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# Original Research Article Effect of Radiotherapy on Flexural Strength of Luting Cementsan In Vitro Study

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***Abstract***

*Aim - The aim of this study was to evaluate changes in the flexural strength of luting cements due to radiotherapy. Methodology- Total of 90 rectangular specimens of 25×2×2 mm dimension were fabricated by utilizing the putty consistency polyvinyl siloxane rubber mould. They were grouped based on their type. Group A included 30 specimens made of zinc phosphate cement, Group B included 30 specimens fabricated using glass ionomer luting cement, and Group C consisted of 30 specimen's fabricated using resin luting cement. Once the specimens were set, they were stored in distilled water between the experiments. After 24 hours, 15 from each group of the mentioned cements were subjected to irradiation fractionally upto 60 Gy by a Cobalt-60 external beam machine. Remaining specimens from each group were used as controls. After radiotherapy, the specimens were stored in distil water for 24 hours until performing the 3 point bend test. All the specimens were subjected to 3 point bend test on universal testing machine for checking flexural strength. Statistics- Kruskal Wallis Test followed by Mann Whitney test as post hoc analysis was used to compare the mean values of different parameters between three groups of Irradiated and controlled samples. The level of significance was set at P<0.05. Results- After exposure to fractional irradiation for 4 weeks, in the zinc phosphate luting cement (Group-A) and glass ionomer luting cement (Group-B), showed a slight decrease in flexural strength. The resin luting cement (Group-C) showed slight increase in flexural strength. Conclusion- Among all the groups, the resin luting cement showed a slight increase in flexural strength when compared to the other luting cement groups after fractional irradiation.*

**Keywords:** *Luting Cements, Flexural Strength, Head And Neck Cancer, Fractional Irradiation*

## 1. Introduction

Ideal dental luting cement should create a durable bond between dissimilar materials, exhibit favourable compressive and tensile strengths, and possess adequate fracture toughness to prevent dislodgment due to cohesive or adhesive failures. This process is crucial for establishing a stable connection between the prosthesis and the tooth. Various types of luting cements are employed in the cementation of various prosthetic devices to teeth.1 They should effectively wet both the tooth and the restoration, maintain an appropriate film thickness and viscosity to ensure complete seating, resist disintegration in the oral environment, be compatible with oral tissues, and demonstrate suitable working and setting times.2 The factors affecting the mechanical properties such as flexural strength and modulus of elasticity plays a significant role in determining the longevity of the prosthesis. An annual report has documented over 550,000 cases of head and neck cancer worldwide3 making it the sixth most prevalent cancer site with a five-year survival rate of 50%.4 Treatment typically involves a combination of surgery and radiotherapy, which can lead to various side effects such as oral mucositis, xerostomia, irradiation caries, blood vessel and soft tissue fibrosis, and impaired bone healing. Research has shown that radiotherapy can cause physical and chemical changes in enamel as a direct consequence of the treatment. Some studies have explored the efficacy of restoring irradiated dentin, particularly after high-dose irradiation. There have been many other studies done in the field of dental material sciences 5,6,7,8,9 which has shown changes properties of the long term restorations. But there is no scientific evidence to prove the effect of fractional irradiation on the flexural strength of luting cements. Understanding this aspect of material sciences, would help us in deciding the type of luting cement to be selected for luting fixed prosthesis in patients undergoing radiotherapy. Hence the present study was conducted to evaluate the changes in the flexural strength of luting cements due to radiotherapy with the null hypothesis stating fractional irradiation does not affect the flexural strength of the following luting cements. And alternative hypothesis stating difference in flexural strength values of the following luting cements subjecting them to fractional irradiation.

## 2. Materials And Methods

As it is an in-vitro study, ethical committee clearance wasn't obtained. A total of 90 test samples were fabricated with dimensions of 25mm length, 2mm width and 2mm thickness as per International Standardization Organization (ISO) by utilizing the putty consistency polyvinyl siloxane rubber mould (putty impression material, Aquasil, Densply)5. These specimens were fabricated and grouped based on the materials used as (Table No. 1, Fig 1,2,3,4).

