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THE EFFECT OF THERAPEUTIC DOSE OF GAMMA RADIATION ON FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TOOTH OBTURATED USING DIFFERENT TYPES OF SEALERS (AN IN-VITRO STUDY)

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ABSTRACT

Background: Radiation therapy is a crucial component of cancer treatment, but it can have adverse effects on oral tissues, including teeth. The impact of radiation on the fracture resistance (FR) of endodontically treated teeth has piqued the interest of dental researchers. Bioceramic sealers like CeraSeal have shown promising dentin bonding and sealing abilities, but there is limited data on their FR compared to traditional resin-based sealers like ADSEAL. Therefore, the aim of this study was to investigate the effect of therapeutic radiation doses on the FR of root canal-treated teeth filled with gutta-percha and two sealers.

Materials and Methods: Ninety extracted mandibular premolars were divided into experimental and control groups. Each group was further subdivided into subgroups with and without irradiation (n=15) and obturated with either ADSEAL or CeraSeal. The FR of each group was tested using a Universal Testing Machine. Statistical analyses included independent t-tests for matched groups and One-Way ANOVA followed by Tukey's Post Hoc test for multiple comparisons ($p < 0.05$).

Results: Before irradiation, both sealers significantly increased the FR compared to the control group. CeraSeal exhibited the highest FR, followed by ADSEAL. After irradiation, all groups showed a significant reduction in FR, with CeraSeal demonstrating the least reduction.

Conclusions: Regardless of the sealer used, irradiation decreases the FR in root canal-treated teeth. CeraSeal outperformed ADSEAL in maintaining tooth strength after irradiation.

KEYWORDS: Bioceramic sealers, Resin sealers, Endodontic treatment, Fracture resistance, Gamma radiation, Radiotherapy

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INTRODUCTION

Head and neck cancer is a significant health concern and is commonly treated with radiation therapy. Patients diagnosed with head and neck cancer often undergo surgical management, chemotherapy, radiotherapy, or a combination of these treatments.(1) Despite protective measures to prevent or minimize tissue damage from therapeutic radiation exposure, radiation therapy consistently weakens tooth structure in the head and neck region. Previous studies have reported the occurrence of physical and chemical changes in teeth after radiation(2,3). Additionally, head-neck radiotherapy may increase the risk of apical periodontitis (4).

Although teeth exposed to therapeutic radiation are weak and prone to fracture, it is common practice to recommend root canal treatment and direct restorations for teeth with compromised coronal structure before undergoing head-neck radiotherapy. This is because extracting teeth in such cases carries the risk of osteoradionecrosis. As a result, reinforcing the tooth structure of irradiated teeth becomes imperative to preserve dental health and functionality. (5)

Root canal treatment, which involves the cleaning, shaping, and obturation of the root canal system, is a common procedure performed to save teeth with pulp-related diseases or injuries. Root canal obturation, which fills the root canal space with a suitable material, such as gutta-percha and sealer, is an essential step in root canal treatment. Different types of sealers are available for this purpose, including resin-based and bioceramic sealers. (6)

Resin-based sealers have gained widespread acceptance in modern endodontics due to their favorable mechanical properties, dentin adhesion, penetration into dentinal tubules, and adaptation to peritubular dentin. (7) Conversely, bioceramic sealers are becoming increasingly popular due to their ability to form hydroxyapatite and bond to dentin, potentially strengthening the teeth.(8) Both resin-based and bioceramic sealers have shown promising bonding properties with radicular dentin. (9)

While the effects of therapeutic radiation on tooth structure and integrity have been studied, limited research has focused on the fracture resistance of endodontically treated teeth filled with different types of sealers after exposure to therapeutic doses of gamma radiation. (10) Understanding the impact of radiation on the fracture resistance of obturated teeth is crucial for providing appropriate treatment recommendations and improving the long-term success of endodontic therapy in irradiated patients.

This in vitro study aims to address the knowledge gap in the literature by investigating the potential reinforcement effect of two different root canal sealers, ADSEAL (resin-based, Meta Biomed) and CeraSeal (calcium silicate-based, Meta Biomed), on irradiated teeth.

MATERIALS AND METHODS

A total of 90 freshly extracted mandibular premolar teeth with single-root and single-canal anatomy were selected for this study. The teeth were obtained from a geriatric outpatient clinic due to clearance, and ethical committee approval was obtained from Faculty of Dentistry, October 6 University with approval number (RECO6U/10-2023) and approval date January 9, 2023.

