



Research Article

Received September 1, 2026; Revised September 30, 2026; Accepted September 30, 2026, Published September 30, 2026

DOI: 10.6026/973206300225854

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478

2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

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Edited by Vini Mehta

E-mail: vmehta@statsense.in

Citation: Elnawawy *et al.* Bioinformation 22(9): 5854-5860 (2026)

Exploring marginal fit impact on fracture resistance of in-ceram alumina onlays in molar restorations: An *in vitro* study

Mohamed Samir Elnawawy¹, Mohammed Ahmad Albahi², Hassan Abdullah Janbi², Mahmoud Majid Alsawaf², Saif Abdulrahman Aliqali², Adnan Hazim Salama² & Fawaz Pullishery^{3,*}

¹Department of Clinical Sciences, General Dentistry Program, Batterjee Medical College, Jeddah, Saudi Arabia; ²Dental intern, General Dentistry Program, Batterjee Medical College, Jeddah, Saudi Arabia; ³Department of Preventive Dentistry, General Dentistry Program, Batterjee Medical College, Jeddah, Saudi Arabia; *Corresponding author

Affiliation URL:

<https://bmc.edu.sa/en>

Author contact:

Mohamed Samir Elnawawy - E-mail: mohamedelnawawy1976@gmail.com

Mohammed Ahmad Albahi - E-mail: mohammedalbahi0@gmail.com

Hassan Abdullah Janbi - E-mail: hasjanbi@gmail.com

Mahmoud Majid Alsawaf - E-mail: saw99.99@icloud.com

Saif Abdulrahman Aliqali - E-mail: saifog@icloud.com

Adnan Hazim Salama - E-mail: dr.adnansalamah1@gmail.com

Fawaz Pullishery - E-mail: fawaz.pullishery@bmc.edu.sa

Abstract:

The reinforcing potential and overall effect of advanced ion-releasing materials, conventional flowable composites and RMGI cements-alongside deep margin elevation-on the fracture resistance of molars restored with in-ceram alumina ceramic onlays remain unclear due to insufficient comparative evidence. Therefore, it is of interest to evaluate the type of deep margin acquisition (DMA) material (Cention Forte, Tetric N-Flow and RMGIC) affects the fracture resistance (FR) of molars restored with In-Ceram Alumina ceramic onlays and which materials best structurally reinforce teeth with deep cervical margins. Five groups of 10 specimens were randomly allocated to enamel margin (control-supragingival), cementum margin (control-subgingival), Cention Forte DMA, Tetric N-Flow DMA and resin-modified glass ionomer (RMGI) DMA. The results of this study indicate that DMA particularly when using RMGI or Cention Forte, enhances the restored molars and improves their biomechanical function. On the contrary, Tetric N-Flow did not show an increase in FR compared to the control groups. The application of RMGI or Cention Forte as a DMA material improves the structural integrity and, consequently, the FR of MOD cavities restored with In-Ceram Alumina onlays.

Keywords: Cention Forte, deep margin acquisition (DMA), fracture resistance (FR), resin-modified glass ionomer, tetric N- Flow

Background:

The restoration of structurally compromised posterior teeth is a key focus in modern restorative dentistry. Indirect partial-coverage restorations, especially ceramic onlays, are favoured for their ability to preserve dental structure while providing aesthetic and mechanical advantages [1]. The long-term success of these restorations relies on factors such as material choice, marginal adaptability, adhesive integrity and the tooth's ability to endure functional occlusal forces [2, 3]. In-Ceram Alumina is noted as the most reliable ceramic for load-bearing applications. Complications such as cavity edges below the cemento-enamel junction (CEJ) can impede restoration procedures such as adhesion and impression-making [4-6]. A conservative management approach for deep cervical margins includes techniques like deep margin acquisition (DMA), also referred to as deep margin elevation (DME), or coronal margin relocation (CMR). This involves applying restorative materials to raise subgingival margins for better clinical access, facilitating indirect restorations and adhesive procedures [7]. DMA enhances access and structural support for restored teeth, employing various materials to boost marginal integrity [8]. Modern dentistry favors minimally invasive DME as an alternative to crown lengthening [9], though subgingival preparations can complicate procedures like rubber dam isolation and impression making, while also raising biological and technological concerns related to indirect partial restorations [5, 8]. Recent investigations suggest that DMA does not affect indirect restoration mechanical behaviour and may increase fracture resistance (FR) when sufficient restorative materials are applied [10]. DMA improved FR and structural integrity of CAD/CAM ceramic restorations, underlining the need for margin relocation restorative material [2, 11]. The kind of restorative material and degree of cervical margin relocation also affected FR and pattern of failure,

