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Original Article

Comparative study of digital radiopacity of dental cements

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Abstract

Introduction: Radiopacity is a necessary property for luting cements. The aim of this study was to investigate the radiopacity of some luting dental cements used in prosthetic dentistry.

Methods: Five disclike samples of each material (6 x 1mm) were prepared from panavia F2.0 (Pa), Chioce2 (Ch.2), Glass ionomer GC (GI GC), zinc phosphate Hoffmann's (ZP hof), zinc polycarboxylate Hoffmann's (ZPC hof), Glass ionomer ariadent (GI ari), zinc phosphate ariadent(ZP ari) and zinc polycarboxylate ariadent (ZPC ari). The radiopacity of each material along with aluminium step wedge were measured from radiographic images using a digital radiography. The average measured radiopacities from five areas were taken into account, which were measured by Digora for windows (DFW) software using a PSP digital sensor.

Results: There was a significant difference between radiopacity value of all luting materials ($p \leq 0.001$). ZP ari had the highest radiopacity with 7.7±0.55 mm aluminium. The Glass ionomer ariadent ari dent showed the lowest radiopacity value with 0.82±0.31 mm aluminium.

Conclusion: All dental cements showed radiopacity values equivalent to or greater than the ISO 4049:2000(E) standard except ariadent Glass ionomer; and this could be considered suitable for use in restoration cementation.

Keywords: Radiopacity, Digital radiography, Dental material

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Radiopacity of dental cements

بررسی مقایسه ای رادیوپاسیته ی دیجیتال سمان های دندانی

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چکیده

مقدمه: رادیوپاسیته یک خاصیت ضروری برای سمانهای دندانپزشکی می باشد. هدف این مطالعه بررسی رادیوپاسیته تعدادی از سمانهای مورد استفاده در پروتزهای دندانی می باشد

موادوروش ها: تعداد پنج نمونه دایره ای شکل به قطر ۶ میلی متر و ضخامت ۱ میلی متر از نمونه سمانهای Panavia F2.0 ،Choice2، گلاسیونومر GC، زینک فسفات Hoffmann's، زینک پلی کربوکسیلات Hoffmann's، گلاسیونومرآریادنت، زینک فسفات آریادنت و زینک پلی کربوکسیلات آریادنت تهیه شد. رادیواپاسیته هرکدام ازنمونه ها به همراه Stepwedge آلومینیوم ی به وسیله ی رادیوگرافی دیجیتالتی اندازه گیری شد. میانگین رادیوپاسیته اندازه گیری شده در ۵ ناحیه منظور شد که بوسیله نرم افزار DFW و گیرنده PSP محاسبه شد.

یافته ها: بین مقادیر میانگین رادیوپاسیته سمانهای مورد مطالعه اختلاف معنی داری بدست آمد ($p\leq0.001$)بیشترین مقدار رادیوپاسیته مربوط به زینک فسفات آریادنت با میانگین و انحراف معیار ۷/۷±۰/۵۵ میلی متر آلومینیوم بدست آمد. همچنین کمترین مقدار میانگین رادیوپاسیته مربوط به سمان گلاس آریادنت با میانگین ۰/۸۲±۰/۳۱ میلی متر آلومینیوم بدست آمد.

نتیجه گیری: تمام سمانهای مورد مطالعه به جز سمان گلاسیونومر آریادنت مقدار رادیوپاسیته برابر یا بیشتر از استاندارد ISO 4049:2000(E) را از خود نشان دادند و می توان به عنوان سمان قابل قبول در سمان کردن رستوریشنها از آنها استفاده نمود.

واژگان کلیدی: رادیوپاسیته، رادیوگرافی دیجیتال، مواد دندانی

Introduction

Dental luting materials are used for cementing restorations and fixed partial dentures to abutment and cavity preparation. Radiopacity is one of the main necessities of cements. The advantages of radiopaque over radiolucent materials are easy detection of recurrent dental caries as well as observation of the radiographic interface between the materials and tooth substrates (1).

It is generally accepted that materials should be sufficiently radiopaque to be detected against a background of enamel and dentin, facilitating the evaluation of restorations in every region of the mouth and enabling the detection of secondary caries, marginal defects, contour of restoration, contact with adjacent teeth, cement overhangs, and interfacial gaps (2). el-Mowafy and et al. concluded that materials with equal radiopacity or more radiopaque than enamel are appropriate for cementing inlay (3).