Upon collection, the teeth were radiographed from a proximal view to ensure they met the inclusion criteria, which included a type I canal system, absence of internal or external resorption, calcification, previous root canal treatment, and pre-testing cracks. The collected teeth were cleaned, disinfected, and preserved in saline solution. Cusp tips of all teeth specimens were trimmed using a separating disc under a continuous water spray. (11)

Mechanical preparation of teeth samples was conducted by creating access cavities using high-speed burs with abundant water coolant. The canal preparations for the experimental teeth samples were performed using rotary instrumentation with

TrueShape NiTi rotary instruments (martensitic) (Densply Maillefer, Switzerland) according to the manufacturer's directions. [12] During the canal preparation process, equal volumes of 2.5% sodium hypochlorite were used for irrigation before, during, and after preparation.

The teeth samples were randomly assigned to six equal groups (G1-G6), each consisting of 15 teeth. The groups were divided into three control sub-groups and three experimental sub-groups, as described below:

G1: Teeth with access and mechanical preparation without obturation or irradiation (Negative control group)

G2: Teeth with access and mechanical preparation without obturation but subjected to gamma irradiation (Negative control group)

G3: Teeth with obturation using ADSEAL and no gamma irradiation (Positive control group)

G4: Teeth with obturation using ADSEAL and subjected to gamma irradiation (Positive control group)

G5: Teeth with obturation using CeraSeal and no gamma irradiation.

G6: Teeth with obturation using CeraSeal and subjected to gamma irradiation.

For groups 3 to 6, the canals were dried, and the specified sealer (ADSEAL or CeraSeal) was applied according to the related subgroups. A modified single cone technique were used for obturation.

Gamma radiation was applied to the extracted teeth samples of groups 2, 4, and 6. Groups. While groups (1, 3, and 5) were not subjected to gamma radiation. The irradiation was performed at The National Centre for Radiation Research and Technology (NCRRT), Cairo, Egypt, using a Cobalt 60 Indian Gamma Cell with a dose rate of 0.709 KGy/h. The teeth were positioned vertically and perpendicular to the cobalt source. The radiotherapy machine setup followed the IMRT protocol under the supervision of a radiotherapist. [13] Following the irradiation, all teeth specimens were mounted in acrylic blocks before undergoing fracture resistance testing. The roots were fixed inside the acrylic blocks, which were then mounted on the lower fixed compartment of a Materials Testing Machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a 5 kN load cell. The roots were securely fastened using tightening screws (figure 1). Fracture resistance testing was conducted by applying a slowly increasing vertical load (0.5 mm/min) until fracture occurred. The failure load was recorded in Newtons when a perceptible crack appeared and was verified by a sharp drop in the load-deflection curve recorded by the computer software (Bluehill Lite Software, Instron). [14]

Statistical analysis was performed using SPSS 16®, GraphPad Prism, and Microsoft Excel. The data were presented as mean ± standard deviation and analyzed using Shapiro-Wilk and Kolmogorov-Smirnov tests to assess normality. Independent t-tests were used for comparisons between two groups, while one-way ANOVA followed by Tukey's post hoc test was used for multiple comparisons between more than two groups at $p < 0.05$.

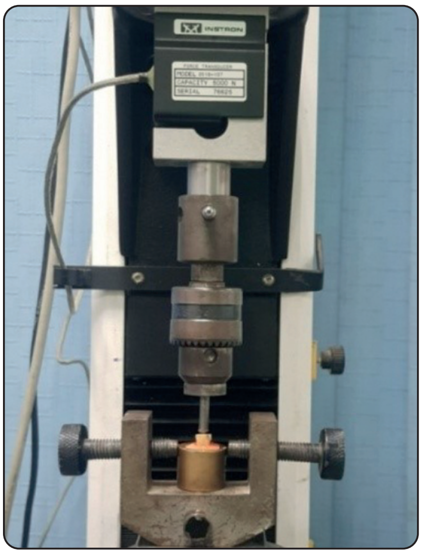

Fig. (1) A sample of a teeth specimen during the fracture resistance test using an Instron Testing Machine

RESULTS

Table 1 summarizes the results of the present study. The comparison between the groups before and after radiation are presented in Figure 2 and 3. The results showed that gamma radiation reduced the fracture resistance of all specimens (P < 0.0001). The highest mean value of fracture resistance belongs to G5 (Teeth with obturation using ADSEAL and no gamma irradiation) while the lowest value was for G2 (Teeth subjected to gamma irradiation without obturation) (P < 0.0001).