highlighting the biomechanical relevance of the margin-elevation substrate [3]. Selecting a DMA restorative material, such as resin-modified glass ionomer cements (RMGIs), can enhance the tooth-restoration complex by providing chemical bonding to dentin, fluoride release and an elastic modulus that absorbs stress. Recent studies suggest that the dentin-like behavior of RMGIs improves biomechanical function [12, 13]. Alkasite materials, particularly Cention Forte, offer strong mechanical properties and effective stress-bearing due to their ion-releasing capabilities [14]. While flowable resin composites like Tetric N-Flow are useful for margin elevation, their lower filler content poses challenges for structural reinforcement compared to bulk-fill and ion-releasing materials [15]. Recent studies highlight that the FR of indirect ceramic restorations is essential for assessing their clinical efficacy. The effectiveness of a DMA is influenced by both the placement of the margin and the mechanical traits of the restorative material used for the restoration of the cervical region [3, 6 and 16]. Therefore, it is of interest to report that this *in vitro* study aimed to determine whether the type of DMA material-Cention Forte, Tetric N-Flow, or RMGI-affects the fracture resistance of molars restored with In-Ceram Alumina ceramic onlays and to identify which material provides the greatest structural reinforcement for teeth with deep cervical margins.

Materials and Methods:**Study design:**

A bench-based comparative study examined the FR of human molars restored with In-Ceram alumina ceramic onlays using various DMA materials. RMGI, Cention Forte and Tetric N-Flow DMA materials were assessed for FR measured under compressive load. (Table 1) illustrates the materials utilised in the study and their composition and manufacturing details.

Sampling Method:

Five experimental groups of equal size ($n = 10$ per group) were assigned 50 extracted human molars using a simple random sampling procedure. Randomisation ensures unbiased distribution and reduces biological diversity. The FR measurements from the pilot study were used to evaluate the mean difference and variability between experimental groups and compute the sample size for this study. Given these preliminary data, the sample size was calculated using the one-way ANOVA procedure for evaluating means across groups:

$$n = [2(Z_{\alpha/2} + Z_{\beta})^2 * \sigma^2] / \Delta^2$$

where n is the required number of specimens per group, $Z_{\alpha/2} = 1.96$ corresponds to a 95% confidence level, $Z_{\beta} = 0.84$ represents 80% statistical power, σ is the pooled standard deviation derived from the pilot study and Δ is the minimum detectable difference in FR considered clinically meaningful. Using pilot data, the pooled standard deviation (σ) was estimated at 150 N and the lowest relevant difference (Δ) was determined at 200 N. By inserting these values into the formula, 8 samples per group were estimated. The sample size was then inflated to 10 teeth per group to ensure robustness, adjust for biological variation and account for specimen attrition during preparation or testing, yielding 50 specimens for the main study. This sample size ensures appropriate power to identify significant differences among groups employing one-way ANOVA and post-hoc analyses.

Study setting:

Experiments were conducted in the Dental Biomaterials Laboratory of the Dentistry Program at Batterjee Medical College, Jeddah, Saudi Arabia. Extracted molars from outpatient dental clinic patients were kept in 0.1% thymol solution and treated under rigorous infection-control and biosafety procedures. The study included human permanent molars that were extracted for periodontal or orthodontic purposes, had fully grown roots and no apparent cavities, fissures, issues with structural integrity, or restorations. Teeth were excluded if they exhibited any type of caries, fractures, internal resorption, previous restorations, incomplete root formation, or failure to comply with infection-control or handling criteria.