**Table 1:** Types of luting cements used in the study

| Groups | Type of Cement | Brand Name | P/L Ratio | Batch No | Manufacturer | Sample Size |
|---|---|---|---|---|---|---|
| A | Zinc Phosphate | Harvard | 3:1 | 1111504 | Harvard Luting Cement, America | 30 |
| B | Glass Ionomer Cement | G C Gold Label | 3:1 | 1703151 | GC Gold Label Luting and Lining, America | 30 |
| C | Resin Cement | Calibra | 2.25:1 | 160723 | Dentsply, Germany | 30 |

As per the previous study conducted on assessment of fractional irradiation modulus of elasticity on luting cements[5], the three grouped luting cements (Fig 1) were mixed according to manufacturer's instructions. These were allowed to set in rubber mould covered with a cellophane sheet between two glass microscope slides at room temperature. Once the specimens were set, they were maintained in distilled water between the experiments. After 24 hours, 15 from each group of the mentioned cements were subjected to irradiation fractionally upto 60 Gy by a Cobalt-60 external beam machine (Theratron – E1, Fig 5) with field size of 35 X 35 cm$^2$, depth was kept to the tray level, source to tray distance was maintained with 56 cm, with output factor of 1.051, Average energy output of the machine- 1.25 Mev and with a total of four doses (15 Gy/day) at different time intervals based on the value of output. (Table no. 2). Other remaining rectangular specimens were used as control and stored in distilled water (Mysore RES-CHEM laboratories) until the tests were performed.

**Table 2:** Total irradiation exposure time for the specimens

| Weeks | Treatment time | Fractional Dose (Total dose- 60 Gy) |
|---|---|---|
| 1$^{st}$ week | 4 min 53 sec | 15 Gy |
| 2$^{nd}$ week | 4 min 54.6 sec | 15 Gy |
| 3$^{rd}$ week | 4 min 55.2 sec | 15 Gy |
| 4$^{th}$ week | 4 min 58.2 sec | 15 Gy |

After radiotherapy, the specimens were stored in distil water for 24 hours until performing the 3 point bend test. All the 90 rectangular test specimens including control were subjected to 3 point bend test on universal testing machine (Mecmesin) for checking flexural strength by applying the formula.

$$F = 3P_f L/2WH^2$$

Where $P_f$ is the measured maximum load at the time of specimen fracture, $L$ is the distance between the supports on the tension surface (20 mm), $W$ is the mean specimen width, $H$ is the mean height of the specimen between the tension and compression surfaces. The obtained results were subjected to the statistical analysis.

