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BRUNA MUA

# HALOS RADIOLÚCIDOS SOB RESTAURAÇÕES DE RESINA COMPOSTA: UM ESTUDO *IN VITRO*.

Porto Alegre
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Trabalho de Pesquisa apresentado para conclusão do Curso de Graduação em Odontologia da Universidade Federal do Rio Grande do Sul, requisito básico para obtenção do Título de Cirurgião Dentista.

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"Aprender é a única coisa de que a mente nunca se cansa, nunca tem medo e nunca se arrepende."

Leonardo da Vinci

**DEDICATÓRIA**

Aos meus pais, Cíntia e Giuseppe, pelo amor, carinho e dedicação. Por me ensinarem que, apesar das dificuldades, os sonhos não devem ser deixados de lado. Que a força de vontade, a garra e a persistência tornam todos os desejos atingíveis. Com vocês aprendi a não desistir e a lutar.

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**SUMÁRIO**

## JUSTIFICATIVAS

A troca de restaurações é responsável por grande parte do tempo clínico gasto pelos dentistas (QVIST, QVIST *et al.*, 1990; FORSS E WIDSTRÖM, 2004). A cárie secundária é a principal razão mencionada pelos dentistas para a troca de restaurações (OLEINISKY, BARATIERI *et al.*, 1996). A troca de restaurações deve ser cuidadosamente indicada, pois promove perda de tecido dentário (ELDERTON, 1979), enfraquecendo e reduzindo a longevidade dentária (OLEINISKY, BARATIERI *et al.*, 1996).

A presença de áreas radiolúcidas sob restaurações de resina composta pode ser interpretada pelos clínicos como cárie secundária ou residual (HARDISON, RAFFERTY-PARKER *et al.*, 1989). Entretanto, quando essas áreas radiolúcidas são relacionadas a cáries secundárias, há uma grande probabilidade de a lesão não ser encontrada após a remoção da restauração (CHANDLER, BOWEN *et al.*, 1970), resultando em sobretratamento. Estudos tem demonstrado que a falta de material restaurador, porosidades e espessas camadas de adesivo podem induzir essas áreas radiolúcidas (CHANDLER, BOWEN *et al.*, 1970; HARDISON, RAFFERTY-PARKER *et al.*, 1989).

Devido à falta de evidências sobre as causas de áreas radiolúcidas sob restaurações de resina composta, este estudo objetivou relacionar a presença de áreas radiolúcidas adjacentes a restaurações com alterações histológicas.

## OBJETIVOS

OBJETIVO GERAL

- Estudar a imagem radiolúcida adjacente a restaurações de resina composta

OBJETIVOS ESPECÍFICOS

- Relacionar a presença de imagem radiolúcida adjacente a restaurações realizadas em dentes cariados com os achados histológicos
- Relacionar a presença de imagem radiolúcida adjacente a restaurações realizadas em dentes hígidos com os achados histológicos
- Comparar as relações entre achados radiográficos e histológicos de restaurações em dentes hígidos com os achados radiográficos e histológicos de restaurações em dentes cariados.

**ARTIGO CIENTÍFICO**

# Radiolucent halos beneath composite restorations: an *in vitro* study.

# Radiolucent halos beneath composite restorations: an *in vitro* study

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Short title: Radiolucent halos beneath composite restorations

Key words: bitewing radiography, radiographic examination, secondary caries.