Also ISO 4049: 2000(E) standard expresses that the radiopacity of luting materials should be equal or more than radiopacity of aluminum in same thickness (4). Material compound and thickness, setup parameters (e.g., object-to-source distance, exposure time), curing time, X-ray radiation angle, method employed for evaluation, film type, time of using developing and fixing solutions and also powder and cement liquid ratio can affect the radiopacity of dental materials.

Common methods for the evaluation of density of radiographic images employ conventional X-ray films and densitometers or spectrophotometers (2, 5-7). Since 1987, alternatives to silver-halide receptors for intraoral radiographic imaging have included Charge Coupled Device (CCD)–based systems and Photo Stimulable Phosphor plates (PSP).

Digital intraoral radiography reduces patients' exposure to X-rays, permits the improvement of image quality by image manipulation, is faster, easy to use, and cheaper than conventional techniques, and also enables the attainment of an accurate evaluation of radiodensity. Also, in digital radiography it is possible to evaluate materials radio density accurately (5, 8).

Based on literatures, it is necessary to evaluate cements radiopacity due to the secondary caries or gaps that might happen and may place exactly under materials upon dental structure and are related to the dental structure (5).

The number of dental cement is increasing every day and each one of them has a sort of improvement in adhesion properties, nevertheless there is limited information about radiographic properties especially the radiopacity of new cements (1). So this study intends to evaluate the degree of different cements radiopacity by digital radiography to improve the accuracy of diagnosis.

Methods

Panavia F2.0 (Kuraray, Japan), Chioce2 (Bisco, USA), Glass ionomer GC (GC, Japan), zinc phosphate (Hoffmann's, Germany), zinc polycarboxylate (Hoffmann's, Germany), Glass ionomer (Ariadent, Iran), zinc phosphate (Ariadent, Iran) and zinc polycarboxylate (Ariadent, Iran) were used.

From each type of cement 5 samples with 1 mm thickness and 6 mm diameter were prepared by factory producer's instruction. Chemically cure materials passed their setting time at the period of time that factory producer had recommended and get cured. And also light cure cements were exposed by light curing device 800mW/cm^2 for 40 seconds and cured. Also the thicknesses of the samples were checked with the accuracy of 0.01 mm by digital Caliper.

Aluminum step wedge (99% aluminum alloys, Hormozgan's aluminum factory) was used for controlling. The radiographs were taken by phosphor plate (PSP) (Soredex, Tussula, Finland) and an X-ray machine (Minray, Soredex, Tussula, Finland). Also the distance between sensor and X-ray was 30 cm and radiation conditions were 60kVp, 10mA and 0.2 second.

Then the sensors were read by Digora PCT (soredex, Tussula, Finland) and processed by Digora for windows (DFW) 2.5 software and saved in related file. The mean and standard deviation of radiopacity of each group of samples and step wedge were calculated from five different areas of each samples using density measurement option of DFW software , as previously described (6, 7).

The avereage obtained radiopacities were analyzed using SPSS Version 20 software and one way ANOVA and Tukey HSD statistical tests. A two tailed p-value of less than 0.05 was considered statistically significant.

Results

In this recent study, 8 cement samples were evaluated in pentamerous groups. The highest level of radiopacity in groups obtained for Iranian zinc-phosphate (Aria dent) with mean and standard deviation of 7.7±0.55 mm aluminum.

Also, the least level of radiopacity in all groups was related to the Iranian glass ionomer cement (Aria dent) with mean and standard deviation of 0.82±0.31 mm aluminum. Figure 1 shows the radiopacity of the studied cements (i.e., the diversity between mean radiopacity in studied groups was statistically significant. $p<0.001$).

Also in comparison of each group with another group in all studied groups, the mean diversity between Hoffmann's zinc-phosphate and Aria dent groups with other groups was significant ($p<0.001$). Besides, this significant diversity in means of groups was obtained in Hoffmann's zinc-poly carboxylate and Aria dent with other groups ($p<0.001$). Table 1 shows the comparison of each group with another group by multi comparison analyses.