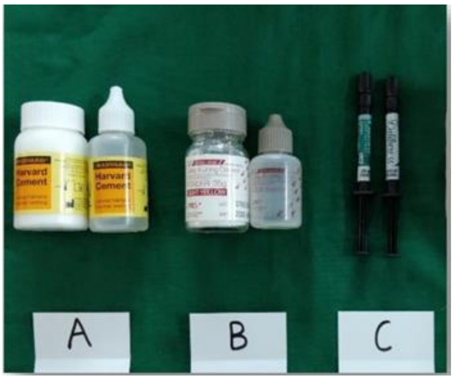



**Fig 1:** Group A,B,C luting cements.

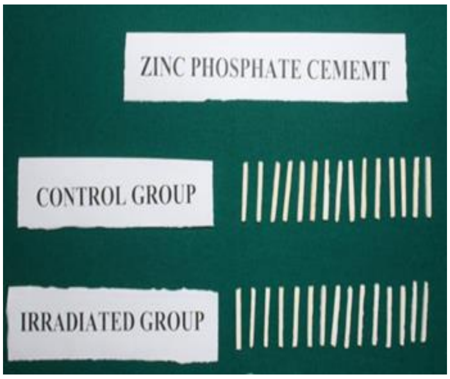



**Fig 2:** Group A Rectangular specimens of zinc phosphate luting cement


**Fig 3:** Group B Rectangular specimens of Glass

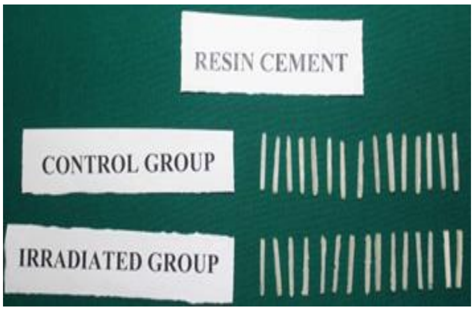



Fig 4: Group C – Rectangular specimens of Resin luting cement

**Fig 5:** 60 Gy by a Cobalt-60 external beam machine (Theratron – E1)

**3. Results and Discussion**

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., was used to perform statistical analyses.

**Descriptiv Statistics**

Descriptive analysis included expression of study parameters in terms of Mean and SD.

**Inferential Statistics**

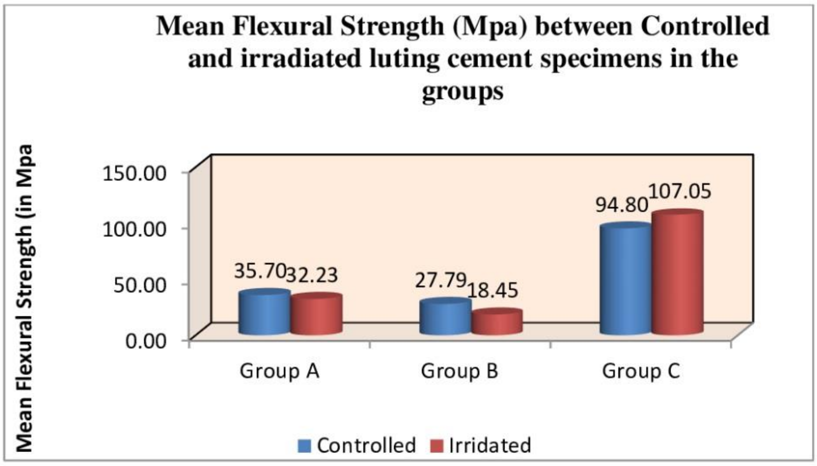
Kruskal Wallis Test followed by Mann Whitney test as post hoc analysis was used to compare the mean values of different parameters between three groups of Irradiated and controlled samples. Mann Whitney U Test was used to compare the mean values of different parameters between Irradiated and Controlled samples with respect to different cement groups. *The level of significance was set at P<0.05.

**Table 3:** Mean, Standard Deviation, P-values of Flexural Strength (MPa) between Irradiated and Controlled specimens in the Group- A, B, C using Mann Whitney U Test

| Parameters | Samples | N | Mean | SD | Mean Diff | P-Value |
|---|---|---|---|---|---|---|
| Group-A | Controlled | 15 | 35.70 | 4.63 | -3.48 | 0.09 |
| | Irradiated | 15 | 32.23 | 5.17 | | |
| Group-B | Controlled | 15 | 27.79 | 8.36 | -9.34 | 0.002* |
| | Irradiated | 15 | 18.45 | 6.94 | | |
| Group-C | Controlled | 15 | 94.80 | 28.39 | 12.25 | 0.21 |
| | Irradiated | 15 | 107.05 | 23.58 | | |

**Table4:** Mean, Standard Deviation, Minimum, Maximum, P-values of Flexural Strength (MPa) between Group- A, B, C including Control & Irradiated specimens using Kruskal Wallis Test followed by Mann Whitney Post hoc Analysis

| Parameters | Groups | N | Mean | SD | Min | Max | P-Value | Sig. Diff | P-Value |
|---|---|---|---|---|---|---|---|---|---|
| Flexural Strength (MPa) Controlled specimen | A | 15 | 35.70 | 4.63 | 25.1 | 42.5 | <0.001* | A Vs B | 0.01* |
| | B | 15 | 27.79 | 8.36 | 15.0 | 42.0 | | A Vs C | <0.001* |
| | C | 15 | 94.80 | 28.39 | 50.3 | 140.9 | | B Vs C | <0.001* |
| Flexural Strength (MPa) Irradiated specimen | A | 15 | 32.23 | 5.17 | 23.8 | 40.6 | <0.001* | A Vs B | <0.001* |
| | B | 15 | 18.45 | 6.94 | 9.4 | 33.8 | | A Vs C | <0.001* |
| | C | 15 | 107.05 | 23.58 | 69.3 | 139.0 | | B Vs C | <0.001* |