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**Abstract**

The presence of radiolucent areas beneath the composite restorations can be interpreted by clinicians as secondary or residual caries leading to restoration replacement. The aim of this study was to relate the presence of radiolucent areas adjacent to restorations with histological alterations in carious and sound teeth. Fifty permanent extracted teeth, 25 sound and 25 with primary caries, were studied. Complete dentin caries removal was performed in the carious teeth. Cavities with similar dimensions to the carious teeth were performed in the sound teeth ($p<0.005$), and both were restored with composite resins. Teeth were serially sectioned in mesio-distal direction. A total of one hundred and nineteen sections were obtained and 349 areas were analyzed. Eight areas could not be analyzed due to defects in sample preparations, resulting in 349 analyzed areas. In each tooth, the sections were grouped and one histological result was obtained for each area (70 areas of carious teeth and 72 areas of sound teeth). The prevalence of demineralized tissue (DEM) and/or gap in the whole sample was 53.5% (IC 95%=45.3-61.6). There was a significant association between the presence of histological alteration and presence of radiolucency, and absence of histological alteration and absence of radiolucency in the whole sample. Although both gap (91%) and DEM (65%) were related to the presence of radiolucency in the radiographic images, the sensibility [73.7% (IC 95%=62.9-82.6)], specificity [59.1% (IC 95%=47.0-70.4)], predictive positive values (PPV) [67.5% (IC = 95%=56.9 – 76.9)], predictive negative values (PNV) [66.1% (IC 95%=53.4-77.3)] and accuracy [66.9% (IC 95%=58.9-74.3)] were low. There was no difference between sound and carious teeth regarding the sensitivity, specificity, PNV and accuracy. However, there was statistically significant difference between the groups when the PPV was analyzed ($p=0.024$). The results show a high number of gap in composite restorations and low values for specificity due to the high number of false positives. The presence of radiolucency beneath restoration cannot indicate restoration replacement.

Key words: bitewing radiography, radiographic examination, secondary caries, dental caries.

Replacement of dental restorations still plays a major role in daily dental practice. Restorations replacement is responsible for most of the dentists clinical time (QVIST, QVIST *et al.*, 1990; FORSS e WIDSTRÖM, 2004). The main reason for restoration replacement is secondary caries (OLEINISKY, BARATIERI *et al.*, 1996). Restoration replacement should be carefully indicated since it leads to loss of dental tissue (ELDERTON, 1979), which weakens and reduces the tooth longevity (OLEINISKY, BARATIERI *et al.*, 1996).

The presence of radiolucent areas beneath the composite restorations can be interpreted by the clinicians as secondary or residual caries (HARDISON, RAFFERTY-PARKER *et al.*, 1989). However, when these radiolucent areas are related to secondary caries, there is a great possibility that no lesion can be found after restoration removal (CHANDLER, BOWEN *et al.*, 1970), leading to an over treatment. Studies showed that the presence of lack of material, porosity and thick layers of adhesive can induce these radiolucent areas (CHANDLER, BOWEN *et al.*, 1970; HARDISON, RAFFERTY-PARKER *et al.*, 1989).

Due to the lack of evidences for the causes of radiolucent areas adjacent to restorations, this study aimed to relate the presence of radiolucent areas adjacent to restorations to histological alterations.

## Materials and Methods

Fifty permanent extracted teeth (48 molars and 2 premolars) used in the study were donated by banks of teeth of the Faculty of Dentistry of São Paulo, Santa Maria and Pelotas. All teeth were stored in a 2% formaldehyde solution. The sound (n = 25) and carious teeth with occlusal cavitated primary lesions (n = 25) were paired according to their anatomical characteristics (position in the dental arch, size, molar or pre-molar).

The study was approved by the Ethics Committee of the Faculty of Dentistry of the Federal University of Rio Grande do Sul (Protocol Nº 11/08).

### Experimental designs

Carious teeth were submitted to complete carious dentine removal , with round steel burs in slowly rotation, according to the current clinical hardness criteria, by one operator (BM). The dentine caries removal was checked by a calibrated examiner (FG). A cavity with similar dimensions was done in each paired sound tooth with round diamond burs in high rotation. The cavities were measured with a digital caliper rule.

All teeth (carious and sound) were restored with composite resin (Tetric Ceram, Ivoclar-VivaDent®, São Paulo, Brazil) according to the same protocol: enamel and dentine were etched with 37% phosphoric acid gel for 30 seconds; the bonding agent Excite Adhesive (Ivoclar-VivaDent®, São Paulo, Brazil) was applied on the enamel and dentine cavity walls and cured for 20 seconds; the composite resin was inserted into the cavity with a maximum increment of 2 mm and each increment was light cured for 40 seconds. All the cavities preparations and restorations were carried out by the same operator (BM).

Digital radiographs (VistaScan Perio®, Bietigheim-Bissingen, Germany) were taken from all teeth using a phosphor storage plate with an exposure of 0.6 seconds. The image plate was read with Vistascan system (Dürr Dental®, Bieitigheim-Bissingen, Germany). The images were exported to the software dbsWin®4, and the Fine Filter was applied. In order to reproduce the effect of soft tissues, a device of wax with 25mm thickness was used (BRAGA, GEGLER *et al.*, 2006).