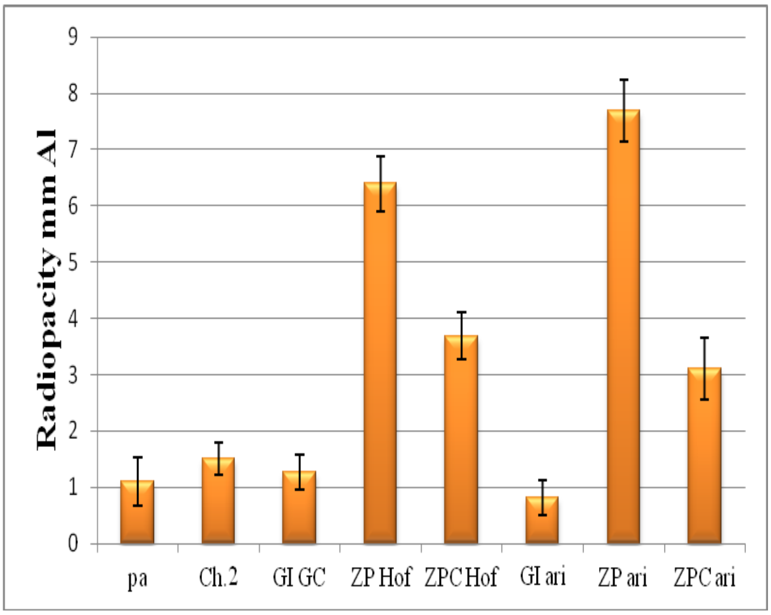

Figure 1. Mean of radiopacity of groups

Table 1. Multi comparison of mean radiopacity of different cements

Cements and significance	**Pa**	**Ch.2**	**GI GC**	**ZP Hof**	**ZPC Hof**	**GI Ari**	**ZP Ari**	**ZPC Ari**
Panavia F2.0	******	p=.02	p=0.9	p<0.001	p<0.001	p=.308	p<0.001	**p<0.001**
Choice2	p=.018	******	p=.41	p<0.001	p<0.001	p<0.001	p<0.001	**p<0.001**
Glass ionomer GC	p=0.9	p=.412	******	p<0.001	p<0.001	p=.010	p<0.001	**p<0.001**
Zinc phosphat Hoffmann’s	p<0.001	p<0.001	p<0.001	******	p<0.001	p<0.001	p<0.001	**p<0.001**
Zinc polycarboxilate hoffmann’s	p<0.001	p<0.001	p<0.001	p=0.02	******	p<0.001	p<0.001	**p<0.001**
Glass ionomer aria	p=.31	p<0.001	p=0.01	p<0.001	p=0.010	******	p<0.001	**p<0.001**
Zinc phosphat aria	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	******	**p=0.000**
Zinc phosphat aria	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	******

(Pa=Panavia F2.0, Ch.2= Choice2, GI GC= Glass inomer GC, ZP Hof= zinc phosphate hoffmann’s, ZPC Hof= Zinc polycarboxylate Hoffmann’s, GI Ari= Glass ionomer Aria dent, ZP Ari= zinc phosphate Aria dent, ZPC Ari= Zinc polycarboxylate Aria dent)

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Discussion

Radiopacity is a necessary property for cements. Ideal cement should have appropriate level of radiopacity as the other physical and chemical properties, because radiographic image should be demonstrated clearly.

Based on ISO 4049: 2000(E), acceptable radiopacity for luting and cement materials should be equal or more than same aluminum thickness (4, 9). The results of this study showed that all of studied groups, except the Iranian glass ionomer cement, had the necessary standards for radiopacity.

Iranian zinc phosphate cement had the highest level of radiopacity and Hoffmann's zinc phosphate cement was the second. Meanwhile, the lowest level of radiopacity belongs to Iranian glass ionomer cement and after that Panavia F2.0. Also, there was a significant difference between the mean values of cements. Based on these results, the hypothesis of study that said "there is no difference between radiopacity of cements" was failed.

It seems that the main reason of difference in cement radiopacity is the diversity of component composition. In this study, zinc phosphate cement had the highest level of radiopacity.In Fonseca's Study, they declared that zinc phosphate had the highest radiopacity (2). Attar and et al. in another study declared that zinc phosphate had the highest level of radiopacity, too (10).

