

# Assessing The Radiopacity of Three Resin Composite Materials Using a Digital Radiography Technique

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## Abstract

**Background:** Radiopacity is one of the prerequisites for dental materials, especially for composite restorations. It's essential for easy detection of secondary dental caries as well as observation of the radiographic interface between the materials and tooth structure. The aim of this study to assess the difference in radiopacity of different resin composites using a digital x-ray system.

**Materials and methods:** Ten specimens (6mm diameter and 1mm thickness) of three types of composite resins (Evetric, Estelite Sigma Quick, and G-aenial) were fabricated using Teflon mold. The radiopacity was assessed using dental radiography equipment in combination with a phosphor plate digital system and a grey scale value aluminum step wedge with thickness varying from 1mm to 10mm in steps of 1mm each. The tested materials were radiographed, we used Image J software, on a computer screen to evaluate the degree of radiopacity for each individual material and compare with the aluminum step wedge. Radiopacity was expressed in mm of equivalent aluminum step wedge. Analysis of variance (ANOVA) and Least Significant Difference (LSD) were used to investigate the significance of differences among the tested groups.

**Results:** Statistical analysis showed highly significant difference among the tested groups ( $p \leq 0.01$ ). Amongst, G-aenial composite shows the most radiopaque and it is above or equivalent to that of enamel, while Estelite Sigma Quick composite has the lowest radiopacity value and is equivalent to that of dentin.

**Conclusion:** In line with previous studies, and within the limitation of our study, considerable variations in radiopacity values were found among materials depending on the radiopaque elements incorporated into the matrix. All composite materials tested complied with the ISO 4049 standard.

**Keywords:** aluminum, digital imaging, radiopacity. (*J Bagh Coll Dentistry* 2017; 29(3):26-30)

## INTRODUCTION

Materials like restorative composites are not inherently radiopaque and without modification of their composition, would not be visible on an x-ray film except as a dark spot when deposited into the tooth structure. On the other hand the decay in tooth structure shows up as a dark area on an x-ray film. In the early days of composite technology, it was a challenge to distinguish radiographically between a composite filling and an area of decay in a tooth.<sup>1</sup> The addition radiopacifiers, zirconium dioxide, barium oxide or ytterbium oxide to any radiolucent material will impart the property of radiopacity. This become one of the requirement of any restorative materials to allow the clinician to evaluate restoration integrity at subsequent recall appointments, distinguish caries from restorative material on radiographs, and detect voids, overhangs and open margins.<sup>2</sup>

A restorative material with radiopacity slightly greater than or equal to enamel considered ideal for detection of secondary caries.<sup>3</sup>

A number of studies have evaluated the radiopacity of dental composites.<sup>4,5,6</sup> Abou-Tabl et al.,<sup>7</sup> used an aluminum step wedge as a radiographic reference for evaluating the radiopacity of dental materials. According to the ISO 4049 guidelines, the dental materials radiopacity should be equal to or greater than the same thickness of aluminum and should not be less than 0.5 mm of any value claimed by the manufacturer.<sup>8</sup>

Radiopacity used to be measured by transmission densitometry, direct and indirect digital radiography. Since 1989 a digital system considered satisfactory for dentistry and dental research.<sup>9</sup>

There are several types of sensor: Charge-Coupled Devices (CCD), Complementary Metal Oxide Semiconductor (CMOS) and photo-stimulable phosphor plates (imaging plate). The most important advantage of digital clinic radiographic system is the greater sensitivity of the detector in comparison with that of silver halide film that results in decrease the hazard of

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radiation exposure (radiation dose). This technique includes digitalization of radiographic images and the use of specific software to discriminate different grey-scale value.<sup>10</sup>

## MATERIALS AND METHODS:

In this in vitro, experimental research, we used three resin composites commercially available, Evetric (Ivoclar Vivadent), Estelite Sigma Quick (Tokuyama Dental America Inc.), and G-aenial (GC Europe).

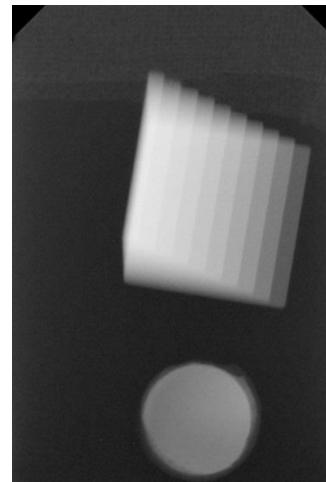
We made ten disk specimens for each material. To do that, Teflon mold 6mm in diameter and 1 mm in thickness as suggested by ISO standard 4049, were used.<sup>8</sup> The specimens were prepared and manipulated according to the manufacturer's instructions for each material. Teflon mold placed between two glass slides. After loading the material, the mold clamped under 150 gm pressure to expel excess material, reduce voids, and to ensure equal pressure and flat surface to all samples,<sup>11</sup> then light cured using (QD, UK) unit with a power of 450 mW/cm<sup>2</sup> for 40 seconds on each side. After removing the specimens from the mold, we polish them using medium, fine, and super fine sandpaper disks (Soflex, 3M ESPE, St. Paul, MN, USA) on a slow handpiece in accordance with the manufacturer's instructions.<sup>12</sup> After polishing, the samples were cleaned with distilled water. The uniformity of the thickness was precisely calculated by a digital caliper (Maplin Electronics, Rotherham, UK). The specimens were stored in distilled water 37°C for a day in order to complete polymerization of the material.<sup>13</sup>