Specimen preparation:

The collected set of 50 teeth was subjected to infection control protocols. Following the excision of soft tissue remnants with a hand scaler, the teeth were preserved in a 1% chloramine-thymol solution (Chloramine-T) for 72 hours at ambient temperature and subsequently kept within distilled water until required. Teeth were polished employing a rubber cup and a fine pumice-water suspension. Teeth roots were inserted in a 1.4×2 cm PVC ring utilising auto-polymerizing acrylic resin (Acrostone, Cairo, Egypt) up to 3 mm below the CEJ. A red pencil was used to outline the dental roots 3 mm below CEJ and then dipped into molten wax to create a 2mm to 3mm layer around the thickness of the periodontal ligament. Acrylic resin cylinders were

employed to mount the teeth with the assistance of a centralisation guide device. After acrylic resin hardening, each tooth was taken from the cylinder. The wax spacer was removed from the root with hot water and a wax knife. Polyether imprint material (Impregum soft, 3M ESPE, St. Paul, Minnesota) was introduced into the acrylic resin alveolus. The scalpel blade was used to remove excess polyether material, resulting in a planar surface that is 3 mm below the CEJ of each tooth. Five primary groups of 10 specimens were randomly selected: Group 1: enamel margin (control - supragingival); Group 2: cementum margin (control - subgingival); Group 3: Cention Forte DMA; Group 4: Tetric N-Flow DMA; and Group 5: RMGI DMA. Using a high-speed handpiece (Sirona T3, Bensheim, Germany) and sufficient air-water cooling, coarse diamond and finishing diamond burs (Onlay Prep-Set, Intensiv, Viaganello-Lugano, Switzerland) were used to cut standardised class II MOD onlay cavities. All preparatory stages were completed by the same operator, following the specified series of specific diamond instruments. The diamond instruments were changed after four preparations to maximise cutting efficiency. Standard cavity preparation parameters set the pulpal floor depth at 2.5 mm from the occlusal surface. Mesial and distal buccolingual widths were 2.5 mm, as was the occlusal isthmus. Each box has a 1.5 mm gingival floor depth and 2 mm axial wall height. Following the anatomical contour of the occlusal surface, the palatal cusp was shortened by 2 mm and the margin was finished as a 1 mm rounded shoulder. For the enamel margin group, the preparation of the gingival margin was 1 mm above the CEJ on the enamel. In the remaining four groups, the preparation ended 2 mm below the CEJ in cementum. All teeth in groups 3 through 5 exhibited a 2 mm DMA to the CEJ.

Restoration procedure for proximal box elevation:

Three distinct restorative materials were chosen and it was utilised in accordance with the manufacturer's guidelines. All polymerisation conducted in this investigation was executed utilising a Blue phase N light-curing unit (Ivoclar Vivadent AG, Schaan, Liechtenstein). A radiometer (Blue phase Meter II, Ivoclar Vivadent, AG and Schaan, Liechtenstein) was utilized to verify that the light output of the Bluephase N consistently reached 1000 mW/cm². Specimens in groups 3 to 5 received the DMA to elevate the gingival edge by 3 mm, positioning the material on the gingival floor 1 mm above the CEJ with a Tofflemire matrix band (Henry Schein, Melville, NY, USA). Place the Cention forte DMA group in a single 3 mm increment, using Cention Primer to condition the proximal box. Subsequently activated and combined within the capsule, the substance was administered into the deep proximal box with minimal manipulation to reduce voids and permitted to self-cure. The Tetric N-Flow DMA group was positioned in a single 3 mm increment, utilising an etch and rinse adhesive solution across all samples, which included N-Etch followed by Tetric N-Bond Universal. Subsequently, the material was positioned in the deep proximal box and then subjected to light polymerisation. Concerning the RMGI DMA group administered in two 1.5 mm increments, following the activation and mixing of the capsule,

the material was injected into the deep proximal box. It is essential to immerse the tip of the capsule beneath the material's surface to avert the generation of air bubbles.

Digital impression:

After specimen preparation and DMA, 50 preparations were scanned with a CEREC Omnicam (Dentsply Sirona, Charlotte, NC, USA) and 50 onlays were designed and milled from In-Ceram alumina.

Fabrication of onlay restorations:

A technician followed the manufacturer's instructions to make all restorations utilising a consistent method. CAD/CAM was used to make all indirect restorations. The samples were intraoral-scanned before and after processing. The software used Cerec's Biogeneric Copy function to create indirect restorations to get prepared samples to their original shape. An In Lab MC XL milling machine (Dentsply Sirona, Bensheim, Germany) was used to create indirect restorations (In-Ceram alumina). Indirect restorations were sintered at 1500°C, glazed and burnt at 710°C (Program at 5000, Ivoclar Vivadent, Schaan and Lichtenstein).