Sample preparation for histological examination: Teeth were embedded in epoxy resin matrices (Araldite®, Brazil). The teeth crowns were separated from their roots and were serially sectioned in mesio-distal direction, using a diamond disk (Buehler ®, number 11-4243, Lake Bluff, USA) in a low speed saw (Isomet, Buehler®, Lake Bluff, USA). The first cut was made at the center of the restoration and parallel cuts were performed with an interval of 1 mm, including the entire restored area. The slices were stored in 100% humidity atmosphere at 4°C. A total of 119 sections were obtained, corresponding to an average of 2.48 per tooth.

Radiographic and Histological Evaluation

All evaluations were performed in three areas of the interface tooth-restoration: mesial, distal and pulp walls. All evaluations were conducted blind.

## Radiographic assessment

Digital radiographs were assessed by three examiners with experience in Radiology, in a closed dark room. In case of disagreement, the most prevalent criterion was chosen. The radiolucent halo adjacent to three areas was classified as present or absent.

## Histological evaluation

From the 119 sections, 357 areas were obtained. However, eight areas could not be analyzed due to defects in sample preparations, resulting in 349 analyzed areas. At the carious group 70 areas were assessed (five areas were lost) and at the sound group 72 areas were assessed (three areas were lost). Histological sections were evaluated by one trained and calibrated examiner (BM) and by a professional with experience in dental pathology (BBS). In case of disagreement, a consensus was obtained. The three areas of tooth-restoration interface were evaluated for the presence of (0) restoration adjacent to sound enamel/dentine, (1) demineralized enamel/dentine, (2) demineralized enamel/dentine and gap or (3) gap. In carious teeth the presence of (1) demineralized enamel/dentine, (2) demineralized enamel/dentine and gap or (3) gap was considered as presence of histological alteration, while in sound teeth, only (3) gap was considered as a case of presence of histological alteration. In both sound and carious teeth (0) restoration adjacent to sound enamel/dentine was considered as absence of histological alteration. In each tooth, the sections were grouped and one histological result was obtained for each area.

## Reproducibility and reability

Reability Tests were performed for (1) Clinical analysis of removal of carious dentin (FG), (2) cavity preparation (BM) and (3) histological assessment (BM). All exams were conducted twice, within at least one week interval.

## Statistical analyses

Shapiro-Wilk normality test was applied to continuous variables (cavity depth, mesiodistal and buccolingual diameter). Mann Whitney U test was used to analyze the differences of these variables between carious and sound teeth. Chi-square test was used to assess the (1) relation between radiographic diagnosis and histological analyze of the areas of carious and sound teeth, (2) distribution of histological alterations (demineralized enamel/dentine [DEM], demineralized enamel/dentine and gap [DEM + GAP] or gap [GAP]) per areas in relation to the radiographic diagnosis in the carious teeth, (3) comparison of radiographic diagnosis values of sensitivity, specificity, predictive positive value (PPV), predictive negative value (PNV) and accuracy between the carious and sound teeth and (4) prevalence of histological alterations in sound and carious teeth. A confidence interval of 95% was measured for sensitivity, specificity, predictive positive value (PPV), predictive negative value (PNV), accuracy and prevalence of histological alterations in sound and carious teeth.

**Results**

The intraclass correlation coefficient for operator reability in cavity analysis was 0.970 for depth, 0.978 for mesiodistal distance and 0,988 for buccolingual distance. The kappa value for clinical analysis of dentine caries removal and histological assessment were, respectively, 0.71 and 0.82.

Shapiro-Wilk test showed that the three continuous variables (cavity depth, mesiodistal and buccolingual diameter) had a non-normal distribution. Table 1 shows the comparison of median interquartile range values ($25^{th}$ and $75^{th}$) of cavity depth, mesiodistal and buccolingual distance for carious and sound teeth. There were no differences between the measures of the carious and sound teeth according to cavity depth, mesiodistal and buccolingual diameter ($p>0.05$).