Also, in the study of Pekkan and et al. zinc phosphate cement demonstrated the highest level of radiopacity (11). However, the results of these studies were similar to this recent study. X-ray absorption of the different material has a strong relationship with the elements with atomic numbers (12).

X-ray absorption of elements like barium and silver in per volume unit is 10 times more than elements like carbon and oxygen (13). Therefore, materials of the tooth that have high amount of heavy elements are expected to be radiopaque. There is much zinc in zinc-phosphate cement composition.

Zinc with high atomic number (Atomic number=30) demonstrates higher radiopacity than elements like aluminum and silicon with 13 and 14 atomic number in order (9). The lowest radiopacity in this study belonged to Iranian glass ionomer. In Watts study, glass ionomer demonstrated low level of radiopacity (9). Also, Hara and et al. (14) declared that the usual glass ionomer cement's radiopacity is not enough, and these results affirm the findings of our study. Glass ionomer cement compound contains aluminosilicate glasses and these materials because of low atomic number decrease the radiopacity of cement. Adding chemical elements like zinc, strontium, barium, lanthanum, zirconium, magnesium, yttrium and ytterbium to cements, results in the enhancement in radiopacity properties (14-16).

In resin, the radiopacity of resin cements depends on the kind of polymer matrix, nature of component elements of fillers, size, fillers density and amounts of fillers in matrix (17, 18). Using radiolucent cement can result in wrong diagnosis of overhangs and also no diagnosis of recurrent caries (19).

Using these materials has contra-indication in some situations like difficult convenience in recurrent caries of margins (8). Also, these radiolucent materials should be used carefully in subgingival restorations because of periodontal problems (11, 20). Using materials with high radiopacity can result in some problems, too.

The diagnosis of void and gap in margins may be put in danger when materials with high radiopacity are used and also the diagnosis of recurrent caries can encounter some problems (18). The use of radiopaque resin cement while using radiolucent restorations like ceramic veneer laminate, ceramic inlay, ceramic on lay, fiber post and restorations with subgingival margins is very important too (21-23).

Due to incomplete cleaning of cements in subgingival areas may result in some periodontal problems (24). In fact, when thickness of cement is less than 25-50 nm, after cementing, for easy detection of radiographic images, it is better to use cements with high radiopacity (17, 22). Variation in measured radiopacity of similar materials in different studies depends on some factors consisting of X-ray film speed, time of exposure, voltage and developing and fixing time (25).

In addition to the distance of image from source, intensifying plates and thickness of samples have influence on the radiopacity of materials (20). Aluminum step wedge was selected as a standard for radiopacity measurement, because it permits to comprise samples thickness as aluminum mm special in similar radiographic situations. As a result, the image of aluminum step wedge is read as aluminum mm thickness in radiography. As a result, all the samples were compared in same situations.

Therefore, in recent studies the amount of different material's radiopacity changed to equivalent aluminum mm to be unified comparing to the obtained results with other studies. In this study, PSP digital radiography is used and aluminum step wedge is placed beside the cement samples and radiography performed. In this radiography, the first PSP film sensor is scanned, and then information is transferred to computer. And radiographic density is obtained directly from digital images by software.

In other studies like Rasimick et al.'s study (5) and also in Ozcan and et al. studies (20), digital radiography were used too. In addition, with the available software, it is possible to analyze images with better situation and higher resolution. Some advantages of direct digital analyze are acceleration of the image preparation, elimination of developing and fixing steps, high sensitivity of films to exposure, acceptability and easy use.

Although using direct digital radiography is preferred in materials radiopacity studies because of low exposure dose, stable images and manipulation, X-ray film technique is used widely by researchers and factories and still utilized as the gold standard.

Conclusions

In the end, considering the obtained results, it was determined that the radiopacity of different cements is not equal. Also, it can be stated that all studied cements except Iranian glass ionomer cement have ISO 4049: 2000(E) standard about radiopacity property.

Zinc phosphate cements showed the highest level of radiopacity. Panavia F2.0 resin cement had the least acceptable radiopacity between cements.

Recommendations

It is recommended that this study be evaluated in intraoral clinical conditions. Also considering that using direct digital radiography system has advantages like low exposure dose, stability of images and image manipulation when comprised to X-ray film technique, it is recommended that the comparison of this technique to ordinary film technique as the gold standard be evaluated in future studies.

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