Adhesive bonding of onlay restorations:

For marginal fit, restorations are tried-in with Try-in paste. Remove any Try-in paste residue from the cavity and restoration. The internal surfaces of each onlay were sandblasted after try-in. G-Cem Capsule self-adhesive cement-bound onlays. To avoid oxygen-inhibited layer development, all edges were encased with Liquid Strip and light polymerised for 40 seconds to achieve complete polymerisation and optimum bonding. Finish the cement lines with OptraPol or Ivoclar Vivadent polishing strips.

Fracture resistance test:

To simulate oral cavity heat changes, all specimens were thermocycled 10,000 times between 5°C and 55°C. The dwell duration at each temperature was 30 seconds, while the bath transfer time was 5 seconds. After a week of distilled water preservation since luting, each sample was exposed to axial compressive loading in a universal testing machine (Instron 3345, Canton, Massachusetts) with an 8-mm metal sphere applied vertically to the cusp slopes at 1 mm/min until failure occurred to assess the FR force measured in Newtons (N).

Statistical analysis:

Data was analysed for fracture resistance employing Shapiro-Wilk test which determined normalcy at maximum compressive stresses. One-way ANOVA and Tukey HSD pairwise

comparison tests were applied to determine the significant differences between the groups. A p-value of 0.05 was deemed to be significant.

Results:

The averages FR of the five experimental groups are presented in **Table 2**. The highest fracture resistance was found in the RMGI DMA group (2089 ± 256 N) followed by Cention Forte DMA (1987 ± 271 N). The fracture resistance values of the Tetric N-Flow DMA group (1739 ± 257 N) and the enamel margin control group (1737 ± 218 N) were similar; the cementum margin control group had the lowest mean FR (1704 ± 221 N). One-way ANOVA showed a statistically significant difference in fracture resistance among the five groups (F = 5.07, p = 0.002) (**Table 3**). The location of the restoration margin and the DMA material had a significant influence on the FR of In-Ceram Alumina ceramic only restoration. Post hoc pairwise comparisons revealed no significant difference between enamel margin and cementum margin controls (mean difference = 33 N, p = 0.74). The difference in enamel margin and cementum margin was not significantly different as compared with Tetric N-Flow DMA groups (mean difference = -2 N, p = 0.98 and -35 N, p = 0.75, respectively). The Cention Forte DMA group had considerably higher fracture resistance than the enamel margin control group (mean difference = 250 N; p = 0.03) and cementum margin control group (mean difference = 283 N; p = 0.02). The fracture resistance was significantly better in Centon Forte DMA than Tetric N-Flow DMA (mean difference = 248 N, p = 0.05). The RMGI DMA group showed significantly higher fracture resistance than the enamel margin control group (mean difference = 352 N; p = 0.004), cementum margin control group (mean difference = 385 N; p = 0.002) and Tetric N-Flow DMA group (mean difference = 350 N; p = 0.007). There was no statistically significant difference between RMGI DMA and Cention Forte DMA (mean difference = 102 N; p = 0.40) (**Table 4**). The results suggest that DMA with RMGI and the advanced ion-releasing alkasite material Cention Forte improved the FR of molars restored with In-Ceram Alumina ceramic onlays compared to enamel or cementum margins. The lack of a substantial distinction between the RMGI and Cention Forte groups implies that both materials provided the tooth-restoration complex with comparable reinforcement. The results of this study indicate that DMA particularly when using RMGI or Cention Forte, enhances the restored molars and improves their biomechanical function. On the contrary, Tetric N-Flow did not show an increase in FR compared to the control groups.