Table 1: Comparison of median and interquartile range values ($25^{th}$ and $75^{th}$) of cavity depth, mesiodistal and buccolingual distance for carious and sound teeth.

| Measures of the cavities (mm) | Teeth | |
|---|---|---|
| | Carious (n = 25) | Sound (n = 25) |
| Depth | 2.68 (2.16 - 3.44) | 2.66 (2.22 - 3.44) |
| Mesiodistal distance | 2.43 (2.17 - 3.09) | 2.55 (2.27 - 3.24) |
| Buccolingual distance | 2.41 (2.06 - 2.91) | 2.65 (2.12 – 3.12) |

Mann Whitney U Test ($p>0.05$)

The prevalence of gap in the sound sample was 38.9% (IC 95% = 28.2 – 50.5), while the prevalence of gap and demineralized tissue (DEM) was 68.9% (IC 57 – 78.6), in carious teeth. Therefore, the prevalence of histological alterations was higher in carious teeth then in sound teeth (p = 0.001). The prevalence of DEM and/or gap in the whole sample was 53.5% (IC 95% = 45.3 - 61.6).

Table 2 shows the relation between radiographic diagnosis and histological analysis of the areas of carious and sound teeth. There was a significant association between the presence of histological alteration and presence of radiolucency, and absence of histological alteration and absence of radiolucency in the sound and carious teeth. However, considering carious and sound teeth, false positive cases (absence of histological alteration and presence of radiolucency) were observed in 27/83 of the sample.

Table 2: Relation between radiographic diagnosis and histological analyze of the areas of carious and sound teeth.

| Groups | Presence of histological alterations | Absence of histological alterations | Totals | P* |
|---|---|---|---|---|
| **Sound Teeth** | GAP | | | 0.030 |
| Presence of radiolucency | 19 | 17 | 36 | |
| Absence of radiolucency | 9 | 27 | 36 | |
| Totals | 28 | 44 | 72 | |
| **Carious Teeth** | DEM and/or GAP | | | 0.019 |
| Presence of radiolucency | 37 | 10 | 47 | |
| Absence of radiolucency | 11 | 12 | 23 | |
| Totals | 48 | 22 | 70 | |
| **Sound and Carious Teeth** | DEM and/or GAP | | | <0,001 |
| Presence of radiolucency | 56 | 27 | 83 | |
| Absence of radiolucency | 20 | 39 | 59 | |
| Totals | 76 | 66 | 142 | |

* Chi-Square Test

Table 3 shows the distribution of histological alterations (demineralized enamel/dentine [DEM], demineralized enamel/dentine and gap [DEM + GAP] or gap [GAP]) per areas in relation to the radiographic diagnosis in the carious teeth. It was observed that both gap (91%) and DEM (65%) were related to the presence of radiolucency in the radiographic images.

Table 3: Distribution of histological alterations (demineralized enamel/dentine [DEM], demineralized enamel/dentine and gap [DEM + GAP] or gap [GAP]) per areas in relation to the radiographic diagnosis in the carious teeth.

| Radiographic diagnosis | DEM | GAP | DEM + GAP | Totals |
|---|---|---|---|---|
| Presence of radiolucency | 13* | 10* | 14 | 37 |
| Absence of radiolucency | 7* | 1* | 3 | 11 |
| Totals | 20 | 11 | 17 | 48 |

*Chi-Square Test (P = 0.115)

Table 4 shows the comparison of radiographic diagnosis values of sensitivity, specificity, predictive positive value (PPV), predictive negative value (PNV) and accuracy between the carious and sound teeth. There was no difference between sound and carious teeth regarding the sensitivity, specificity, PNV and accuracy. However, there was statistically significant difference between the groups when the PPV was analyzed (p = 0.024).