A 99.5% pure aluminum step wedge with ten 1-mm incremental steps was used as an internal radiographic standard and as a gauge to calculate the radiopacity of each material in terms of Al thickness.<sup>14</sup>

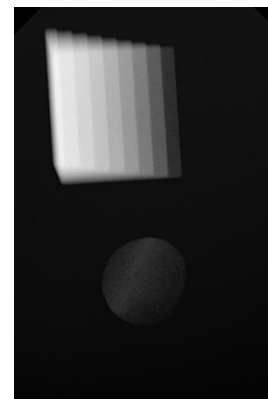
The specimens were then radiographed using a periapical film supplied with storage phosphor plate (Digora, Soredex, Helsinki, Finland) together with Al step wedge using radiography unit. The exposure parameters were set up at 70 KV, 8 MA, and 0.2s. The object to focus distance was 30 cm. Storage phosphor plates were then scanned using Digora scanner and digital images were obtained and converted to the computer using Digora for windows software. The optical densities of the tested materials were analyzed on computer screen using specific image J software (Image J processing and analysis in Java, version 1.47g) and the grey-scale values (density measurements) converted into mm equivalents of aluminum and recorded.<sup>15</sup>

**Table 1: Filler compositions taken from the manufacturers' instruction and data sheet**

Composite	Filler composition	% weight
G-aenial	Prepolymerised filler with silicon	77%
Evetric	Barium glass, ytterbium trifluoride, mixed oxide and copolymers	80-81%
Estelite Sigma Quick	Silica-zirconia filler and composite filler	82%



**Figure 1: radiograph showing the radiopacity values of Evetric composite in relation to the density of aluminum step wedge**



**Figure 2: radiograph showing the radiopacity values of Estelite Sigma Quick composite in relation to the density of aluminum step wedge significant difference between A and C (Evetric and G-aenial) Table 4**

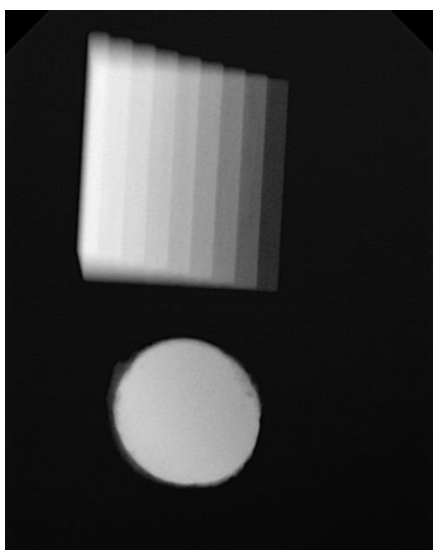


Figure 3: radiograph showing the radiopacity values of G-aenial composite in relation to the density of aluminum step wedge

**RESULTS:**

After calculating the parametric values Table 2, we found that G-aenial composite resin (group C) showed the highest mean of radiopacity value followed by Evetric composite (group A) and Estelite Sigma Quick (group B) composite materials. Analysis of variance "ANOVA" revealed that there was a highly significant statistical difference among the tested groups, A Evetric, B Estelite Sigma Quick, and C G-aenial composite materials ( $P \leq 0.01$ ) Table 3. Further investigations using Least Significant Difference (LSD) showed that there was a highly significant difference in radiopacity between A and B (Evetric and Estelite Sigma Quick) also between the latter and C (G-aenial) and a highly

**Table 2: Descriptive statistics of radiopacity values in mm for all groups. Group A Evetric composite resin, group B Estelite Sigma Quick composite resin, and group C G-aenial composite resin**

Tested groups	Mean (mm)	Std. Deviation	Minimum value (mm)	Maximum value (mm)
Group A	1.93	0.1473	1.70	2.20
Group B	0.79	0.0626	0.70	0.88
Group C	2.80	0.1617	2.43	2.93

**Table 3: ANOVA test comparison among groups. Group A Evetric composite resin, group B Estelite Sigma Quick composite resin, and group C G-aenial composite resin**

Compared groups	Mean	Std. Deviation	F	Significance
Group A	1.93	0.1473	587.24	HS*
Group B	0.79	0.0626		
Group C	2.80	0.1617		

\* donates highly significant difference of  $p \leq 0.01$

**Table 4: Group by group comparison using Least Significant Difference test for radiopacity among groups. Group A Evetric composite resin, group B Estelite Sigma Quick composite resin, and group C G-aenial composite resin**

Compared groups	Mean difference	Significance
A vs.B	1.139	HS*
A vs.C	0.869	HS*
B vs.C	2.008	HS*