**GRAPH 1:** The mean flexural strength (MPa) of controlled and irradiated luting cements specimens in Group- A, B, C

It is proven in the literature that one of the important factors for the long term prognosis of fixed prosthesis is the luting cement of choice. It needs to have favourable mechanical and physical properties to prevent dislodgment as a result of interfacial or cohesive failures and be resistant to disintegration in the oral cavity.[1,2,4,6,10,11] Among these, flexural strength helps in assessing the amount of stress particular cement can take before it yield in a flexure test. This is one of the important factors in assessing the longitivity of the prosthesis. If the clinical situation is altered like, people undergoing radiotherapy then choice of luting cement for a fixed partial denture is questionable. Studies have proved that the properties have shown significant changes in the restorative materials due to irradiation and significantly affecting the stability and longevity of restorations.[5,6,7,8,9,15,16,17,18,19] Zinc phosphate (ZnPO4), glass ionomer (GIC) and resin luting cements are one of the most common luting cements used for long term cementation of the fixed prosthesis. Hence they were assessed in the present study and after the results obtained the null hypothesis was rejected.

As per the previous study done,[5] rectangular bar-shaped luting cement specimens (45 control and 45 irradiated) were fabricated as per ISO standardisation-4049 and were subjected to 3 point bend test to check for flexural strength (fig.2).They were divided equally into 3 groups: Group-A (ZnPO4), Group-B (GIC), Group-C (Resin). The specimens were subjected to fractional irradiation of 60 Gy by total of four doses (15 Gy/day)[12] (Fig.1). Distilled water was used as a media to store the control and the irradiated specimens in between the fractional dose exposure, so that it reproduces the condition of moisture present in the oral cavity.[13] This would further help in providing the reliability of the results.

In Group-A: $ZnP0_4$ luting cement, the mean flexural strength value of the controlled specimens after 4 weeks of storage in distilled water was 35.70 MPa and for irradiated specimens were reduced to 32.23 MPa, but was statistically insignificant (P=0.09) as per Mann Whitney U test(Table-3). These values are higher than the ideal flexural strength (according to ADA specification No. 96) for zinc phosphate luting cement which is in the range of 5.5 to 9.5 MPa and even according to Diaz-Arnold A M et al[14], the flexural strength of zinc phosphate luting cement is in the range of 5-7 MPa. These variations could be due to the methodology, where the ideal values are obtained after immersion in distilled water for 24 hours as per ADA specification No. 96.

In Group-B: GIC luting cement, the mean flexural strength of the controlled specimens after 4 weeks of storage in distilled water was 27.79MPa. The mean flexural strength of irradiated specimens was 18.45MPa. There was a decrease in flexural strength (P=0.002)after radiotherapy which was found to be statistically significant as per Mann Whitney U test (Tables-3).This can be validated by the study conducted by Cheung et al.[24] where he said that radiation may break the chemical bonds in the glass ionomer matrix causing weakening of the material. These gamma irradiation may affect the setting of glass ionomer matrix, thus disrupt the chemical exchange lasting for weeks (long-term interaction) or bonding between the leached ions from the matrix and the calcium, phosphate ions in dentin. Another study done by Novias V R et al.[13] showed similar results where there was significant reduction in diametral tensile strength and increase in hardness values for restorative GIC due to gamma irradiation. The author also quoted that glass ionomer, irrespective of the composition, was the material that developed more alterations in mechanical properties after irradiation. The study conducted by Yesilyurt C et al.,[23] has stated that irradiation seems to interfere with the chemical adhesion of restorative GIC to dentin which could also result decrease in flexural strength.