Table 1: Restorative materials used in the study

Materials used	Composition	Manufacturer
Cention Forte (Self-cured, glass ionomer)	UDMA, initiator, glass filler, pigments	Ivoclar Vivadent, Schaan, Liechtenstein
Tetric-N Flow (Light-cured, flowable composite)	Barium glass, UDMA, Bis-GMA, ytterbium trifluoride, TEGDMA, mixed oxide (SiO2/ZrO2), barium-aluminiumfluorosilicate glass	Ivoclar Vivadent, Schaan, Liechtenstein
RMGI (Light-cured, resin-modified glass ionomer)	Polyacrylic acid 20-30%, 2-HEMA 30-35%,	Hasunumacho, Itabashiku Tokyo, Japan

In ceram alumina	Alumina (Al ₂ O ₃): 70% – 80% by weight, Glass Matrix: 20% – 30% by weight,	VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany
<i>Bis-GMA - Bisphenol A-glycidyl methacrylate; TEGDMA – Triethylene glycol dimethacrylate; UDMA - Urethane dimethacrylate</i>		

Table 2: Descriptive statistics of Force at maximum compressive stress (N) between the groups

Groups (n=10/group)	Mean	SD
Enamel margin	1737	218
Cementum margin	1704	221
Cention Forte DMA	1987	271
Tetric-N Flow DMA	1739	257
RMGI DMA	2089	256

Table 3: ANOVA table of comparisons of force at maximum compressive stress (N) between the groups

	Sum of squares	df	MS	F-test	p-value
Between	1,222,888	4	305,722	5.07	0.002**
Within	2,712,519	45	60,278.2		
Total	3,935,407	49			

**highly significant

Table 4: Post hoc analysis of pairwise comparisons of the groups

Variables	Pairwise comparison	Mean differences	95% CI		P-value
			Lower limit	Upper limit	
Enamel margin	Cementum margin	33	-	239.24	0.74
	Cention Forte DMA	-250	-	-18.93	0.03*
	Tetric-N Flow DMA	-2	-	221.90	0.98
	RMGI DMA	-352	-	-	0.004**
Cementum margin	Enamel margin	-33	-	173.24	0.74
	Cention Forte DMA	-283	-	-50.68	0.02*
	Tetric-N Flow DMA	-35	-	190.19	0.75
	RMGI DMA	-385	-	-	0.002**
Cention Forte DMA	Enamel margin	250	18.93	481.07	0.03*
	Cementum margin	283	50.68	515.32	0.02*
	Tetric-N Flow DMA	248	-0.13	496.13	0.05*
	RMGI DMA	-102	-	145.67	0.40
Tetric-N Flow DMA	Enamel margin	2	-	221.90	0.98
	Cementum margin	35	-	260.19	0.75
	Cention Forte DMA	-248	-	0.13	0.05*
	RMGI DMA	-350	-	-	0.007**
RMGI DMA	Enamel margin	352	128.61	575.39	0.004**
	Cementum margin	385	160.31	609.69	0.002**
	Cention Forte DMA	102	-	349.67	0.40
	Tetric-N Flow DMA	350	109.00	591.00	0.007**

**highly significant; * significant

Discussion:

The study findings showed that DMA significantly affected the FR of molars restored with In-Ceram Alumina ceramic onlays. The RMGI DMA group exhibited the highest resistance to fracture, followed by the Cention Forte DMA group, while the Tetric N-Flow DMA group showed values similar to the control groups. These results align with the increasing evidence that the material employed for the margin elevation is of paramount importance for the biomechanical effectiveness of indirect ceramic restorations. The considerably higher FR reported in the RMGI and Cention Forte groups endorses the concept that DMA can function as a reinforcing base for indirect restorations rather than simply a margin relocation procedure. This finding concurs with the study by Vertolli *et al.* [11], who disclosed that DMA enabled maintaining the structural integrity of CAD/CAM ceramic inlays and contributed positively to the fracture behavior of restored teeth. Their study results demonstrated that an overcontoured margin did not compromise the restoration and may have biomechanical benefits if the appropriate filling materials were selected. Likewise, Salah and Sleibi [2] assessed the effect of DMA on FR of ceramic onlay restorations and found that the teeth with margin elevation presented higher FR than the teeth restored without elevation. Moreover, specimens restored with short fibre-reinforced composite showed considerably greater FR than those restored with conventional bulk-fill flowable composite, pointing out the crucial role of the mechanical characteristics of the DMA material [17]. This is supported in the present study, where selecting the type of DMA material profoundly influenced the FR, with RMGI and Cention Forte functioning better than Tetric N-Flow. The RMGI DMA group had the better performance in this testing due to its elastic modulus and stress-absorbing properties. The modulus of elasticity of RMGI is closer to dentin, which may help distribute cervical tension more uniformly to avoid the concentration of stress under the ceramic restoration. Chemical bonding to dentin may contribute to durability and load transfer at the interface [18]. The present data indicate that RMGI might have a biomechanically favourable dentin-replacement effect for elevation of the cervical margin. Additionally, the FR of Cention Forte DMA was significantly higher than that of both control groups. This is possible due to its high compressive strength, fracture toughness and lower polymerisation shrinkage than conventional flowable composites. Strengthening the cervical foundation under the ceramic onlay with Cention Forte may have changed the stress distribution in the tooth-restoration complex and averted cracking under compressive loading [19]. Tetric N-Flow DMA FR was similar to that of the enamel and cementum margin controls. Flowable composites are frequently used for margin relocation owing to their good adaptation and mechanical features, but their lower filler loading and inferior mechanical properties suggest that they may not reinforce compromised tooth structure. According to Salah and Sleibi [2], DMA with bulk-fill flowable composite had lower FR than fibre-reinforced materials. The findings of Diao *et al.* [6] found that