Teeth obturated with ADSEAL showed higher fracture resistance than those obturated with CeraSeal (P < 0.0001).

The effect of radiation on the teeth obturated using ADSEAL and CeraSeal was statistically significant however, this effect on obturated teeth using CeraSeal was more pronounced. However, the mean value of fracture resistance of teeth obturated with ADSEAL, before radiation, was higher than of teeth obturated using CeraSeal, before radiation, but this difference was statically insignificant (P > 0.005). The mean difference and percentage difference are presented in Table 2.

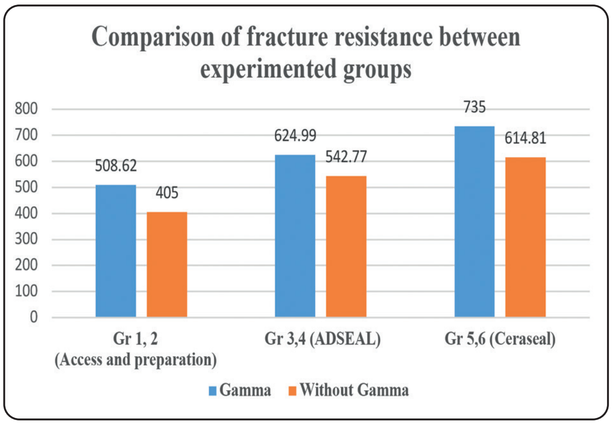

Fig. (2) Bar charts comparing the fracture resistance between Group 1 (Access and preparation), Group 3 (ADSEAL), and Group 5 (CeraSeal) before irradiation.

TABLE (1) Fracture resistance in Newton (N) of control and experimental sealer groups before and after irradiation (presented as Mean and Standard Deviation)

	Without Gamma		**Gamma**		**Difference**				
					MD	SD	95% CI		P value (Independent t test)
	M	SD	M	SD			L	U	
Gr 1, 2 (Access and preparation)	508.62 b	25.43	405.00 b	20.25	103.6	7.26	-118.3	-88.9	<0.0001*
Gr 3,4 (ADSEAL)	624.99 c	31.25	542.77 c	27.14	82.22	9.22	-101.1	-63.48	<0.0001*
Gr 5,6 (Ceraseal)	735.00 d	36.75	614.81 d	30.74	120.2	10.71	-141.9	-98.5	<0.0001*
P value (One Way ANOVA test)	<0.0001*		<0.0001*						

M: mean SD: standard deviation MD: mean difference

CI: confidence interval *Significant difference as P<0.05.

Means with different superscript letters in the same column were significantly different as P<0.05.

Means with the same superscript letters in the same column were insignificantly different as P>0.05.

TABLE (2) Comparison of Fracture Resistance between CeraSeal and ADSEAL before and After Irradiation

Sealer	M Before Irradiation	M After Irradiation	MD	SD	% D	P-value
ADSEAL	624.99	542.765	82.225	43.20	13.16%	<0.0001*
CeraSeal	735	614.805	120.195	7.35	16.35%	<0.0001*

M: mean SD: standard deviation MD: mean difference % D: Percentage difference

**Significant difference as P<0.0001.*

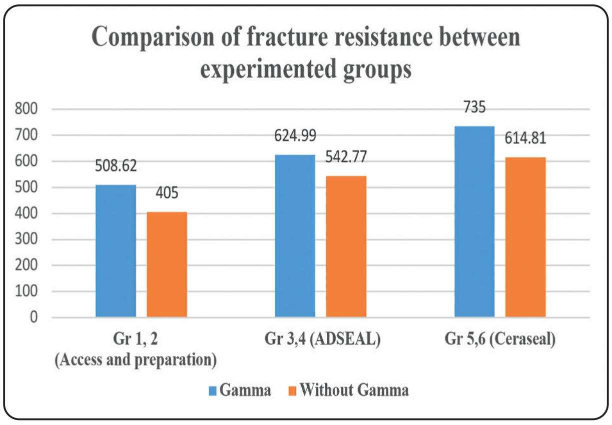

Fig. (3) Bar chart illustrating the reduction in teeth strength after irradiation for the Control group, ADSEAL group, and Ceraseal group

DISCUSSION

The aim of this study was to investigate the effect of therapeutic gamma irradiation on the fracture resistance of endodontically treated teeth obturated with ADSEAL and CeraSeal sealers. The results revealed significant changes in fracture resistance after irradiation, with CeraSeal-obturated teeth exhibiting superior resistance compared to ADSEAL.