Contrary to the present study results, Brandeburski SBN et al.[17] observed increase in mean flexural strength and dimetral tensile strength values for glass ionomer cements after irradiation. These results may be partially explained by the additional polymerization resulting from the irradiation. Cruz A et al,[16] has quoted that ionizing radiation promote molecular excitation that can improve linking among chains after light activation. This may explain the significant increase in strength of GIC cement.

In Group-C: Resin luting cement, the mean value of flexural strength of controlled specimens was 94.80 MPa and for irradiated resin specimens it was increased to 107.05 MPa (table-3). There was no significant difference (P=0.21) observed between the flexural strength values of controlled and irradiated specimens as per Mann Whitney U test. This could be explained by the study done by Hegde et al.[18] ᵗhat the high degree of polymerisation is due to the high dose of radiation which causes alteration in chemical bonds in the resin matrix. This gamma radiation is known to build up components of polymer and also undergo cross linkage of chains during chemical reaction. This leads to increase in micro-hardness of the composite material. This might be the reason for a slight increase in flexural strength of the resin luting cement specimens in our study. It was explained that electron beam radiation has high dose rate and has low penetrating power compared to any other ionising radiations. It mainly targets the superficial layer and the strength increases as the energy increases by dosage rate. This results in an increase in the micro-hardness of composite specimens leading to slight decrease in solubility rate.

The flexural strength (MPa) among the groups-A, B, C of controlled specimens were found to be statistically significant (P=0.001) as per Kruskal Wallis test (table-4,Fig 6). In irradiated specimens among the groups, the flexural strength showed statistically significant difference (P=0.001). When Mann Whitney Post hoc Analysis was applied between the groups, it was found to be statistically significant (P=0.001) for all groups except when compared with ZnPO4 to GIC in controlled specimens with significance levels at P=0.01. Among all irradiated groups, the flexural strength of resin luting cement was better followed by ZnPO4 and GIC.

The obtained results of this study are based on in-vitro without mimicking the in oral cavity like: saliva, pH, temperature, etc. And further in-vivo and in-vitro studies are needed to study the properties of luting cements after radiotherapy.

## 4. Conclusion

Within the limitations of the study, the following conclusions were drawn: After exposure to fractional irradiation for 4 weeks, in the zinc phosphate luting cement (Group-A) and glass ionomer luting cement (Group-B), showed a slight decrease in flexural strength. The resin luting cement (Group-C) showed slight increase in flexural strength. Among all the groups, the resin luting cement (Group-C), showed a slight increase in flexural strength when compared to zinc phosphate (Group-A) and glass ionomer (Group-B) luting cement groups after fractional irradiation. In this study, the resin luting cement showed slight increase in flexural strength after irradiation. Hence resin cements can be used for luting prosthesis among patients planning to undergo head and neck radiation.

### Limitations of The Study

It's an in-vitro study, hence the changes that takes place in oral cavity like: saliva, pH, temperature, etc. were not simulated