\* donates highly significant difference of  $p \leq 0.01$

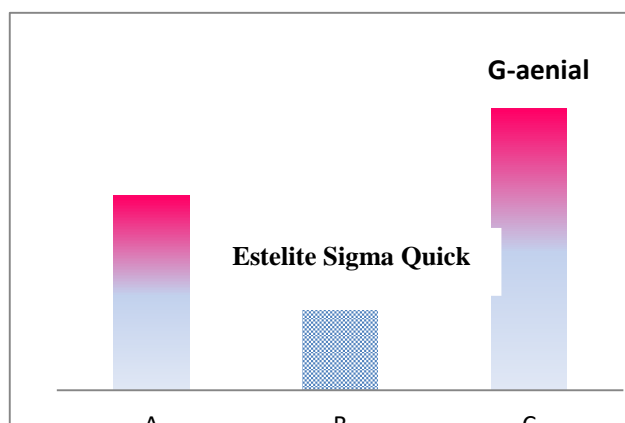


Figure 4: showing mean of radiopacity values in mm for all groups

**DISCUSSION**

Nowadays radiopacity becomes essential to evaluate any type of restorative material in terms of quality and the long term success of restorations.<sup>5</sup> ISO standard 4049 states that resin composite radiopacity should exceed that of

dentin and equal or exceed the same thickness of aluminum. It has been recommended that the radiopacity of resin composites should be equal to or greater than that of the enamel.<sup>3, 10,16,17,18</sup>

However, the higher radiopacity of amalgam restorations may lead to under and over scoring secondary caries and marginal defects compared to composite restorations. Caries lesions and marginal defects may be over diagnosed with high radiopaque restorations, so moderate radiopacity might be more favorable and will make caries detection easier. Distinguishing the restoration from tooth structures radiographically was reported to be more visible in areas primarily composed of dentin because of the lower dentinal radiopacity compared to composite materials.<sup>19</sup>

The methodology used to measure radiopacity value in the present study is based on measurement of the pixel grey scale (Image J) value using specific software after digitalization of conventional film. The digital radiographic system has been used effectively in recent studies for radiopacity measurements of composite materials.<sup>9, 11, 20</sup> Each composite material was radiographed along with aluminum step wedge that was used for reference. For every radiograph the average greyscale value of the material was converted into absorbance and compared with that of the reference step wedge using image J software in order to determine the equivalent radiopacity in terms of millimeters of Al per millimeter of material. The material's radiopacity values are related to the relative atomic mass of constituent elements.

Polymeric dental materials can be made radiopaque by incorporation of radiopaque elements into either the filler particles or monomer liquids. The radiopacity of resin composites depends on the percentage and type of fillers.<sup>10, 12, 21</sup>

Introduction of chemical elements with high atomic numbers such as zinc, strontium, zirconium, barium, ytterbium and lanthanum result in more radiopaque materials. They are usually added to inorganic fillers before preparation of splintered filler particles.<sup>3, 12</sup>

The more radiopaque the elements are, the more radiopaque the material will be. According to our results, the radiopacity value of Estelite Sigma Quick (supra nanofilled) is the lowest one, this may be related to the insufficient amount of radiopaque elements incorporated into the matrix. It contains silica-zirconia filler only which is spherical submicron one (0.2  $\mu\text{m}$ ). Silica (silicon dioxide filler) has low atomic number, this make the material has low radiopacity but it is comparable to that of dentin and equal to that

of the same thickness of Al. Also it may be related to the presence of BisGMA in the resin matrix, this content make the composite material appear more radiolucent than UDMA and TEGDMA based composite.<sup>22</sup>

Evetric composite material show a radiopacity in between to that of enamel and dentin and higher than that of Estelite Sigma Quick and lower than that of Estelite Sigma Quick and lower than that of G-aenial composite. Its high radiopacity may be related to the presence of barium glass (Ba atomic number 56) and Ytterbium (Yb atomic number 70), these elements incorporated into composite materials to increase radiopacity. It is a nanohybrid composite with 40-30000 nm filler particle size and dimethacrylate resin matrix.

G-aenial composite material showed the highest radiopacity among the tested material, however, it is comparable to that of enamel. This composite material is nanohybrid with prepolymerised filler (PPF) with silicon. The PPF containing 400 nm strontium glass (St atomic number 38) and 100 nm Lanthanoid fluoride (La atomic number 57) with 16 nm fumed silica. It is a Bis-GMA free composite, it contains a mixture of UDMA and dimethacrylate comonomers.

Adequate radiopacity of restorative materials assists in the radiological diagnosis of caries and the overall condition of existing restorations. Adequate radiopacity must, therefore, be accepted as one of the major factors when evaluating the clinical success of restorations.

## CONCLUSION

The contemporary restorative resin composites assessed in this study presented different radiopacity values. The radiopacity of resin composites is dependent on the material type. The use of materials with radiopacity close to or less than dentin may result in further diagnostic challenges. However, all the tested materials complied with the requirement of ISO 4049 guidelines.

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