Radiation therapy is an essential treatment modality for cancer patients, but it can have detrimental effects on dental structures, leading to potential complications in endodontic treatment. The literature has shown that irradiation can affect the mechanical, biological properties of teeth.(15,16) Therefore, it is crucial to explore the potential of modern obturation materials, such as ADSEAL and CeraSeal, to withstand the impact of radiation and maintain tooth integrity.In recent times, there has been increased attention towards reinforcing endodontically treated teeth using dentin bonding or Bioceramics. These approaches have gained prominence due to modern endodontic obturation concepts that rely on sealers in combination with gutta-percha using a single cone technique. (17) Such methods hold promise in strengthening treated teeth, but their potential to counteract the detrimental effects of radiation on tooth survival remains uncertain. The existing literature in this area is limited and inconclusive, necessitating further investigation to better comprehend the efficacy and impact of these strategies in mitigating the adverse consequences of radiation on endodontically treated teeth.

The results of the current study demonstrated a significant reduction in fracture resistance in all groups after irradiation, indicating that gamma radiation negatively affects tooth strength. The irradiated groups exhibited the most pronounced reduction, highlighting the deleterious effects of irradiation on teeth, both with and without obturation. This reduction in fracture resistance may be attributed to gamma radiation inducing structural and chemical changes in dentin components, such as denaturation, mineral loss, and alterations in the organic matrix, leading to a more brittle dentin. Additionally, gamma radiation can cause dehydration of dental tissues, which further reduces flexibility and resilience, making the tooth more susceptible to fracture. (3)

The results of the current study showed that teeth obturated with ADSEAL and CeraSeal exhibited enhanced fracture resistance, with CeraSeal-obturated teeth showing significantly higher resistance compared to ADSEAL.The improved fracture resistance of CeraSeal can be attributed to its unique properties as a bioceramic sealer. Bioceramics have been shown to adhere to both organic and inorganic components of dentin, providing added structural support. Besides, it shows deeper penetration ability inside dentinal tubules with superior marginal adaptation as compared to resin sealer. [18] These exceptional properties of CeraSeal likely play a crucial role in maintaining its fracture resistance even in the presence of irradiation-induced changes in the organic dentin components. Additionally, the reported shrinkage of resin-based sealers like ADSEAL upon setting may affect their adhesive properties, potentially contributing to a lower fracture resistance compared to CeraSeal. This finding aligns with previous research which highlights the potential of these sealers to enhance tooth strength. [19] On the other hand, a study conducted by **Ismail, et al** [20] has shown contradictory findings. However, this contradictory may be due the sample of that study were dog's incisors teeth which may have different compositing and properties than human premolars.

Following irradiation, a reduction in fracture strength was observed in all tested teeth groups, regardless of the obturation condition. Both the control teeth and the ADSEAL group exhibited statistically significant reductions in fracture resistance. Although, the reduction in fracture resistance after irradiation for teeth obturated with CeraSeal was statistically significant, the mean value of their fracture resistance (614.8 N) was near the mean value of ADSEAL (624.9 N) before irradiation. After radiation, it was found that the mean value of fracture resistance of teeth obturated using ADSEAL (542.7 N) was less than the mean value of fracture resistance of teeth obturated using CeraSeal (614.8 N) This observation suggests that the adhesive properties of bioceramic sealers, which adhere to both organic and inorganic components of dentin, may contribute to maintaining tooth strength even in the presence of irradiation. [21, 22]

It is worth mentioning that the reduction percentage of fracture resistance of CeraSeal-obturated teeth was higher than ADSEAL-obturated teeth (Table 2). This finding represents a challenge to explain. However, the chemical bond of CeraSeal may be more affected by radiation than the mechanical interlock of resin based sealer such as ADSEAL. [23] Hence, further research involving more tests like marginal adaptation are needed to reveal the behavior of these sealers under radiation.

CONCLUSIONS

The study concludes that Gamma irradiation reduce the fracture resistance of endodonticaly treated teeth significantly regardless of the sealer used . However, bioceramic sealers provide better resistance to the adverse effects of irradiation. Further clinical studies are needed to validate these findings and optimize management for patients receiving radiation therapy.