### References:


1) Beumer J, Curtis T,Harrison R E. (1979). Radiation therapy of the oral cavity: sequelae and management, Part 2. Head & Neck Surgery. ;1(5):392-408.
2) Iwaku M, Takatsu T, Fusayama T. (1980) Comparison of three luting agents. J Prosthet Dent. 43(4):423-5.
3) Pioch T, Golfels D, Staehle HJ. (1992). An experimental study of the stability of irradiated teeth in the region of the dentinoenamel junction. Endod Dent Traumatol. 8(6):241-4.
4) White SN, Yub Z. (1993). Compressive and diametral tensile strengths of current adhesive luting agents. J Prosthet D. 69(6):568-72.
5) Pandya PA, Rajeswari CL, Pasha T, Rohit S, Srivatsa G, Zeel M, Effect of radiotherapy on modulus of elasticity of luting cements – an in vitro study. Journal of pharmaceutical Negative Results. June 2022;13(6);4382-90
6) Kielbassa AM, Beetz I, Schendera A, Hellwig E. (1997). Irradiation effects on microhardness of fluoridated and non-fluoridated bovine dentin. Eur J Oral Sci; 105(5 Pt 1):444-7.
7) Yap A U J. (1997). Post-irradiation hardness of resin-modified glass ionomer cements and a polyacid-modified composite resin. JOURNAL OF MATERIALS SCIENCE: MATERIALS IN MEDICINE. 8(7):413-6.
8) Kielbassa AM. (2000). In situ induced demineralization in irradiated and non-irradiated human dentin. Eur J Oral Sci. 108(3):214-21.
9) Kielbassa AM,Schendera A, Schulte-Mönting J. (2000) Microradiographic and Microscopic Studies on in situ Induced Initial Caries in Irradiated and Nonirradiated Dental Enamel. Caries Res; 34(1):41-7.
10) Li ZC, White SN. (1999) Mechanical properties of dental luting cements. J Prosthet Dent; 81(5):597-609.
11) Hu JY et al. (2002) Restoration of teeth with more viscous glass ionomer cements following radiation-induced caries. International Dental Journal; 52(6):445-8.
12) Kielbassa A M, Wrbas K-Th, Schilte-Monting J, Hellwig E. (1999) Correlation of transversal microradiography and microhardness on in situ-induced demineralization in irradiated and nonirradiated human dental enamel. Archieves of Oral Biology 44(3):243-51.
13) Novais V R, Simamoto Jr P C., Rodrigues R B, Roscoe M G, Valdivia A D C M, Soares C J. (2015). Effect of irradiation on the mechanical behavior of restorative materials, Rev Odontol Bras Central. 24(68); 44-8.
14) Diaz-Arnold AM, Vargas MA, Haselton DR. Current status of luting agents for fixed prosthodontics. J Prosthet Dent 1999;81:135-41
15) Shillingburg H T et al : Fundamentals of fixed prosthodontics, ed 3, Chicago , Quintessence Publishing, Chapt 22, Pg 402, Table 22-2.
16) Cruz A, Sinhoreti M, Ambrosano G, Rastelli A, Bagnato V,Bóscolo F. (2008) Effect of therapeutic dose X rays on mechanical and chemical properties of esthetic dental materials. MaterRes. 11:313–8.
17) Brandeburski SBN, Della Bona A. Effect of ionizing radiation on properties of restorative materials. Dent Mater (2017)

18) Hegde M N , Hegde N D , Kumari S N , Sanjeev G, Priya. (2016) Effect of Ionising Radiation on Micro Hardness Property of Restorative Materials. March. NUJH; 34(2):221-227.
19) Yap A U J. (1997) Post-irradiation hardness of resin-modified glass ionomer cements and a polyacid-modified composite resin. JOURNAL OF MATERIALS SCIENCE: MATERIALS IN MEDICINE. 8(7):413-6.
20) Bodrumlu E H, Bodrumlu E, Avşar A, Meydan A D. (2015) Effect of radiotherapy on the sealing ability of temporary filling materials, European Journal of General Dentistry. 4 (1);8-11.
21) Naves LZ, Novais VR, Armstrong SR, Correr-Sobrinho L, Soares CJ. (2012) Effect of gamma radiation on bonding to human enamel and dentin . Support Care Cancer. 20(11):2873-8.
22) Shugaa-Addin B, Al-Shamiri HM, Al-Maweri S, Tarakji B. (2016) Effect of radiotherapy on survival of den¬tal implants in head and neck cancer patients. J Clin Exp Dent. 8(2):e194-200.
23) Yesilyurt C, Bulucu B, Sezen O, Bulut G and Celik D, Bond strengths of two conventional glass-ionomer cements to irradiated and non-irradiated dentin Dental Materials Journal; 2010;27(5): 695－701
24) Cheung DT, Perelman N, Tong D, Nimni ME. The effect of γ-irradiation on collagen molecules, isolated α-chains and cross linked native fibers. J Biomed Mater Res 1990; 24: 581-589.