Table 4: Comparison of radiographic diagnosis values of sensitivity, specificity, predictive positive value (PPV), predictive negative value (PNV) and accuracy between the carious and sound teeth.

| Radiographic Diagnosis Values | Carious and Sound Teeth % (IC 95%) | Carious Teeth % (IC 95%) | Sound Teeth % (IC 95%) | p* |
|---|---|---|---|---|
| Sensitivity | 73.7 ( 62.9 - 82.6) | 77.1 (63.7 - 87.3) | 67.8 (49.1 – 83.0) | 0.541 |
| Specificity | 59.1 (47.0 - 70.4) | 54.5 (33.8 - 74.1) | 61.4 (46.5 - 74.8) | 0.791 |
| PPV | 67.5 (56.9 - 76.9) | 78.7 (65.3 - 88.7) | 52.8 (36.6 - 68.6) | 0.024 |
| PNV | 66.1 (53.4 - 77.3) | 52.2 (32,1 - 71.7) | 75.0 (59.1 - 87.1) | 0.127 |
| Accuracy | 66,9 (58.9 - 74.3) | 70.0 (58.5 - 79.8) | 63.9 (52.3 - 74.3) | 0.552 |

* Chi-Square Test

**Discussion**

In this study, the authors aimed to analyze the interface of restored tooth. It was found that the presence of radiographic radiolucency was related to defects like gaps and/or demineralization, and the absence of radiographic radiolucency was related to restoration adjacent to sound enamel/dentine (Table 2). Both sensitivity and specificity of radiographic diagnosis was low (Table 4).

Some authors had suggested that the occurrence of radiolucent areas adjacent to composite restorations is associated with thick adhesive layers (HARDISON, RAFFERTY-PARKER *et al.*, 1989; OPDAM, ROETERS *et al.*, 1997). The ideal thickness of the adhesive layers is controversial. While several studies had concluded that thick layer could provide a decrease of the composite polymerization shrinkage, reducing the gap formation, acting like a stress absorbing layer (OPDAM, ROETERS *et al.*, 1997; CHOI, CONDON *et al.*, 2000; CHO e DICKENS, 2004), Pazinatto (2008) had shown that thin adhesive layers result in high dentin bond strength values. In addition, great amounts of adhesive could provide polymerization contraction and thermal expansion causing changes in restorations proprieties (HARDISON, RAFFERTY-PARKER *et al.*, 1989; D'ARCANGELO, VANINI *et al.*, 2009). According to Opdam (1997), microscopic translucent zones larger than 40 μm are detectable by radiographs. However, depending on the type of the adhesive system and its composition, when one coat is applied its thickness can range from 5 to 30 μm (LUZ, ARANA-CHAVEZ *et al.*, 2005; PAZINATTO e ATTA, 2008; D'ARCANGELO, VANINI *et al.*, 2009). In this study, only one coat of the bonding agent was applied and its layers were not detected by stereomicroscopic observation. Therefore, adhesive layer was not responsible for the radiolucent areas observed adjacent to restorations.

The gap formation is a multifactor phenomenon that depends of several factors, as composite features, C-factor and light-curing protocol (LOGUERCIO, REIS *et al.*, 2004; DOS SANTOS, DA SILVA *et al.*, 2007). Its occurrence is associated with radiolucent areas beneath restorations (HARDISON, RAFFERTY-PARKER *et al.*, 1989). In the present paper, only class I restorations were studied and a high prevalence of gap was observed (39%). The C-factor is the ratio of the bonded to unbonded restorations surfaces. Restorations placed in class I cavities have the highest C-factor. This factor leads to a decrease of the bond strength values, an increase in the mean gap width, deflection of the unbonded surface, deformation of the tooth structure, in addition to cracks and failures inside the restoration (LOGUERCIO, REIS *et al.*, 2004). The incremental filling technique was developed to minimize the C-factor by inserting little composite increments no greater than 2mm. Thus, less polymerization shrinkage would happen since each increment would be separately light-cured (NEIVA, DE ANDRADA *et al.*, 1998). However, Sakaguchi (1992) demonstrate that all polymerization contraction does not occur immediately after light-curing. So, all increments tend to have their complete polymerization almost together. Although this technique can reduce the harmful consequences of the polymerization shrinkage, it cannot eradicate the stress development on the adhesive interface (LOGUERCIO, REIS *et al.*, 2004). The

light-curing protocol also plays a role in the polymerization shrinkage. If the light intensity is high, a rapid light-cure process occurs, triggering a higher shrinkage stress than when lower intensity light is used. Meanwhile, lower intensity light must induce degree of conversion and alterations of the mechanical proprieties of the composites (DOS SANTOS, DA SILVA *et al.*, 2007). So, the high polymerization shrinkage associated to a great c-factor and the high light-cure intensity can be the reason for the occurrence of numerous gaps on this study samples.