relocation of the cervical margin significantly reduced FR of endodontically treated molars restored with indirect ceramic restorations and that biomechanical efficiency was influenced by restorative material and scope. Their study showed that procedures of margin relocation could increase FR and change the mode of failure, emphasising the importance of choosing a cervical-reinforcing material. Musapoor *et al.* [3] observed that material and cervical margin relocation influenced FR. The FR decreased with the increase in relocation length, but the better mechanical properties had better biomechanical characteristics. These results are consistent with the present results that material selection is important to the reinforcing effect of DMA. Further, Roshdy *et al.* [16] evaluated the FR of CAD/CAM onlays restored molars after cervical border elevation with different injectable restorative materials. Their results showed that FR varied by elevation material, demonstrating that the mechanical properties of the margin-elevation substrate significantly affect the load-bearing capacity of indirect restorations. This result is in good agreement with the present study, where the FR measurements for RMGI and Cention Forte were significantly higher than those of Tetric N-Flow and the control groups. The present study data did not support the concept that advanced ion-releasing restorative materials are more fracture-resistant than RMGI. Cention Forte showed significantly higher FR than Tetric N-Flow and the control groups, while the highest mean FR was observed in RMGI. There was no statistical difference between the RMGI and Cention Forte groups, which suggests that both materials reinforced the tooth-restoration complex to the same degree. The results were in line with previous studies that the elastic modulus, stress distribution, interfacial adaptability and bonding efficacy, other than ion release, affect the FR of the restored teeth [3, 5 and 20]. While Cention Forte has well compressive, flexural and fracture toughness, RMGI has a modulus of elasticity more similar to dentin and can be used as a stress-absorbing layer to reduce cervical stress concentration [20, 21]. Recent studies on DMA have shown that the biomechanical efficiency of indirect restorations depends more on the mechanical properties of the margin-elevation material and its ability to transfer and dissipate occlusal forces than on its bioactivity [2, 6 and 22]. Thus, the ion-releasing ability, mechanical compatibility with dentin and potential to maintain the integrity of the tooth-restoration complex under functional loading of the restorative material may be the explanation for the strengthening effect observed in this study. This study provides useful information about the impact of DMA materials on the FR of In-Ceram Alumina ceramic onlay restorations, but it has some important limitations. The study was performed in laboratory conditions that are not totally representative of the oral environment, as it does not consider factors such as saliva, thermal variations and patient-specific occlusal patterns. However, statistically significant differences were observed and study power would be increased with a larger sample size. The FR was measured under a single static load, which does not reflect the cyclic loading of restorations *in vivo*. The generalisability of the present results is limited by the differences in tooth morphology and enamel thickness and the fact that only

In-Ceram Alumina onlays were studied. The study only used three margin elevation materials and not different modern alternatives that may behave differently. Thermocycling was used to simulate thermal stresses, but it does not reproduce long-term effects like ageing and material fatigue. For future research, laboratory evaluations with cyclic mechanical loading and thermomechanical ageing should be performed to simulate masticatory stresses and to evaluate fatigue performance. Comparative studies of fibre-reinforced composites, bioactive restorative materials and newer systems of ion release are recommended to identify the most effective material for DMA. In addition, studies on the interaction of DMA materials with indirect restorative materials such as lithium disilicate and zirconia reinforced ceramics are required. Moreover, clinical studies are needed to validate *in vitro* results and to evaluate long-term survival and success rate of DMA restorations, creating evidence-based norms for the choice of materials and use in clinical settings.

