applied in different dental fields with the advantages of enhanced strength, sealing, regenerative and antibacterial abilities.[25]

The biomimetic concept is very important in restorative dentistry because it aims to process restorative materials in a way that mimics the natural processing mechanisms of the oral environment. The secondary goal is to create restorative materials that can mimic or restore natural tooth biomechanics.[7]

Regarding the results of structural integrity,it was noted that RMGIC showed higher structural integrity than amalgam. In agreement to our result, Mohammad N et al. (2019)[14] and this explained by its adhesive property and probably by water sorption and expansion of the material during setting.

Rekha et al. (2012) [25]illuminate in their study that the addition of a 20% resin component in RMGIC restoration may explain the higher tensile bond strength of resin modified glass ionomer cement.

In the present study results showed that amalgam had the leastforce at maximum compressive stressamong all groups. In agreement to our result, the findings of Ghahramani et al.(2021), [26] When compared amalgam to prepared non-restored teeth, amalgam did not improve fracture resistance of pulpotomized teeth. This can be explained by the inability of amalgam to reinforce the remaining tooth structure.

Some studies have suggested that bonded composite restorations will strengthen a tooth when compared with amalgam. [27] On the other hand, this result disagrees with Cobankara et al(2008) [28] as they found that indirect hybrid ceramic inlay restorations prevented unfavourable fractures of teeth under occlusal loading, it seems to be a more reliable restorative technique than amalgam, resin composite and fibre reinforced resin composite restorations.

For restoring proximal caries in primary molars, resin modified GICs performed better than conventional GICs. The risk of a failed restoration was more than five times higher with Fuji II than with Vitremer. The main reasons for failure in both types of GICs were loss of retention and secondary caries. [29]

Regarding the result of the current study there was no significant difference between upper and lower teeth and this result comes in accordance withSheen et al.(2019)except in RMGIC group , upper teeth had higher structural integrity and thismay explained by their crown anatomy differs. The oblique and transverse ridges of maxillary molars (which link the distobuccal and mesiobuccal cusps to the mesiolingual cusp) make them more resistant to fracture compared to their mandibularand this finding disagree with Bhanderi, Sanjeev(2021)[30]

V. CONCLUSION

From the current investigations, several points could be declared:

a)RMGIC showed higher structural integrity than amalgam.

b)No difference between upper and lower primary molar teeth except in RMGIC group , upper teeth had higher structural integrity.

REFERENCES

[1]. Zareiyan, M., et al., Evaluation of fracture resistance of pulpotomized second primary molars restored with fiber-reinforced composite. Pediatric Dental Journal, 2020. **30**.

[2]. Aslan, T., et al., Evaluation of fracture resistance in root canal-treated teeth restored using different techniques. Niger J Clin Pract, 2018. **21**(6): p. 795-800.

[3]. Seale, N.S., The use of stainless steel crowns. Pediatr Dent, 2002. **24**(5): p. 501-5.

[4]. Afraa, S., et al., Restoration of Primary Anterior Teeth with Glass Fiber-Reinforced Post and Core: 3-Year Follow-Up Case Report. Case Rep Dent, 2021. **2021**: p. 5537437.

[5]. Deliperi, S., D. Alleman, and D. Rudo, Stress-reduced Direct Composites for the Restoration of Structurally Compromised Teeth: Fiber Design According to the "Wallpapering" Technique. Oper Dent, 2017. **42**(3): p. 233-243.

[6]. Mehnu, Z., et al., Era of Biomimetic Restorative Dentistry - A Narrative Review. Journal of Indian Dental Association, 2021. **3**: p. 10-15.

[7]. Zafar, M.S., et al., Biomimetic Aspects of Restorative Dentistry Biomaterials. Biomimetics (Basel), 2020. **5**((3)).

[8]. Beaumont, P., The Structural Integrity of Composite Materials and Long-Life Implementation of Composite Structures. Applied Composite Materials, 2020. **27**.

[9]. Birant, S., et al., Assesment of the compressive strength of the current restorative materials. Pediatric Dental Journal, 2021. **31**.

[10]. Luthria, A., et al., The reinforcement effect of polyethylene fibre and composite impregnated glass fibre on fracture resistance of endodontically treated teeth: An in vitro study. Journal of conservative dentistry : JCD, 2012. **15**: p. 372-6.

[11]. Dindukurthi, M.K., et al., Restoration of Proximal Contacts in Decayed Primary Molars Using Three Different Matrix Systems in Children Aged 5-9 Years: An In Vivo Study. Int J Clin Pediatr Dent, 2021. **14**(1): p. 70-74.