REFERENCES

1. Alfouzan AF. Radiation therapy in head and neck cancer. Saudi Med J. 2021 Mar;42(3):247-254.
2. Hideaki W, Kobayashi-Velasco S, Gialain IO, Caldeira CL, Cavalcanti MGP. Endodontic treatment in patients previously subjected to head and neck radiotherapy : a literature review. J Oral Diagnosis. 2019;4:1–6.
3. Soares CJ, Castro CG, Neiva NA, Soares P V., Santos-Filho PCF, Naves LZ, et al. Effect of gamma irradiation on ultimate tensile strength of enamel and dentin. J Dent Res. 2010;89(2):159–64.
4. Hommez GM, De Meerleer GO, De Neve WJ, De Moor RJ. Effect of radiation dose on the prevalence of apical periodontitis--a dosimetric analysis. Clin Oral Investig. 2012 Dec;16(6):1543-7.
5. Devi S, Singh N. Dental care during and after radiotherapy in head and neck cancer. Natl J Maxillofac Surg. 2014;5(2):117.

6. Patel, S., and J. J. Barnes. Contemporary endodontics–part 2." British Dental Journal 211.11 (2011): 517-524.

7. Subbiya A, Kumar EP, Anuradha B, Mitthra S. Properties and clinical application of resin based sealers: A review. Eur J Mol Clin Med . 2020;7(5):1287–92.

8. Ricardo S, Marissa C, Usman M, Suprastiwi E, Yusuf RM, Meidyawati R. Comparison of three bioceramic sealers in terms of dentinal sealing ability in the root canal. Int J Appl Pharm. 2020;12(Special Issue 2):4–7.

9. Teja KV, Ramesh S. An update on bioceramic sealers. Drug Invent Today. 2020;14(3):17–20.

10. American Academy of Endodontics (AAE). Art and Science of New Materials in Endodontics. 2017;1.

11. Johnsen GF, Sunde PT, Haugen HJ. Validation of contralateral premolars as the substrate for endodontic comparison studies. Int Endod J. 2018 Aug;51(8):942-951.

12. Campbell F, Cunliffe J, Darcey J. Current technology in endodontic instrumentation: advances in metallurgy and manufacture. Br Dent J. 2021;231(1):49–57.

13. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin. 2021;71(3):209–49.

14. Sedgley CM, Messer HH. Are endodontically treated teeth more brittle? J Endod. 1992 Jul;18(7):332-5.

15. Munoz, Miguel Angel, et al. The adverse effects of radiotherapy on the structure of dental hard tissues and longevity of dental restoration." International journal of radiation biology 96.7 (2020): 910-918.

16. Velo, Marilia Mattar de Amoêdo Campos, et al. Radiotherapy alters the composition, structural and mechanical properties of root dentin in vitro." Clinical oral investigations 22 (2018): 2871-2878

17. Lee M, Winkler J, Hartwell G, Stewart J, Caine R. Current trends in endodontic practice: emergency treatments and technological armamentarium. J Endod 2009;35(1):35-39.

18. Najafzadeh R, Fazlyab M, Esnaashari E. Comparison of bioceramic and epoxy resin sealers in terms of marginal adaptation and tubular penetration depth with different obturation techniques in premolar teeth : A scanning electron microscope and confocal laser scanning microscopy study. 2022;1794–7.

19. Porter, Micah L., et al. Physical and chemical properties of new-generation endodontic materials." Journal of endodontics 36.3 (2010): 524-528.

20. Ismail S, Fayad D, Mohamed D, Eldaharawy M. Effect Of Two Calcium-Silicate and One Resin Sealers On The Fracture Resistance Of Root Dentin Using Different Treatments In Dog's Teeth (An In Vivo Study). Dent Sci Updat. 2023;4(1):25–33.

21. Al-Haddad, Afaf, and Zeti A. Che Ab Aziz. Bioceramic-based root canal sealers: a review." International journal of biomaterials 2016

22. Komabayashi, Takashi, et al. Comprehensive review of current endodontic sealers." Dental 1. Alfouzan AF. Radiation therapy in head and neck cancer. Saudi Med J. 2021 Mar;42(3):247-254.

23. Kim, Young Kyung, et al. "Critical review on methacrylate resin–based root canal sealers." Journal of endodontics 36.3 (2010): 383-399.