The conventional clinical hardness criterion used for carious dentine removal is a subjective criterion that depends on operator's knowledge and training. In this study, a trained and calibrated examiner assessed all cavities preparations and caries removal. Even after the clinical caries removal performance, demineralized tissue remained at the cavity floor, which might have created radiographic radiolucency lines.

It is very important that the posterior composite restorations are sufficiently radiopaque to allow an easily distinction of itself from dental structure. Radiopacity is important to correctly interpret and assess the cavity wall adaptation, marginal gaps, voids or recurrent caries (BOUSCHLICHER, COBB *et al.*, 1999). Despite ISO standard 4049 recommendations, that composite radiopacity must be greater than the dentin, studies show that composite with radiopacity slightly greater than enamel could improve the radiographic diagnosis of secondary caries, increasing its accuracy (ESPELID, TVEIT *et al.*, 1991) and sensitivity (NAIR, TYNDALL *et al.*, 1998). The radiopacity of the composite resin used in the present study was greater than that of the enamel. However, the higher the radiopacity of a composite, the greater the possibility of occurrence of mach band effect. The mach band is an optical illusory effect produced by protective inhibitory forces in adjacent receptors within the retina (BERRY, 1983). It occurs when a dark area meets a lightly area and it seems that the junction of the areas become even more darker (NIELSEN, 2001). According to Chasen (2001), if an object has greater radiopacity than its surround and presents a convex contour relate to a concave surface at the interface, than a negative mach band will occur (radiolucency); a positive mach band (radiopacity) will occur if one of the conditions is reversed. In tooth radiographs, the most common localization of this effect in sound teeth is at the dentoenamel junction. This phenomenon is associated with the occurrence of mistaken diagnosis of recurrent caries when the tooth restoration interface is assessed (ESPELID, TVEIT *et al.*, 1991). The theory of Chasen (2001) fits very well in this situation: the composite restoration has a greater radiopacity than its surround and often has a convex contour; the dentine/enamel substrate has a

convex shape. The association of this features results on a negative mach band effect at the tooth restoration interface, which is strongly related to radiographic false positive diagnosis of recurrent caries (ESPELID, TVEIT *et al.*, 1991). This phenomenon could explain the occurrence of 27/83 false positive values in the radiographic diagnosis (Table 2).

The sensitivity, specificity and PNV for the presence of radiolucent lines beneath composite restorations were similar in carious and sound teeth. It is important to point out that all sensitivity and specificity values were below 80%, being the specificity values low in both carious and sound teeth, due to a high number of false positives. The higher PPV found in carious teeth compared to sound teeth could be explained by the presence of some demineralized areas found in the carious specimens. These finding have great importance in the interpretation of the causes of the radiolucency beneath restorations and consequent clinical indication of restoration replacement. Therefore, radiolucent areas beneath restorations cannot be an indicator for restoration replacement. When no clinical sign of loss of marginal integrity is found, the better clinical decision is no intervention and systematic proservation. The unnecessary restoration replacement leads to waste of sound tissue and decrease of the longevity of the tooth (ELDERTON, 1979).

## CONSIDERAÇÕES FINAIS

A sensibilidade, especificidade e valor preditivo negativo para a presença de áreas radiolúcidas abaixo de restaurações de resina composta foram similares em dentes cariados e hígidos. É importante ressaltar que todos os valores de sensibilidade e especificidade foram inferiores a 80%, sendo o valor de especificidade baixo em dentes cariados e hígidos, devido ao alto número de falsos positivos. O elevado valor preditivo positivo encontrado nos dentes cariados, comparado ao dos dentes hígidos, pode ser explicado pela presença de algumas áreas desmineralizadas nos espécimes cariados. Estes achados apresentam grande relevância para interpretação da origem da radiolucidez abaixo de restaurações e consequente indicação clínica de troca de restauração. Portanto, áreas radiolúcidas sob restaurações não podem ser um indicativo para troca de restauração. Quando não houver sinais clínicos de perda de integridade marginal, a melhor conduta é não intervir e proservar sistematicamente. A troca desnecessária de restaurações leva à perda de tecido hígido e diminui a longevidade do dente (ELDERTON, 1979).

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