[12]. Dimitraki, D., S.N. Papageorgiou, and N. Kotsanos, Direct pulp capping versus pulpotomy with MTA for carious primary molars: a randomised clinical trial. Eur Arch Paediatr Dent, 2019. **20**(5): p. 431-440.

[13]. Hamama, H., M. Burrow, and C. Yiu, Effect of dentine conditioning on adhesion of resin-modified glass ionomer adhesives. Australian Dental Journal, 2014. **59**.

[14]. Mohammad, N., et al., Comparative Evaluation of the Fracture Strength of Pulpotomized Primary Molars: An In Vitro Study. Int J Clin Pediatr Dent, 2019. **12**(1): p. 5-9.

[15]. Chou, R., et al., U.S. Preventive Services Task Force Evidence Syntheses, formerly Systematic Evidence Reviews, in Prevention of Dental Caries in Children Younger Than 5 Years Old: Systematic Review to Update the U.S. Preventive Services Task Force Recommendation. 2014, Agency for Healthcare Research and Quality (US): Rockville (MD).

[16]. Jafari, A., et al., Effect of Primary Molar Caries on Caries Development in the Adjacent Permanent First Molars. Front Dent, 2021. **18**: p. 24.

[17]. Papadopoulos, C., et al., Structural Integrity Evaluation of Large MOD Restorations Fabricated With a Bulk-Fill and a CAD/CAM Resin Composite Material. Oper Dent, 2019. **44**(3): p. 312-321.

[18]. Igna, A., Vital Pulp Therapy in Primary Dentition: Pulpotomy-A 100-Year Challenge. Children (Basel), 2021. **8**(10).

[19]. Motisuki, C., et al., Restorative treatment on Class I and II restorations in primary molars: a survey of Brazilian dental schools. J Clin Pediatr Dent, 2005. **30**(2): p. 175-8.

[20]. Mahdi, S., et al., Comparison of shear bond strength of amalgam bonded to primary and permanent dentin. 2008. **26**(2): p. 71-73.

[21]. Hübel, S. and I. Mejàre, Conventional versus resin-modified glass-ionomer cement for Class II restorations in primary molars. A 3-year clinical study. International journal of paediatric

dentistry / the British Paedodontic Society [and] the International Association of Dentistry for Children, 2003. **13**: p. 2-8.

[22]. Khalid, M., Saghir, T., Yousaf, A., Hussain, S. M., Daud, Z., & Sultan, U. , Comparison of Efficacy of Resin-Modified Glass Ionomer and Composite Restoration in Inhibition of Secondary Caries in Primary Molars. Pakistan Armed Forces Medical Journal, 2023. **1**: p. 180-83.

[23]. Koc Vural, U., L. Kerimova, and A. Kiremitci, Clinical comparison of a micro-hybride resin-based composite and resin modified glass ionomer in the treatment of cervical caries lesions: 36-month, split-mouth, randomized clinical trial. Odontology, 2021. **109**(2): p. 376-384.

[24]. Moslemi, F., A.M. Yasaie, and R. Shojaeipour, Is the Metallic Color of Stainless Steel Crown Satisfying for Cooperative Children and their Parents? a Preliminary Study %J Journal of Dentistry. 2022. **23**(4): p. 480-488.

[25]. Singer, L., A. Fouda, and C. Bourauel, Biomimetic approaches and materials in restorative and regenerative dentistry: review article. BMC Oral Health, 2023. **23**(1): p. 105.

[26]. Ghahramani, Y., et al., The Effects of Various Restorative Techniques on the Fracture Resistance of Pulpotomized Permanent Premolars. International Journal of Dentistry, 2021. **2021**: p. 1-7.

[27]. Hürmüzlü, F., et al., Fracture resistance of endodontically treated premolars restored with ormocer and packable composite. J Endod, 2003. **29**(12): p. 838-40.

[28]. Cobankara, F.K., et al., The effect of different restoration techniques on the fracture resistance of endodontically-treated molars. Oper Dent, 2008. **33**(5): p. 526-33.

[29]. Hübel, S. and I. Mejàre, Conventional versus resin-modified glass-ionomer cement for Class II restorations in primary molars. A 3-year clinical study. Int J Paediatr Dent, 2003. **13**(1): p. 2-8.

[30]. Bhanderi, S., Facts About Cracks in Teeth. Primary Dental Journal, 2021. **10**(1): p. 20-27.