Conclusion:

Both RMGI DMA and Cention Forte DMA showed significantly increased fracture resistance compared to control groups, with no significant difference between the two. The mean FR of Tetric N-Flow DMA was similar to that of enamel and cementum controls, with no significant difference. The results indicate that the application of RMGI or Cention Forte as a DMA material improves the structural integrity and consequently, the FR of MOD cavities restored with In-Ceram Alumina onlays.

Advancement to Knowledge:

There is limited comparative evidence on advanced ion-releasing materials, conventional flowable composites and RMGI cements as base materials under In-Ceram Alumina ceramic onlays. Although deep margin elevation helps manage subgingival margins, its effect on the fracture resistance of indirect restorations remains unclear. In particular, there is insufficient data on the reinforcing potential of Cention Forte, Tetric N-Flow and RMGI. Therefore, this *in vitro* study aimed to evaluate whether these DMA materials influence the fracture resistance of molars restored with In-Ceram Alumina ceramic onlays and to identify the material that offers the best structural support for teeth with deep cervical margins.

References:

- [1] Mohamed AA *et al.* *Biomimetics*. 2026 **11**:291. [DOI: 10.3390/biomimetics11050291]
- [2] Salah Z & Sleibi A. *J Clin Exp Dent*. 2023 **15**:e446. [PMID: 37388433]
- [3] Musapoor N *et al.* *Int J Dent*. 2024 **2024**:9274141. [PMID: 39229333]
- [4] Hassan SM *et al.* *BMC Oral Health*. 2025 **25**:793. [PMID: 40414841]
- [5] Juloski J *et al.* *J Prosthodont Res*. 2018 **62**:273. [PMID: 29153552]
- [6] Diaa M *et al.* *Prosthesis*. 2024 **6**:1106. [DOI: 10.3390/prosthesis6050080]

- [7] Alqurshi A I *et al.* *Mans J Dent.* 2023 **10**:148. [DOI: 10.21608/mjd.2023.302002]
- [8] Aldakheel M *et al.* *Medicina (Kaunas).* 2022 **58**:1482. [PMID: 36295642]
- [9] Sarfati A & Tirlet G. *Int J Esthet Dent.* 2018 **13**:334. [PMID: 30073217]
- [10] Kitin E & Yazicioglu O. *J Esthet Restor Dent.* 2026 **38**:115. [PMID: 40910556]
- [11] Vertolli TJ *et al.* *Oper Dent.* 2020 **45**:608. [PMID: 32243253]
- [12] Ouldryerou A *et al.* *PLoS One.* 2023 **18**:e0295582. [PMID: 38128035]
- [13] Rêgo C *et al.* *Biomed Res Int.* 2022 **2022**:4690656. [PMID: 35958806]
- [14] Laporte C *et al.* *J Funct Biomater.* 2026 **17**:93. [PMID: 1745556]
- [15] Ragab R *et al.* *Sci Rep.* 2026 **16**:16011. [PMID: 42177277]
- [16] Roshdy B *et al.* *Clin Oral Investig.* 2025 **29**:415. [PMID: 40820041]
- [17] Obeid AT *et al.* *Front Dent Med.* 2025 **6**:1634533. [PMID: 41159005]
- [18] Karageorgiou A & Gkavela G. *Appl Sci.* 2026 **16**:2714. [DOI: 10.3390/app16062714]
- [19] Pai D *et al.* *ScientificWorldJournal.* 2024 **2024**:9420336. [PMID: 38205145]
- [20] Sidhu SK & Nicholson JW. *J Funct Biomater.* 2016 **7**:16. [PMID: 27367737]
- [21] Roshdy BN *et al.* *J Esthet Restor Dent.* 2025 **37**:1522. [PMID: 39825633]
- [22] Mertsöz B *et al.* *Materials (Basel).* 2023 **16**:2059. [PMID: 36903174]
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