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ORIGINAL ARTICLE

Dimensions of Occlusoproximal Cavitated Carious Lesions as a Cut-Off Point for Restorative Decision in Primary Teeth

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ABSTRACT

Objective: To investigate whether the dimensions of cavitated dentin carious lesions on the occlusoproximal surfaces of primary teeth could predict the location of cement-enamel junction (CEJ). **Material and Methods:** Two hundred extracted primary molars were selected and digital images were obtained. The teeth were set in arch models for clinical measurement. The cervical-occlusal (CO) and buccal-lingual/palatal (BL/P) cavities' dimensions were obtained by digital (Image J) and clinical (periodontal millimeter probe) assessments. The cervical margin location was also determined. The thresholds (cut-off points) were determined by sensitivity, specificity and the areas under the receiver operating characteristics curves (Az) for the two methods. Pearson's correlation coefficient was used to investigate the correlation between clinical and digital measurements. Logistic regression analysis was performed to evaluate the association between the dimensions and cervical margin location. **Results:** There was a strong correlation between methods for all measurements (CO: r=0.90, VL/P: r=0.95). Cavities with BL/P distance higher than 4.5 mm and CO dimension higher than 3.5 mm had a lower chance of presenting the cervical limit above the CEJ, irrespective of the measurement method. **Conclusion:** CO and VL/P dimensions could be used to predict the CEJ location and, ultimately, as a clinical parameter for restorative decision-making.

Keywords: Decision Making; Dental Caries; Tooth, Deciduous.

Introduction

Cavitated dentin carious lesions are still prevalent in primary dentition [1–3]. The proximal surfaces of primary teeth present a greater caries risk, especially due to the larger contact area between adjacent teeth and limited salivary access [4]. Moreover, depending on the age of the children, they may not have developed adequate motor skills to carry out interproximal flossing and may require parental assistance [5]. Most cavitated carious lesions in proximal surfaces hardly ever-present favourable conditions to be arrested only by biofilm control, as it is possible in smooth or occlusal surfaces. Hence, restorative approaches are indicated aiming to aid biofilm control and thereby manage caries activity, protect the pulp-dentin complex and arrest the lesion by sealing it; restore the function, form, and aesthetics of the tooth [6,7], and prevent arch length discrepancy [8].

Restoring occlusoproximal cavities in children is challenging due to several factors such as broad contact area, high pulp horns – as a result, shallow cavity, difficulty matrix band placement, less retentive cavity due to reduced enamel dentin thickness – increase the chance of failure, and child cooperation for the treatment [9]. Extensive posterior restorations are often extended to or below the cemento-enamel junction (CEJ), leaving little or no enamel at the cervical margin [10]. It has been shown that the presence of enamel at the cervical margin of an occlusoproximal cavity increases the fracture strength of the composite resin restoration at the marginal ridge than restorations that extend below the CEJ [10]. On the contrary, the absence of enamel at the cervical margins favours the occurrence of adhesive fractures. Overall, occlusoproximal restorations with cervical margins below the CEJ show a larger risk of failure than those with margins coronal to the CEJ [11].

It has been shown that restorations of primary molars with conventional glass ionomer cement had a higher risk of failure than other restorative materials such as compomer, resin-modified glass ionomer cement, composite resin [12], or high-viscous glass ionomer cement [13]. Even though these materials have shown satisfactory properties, a large number of functional and biological failures are still reported, mainly related to caries recurrence and fracture [14].

Hall technique is a less invasive approach recommended for the management of dental caries in primary molars involving two or more surfaces [15]. A preformed metal crown is cemented, using glass ionomer cement, over the carious tooth, without tooth preparation or carious tissue removal. A recent systematic review [16] found that treated occlusoproximal cavities resulted in a higher success rate when using the Hall technique. It may be attributed to the use of a preformed metal crown, which can isolate the dentinal lesion from biofilm deposition and dietary challenges, leading to carious lesion arrestment [17]. Therefore, this approach would be an interesting option for treating carious lesions that extend below the CEJ, avoiding premature tooth loss.

Considering that the location of cervical margins is an essential factor for the clinical performance of resin composite restorations and that the reduced visual access can hinder the cervical extension location, establishing a clinical parameter to predict the location of cervical margins in occlusoproximal carious lesions in primary teeth might help the professional in decision-making about the choice of restorative material. However, no study to date investigated the relationship between cavity dimensions and the location of CEJ. Thus, this study aimed to investigate whether the dimensions of cavitated dentin carious lesions on occlusoproximal surfaces of primary teeth could predict the location of CEJ.

Material and Methods

Selection and Tooth Preparation

The protocol of this laboratory-based study was previously approved by the local Research Ethics Committee. Two hundred primary molars with cavitated dentin carious lesions on occlusoproximal surfaces were

selected from a pool of the human teeth Biobank of the University of São Paulo. The teeth were disinfected in 0.5% aqueous chloramine and stored in distilled water at 4ºC until use. Subsequently, they were individually fixed in a block of utility-wax (Artigos Odontológicos Clássico, São Paulo, SP, Brazil) of approximate dimensions of 6 x 6 x 2 mm.

Digital Images

An image for each occlusoproximal cavity was obtained. Teeth were positioned over a black coloured (double-sided) cardboard to standardize the images. The same operator took all photographs with a 12 megapixel + 12 megapixel dual camera at a 5.5x magnification and 4608x2592 pixel resolution using a smartphone (iPhone 8 Plus, Apple, Silicon Valley, CA, USA) at a distance of 10 cm above the carious cavity.

Clinical and Digital Assessments

Teeth were set in arch models to simulate mouths in primary dentition for clinical measurement (Figure 1). Care was taken to simulate as best as possible the order and correct side of the teeth. The dimensions of the cavitated dentin carious lesions on occlusoproximal surfaces (cervical-occlusal height and buccal-lingual/palatal width) were measured by clinical and digital assessments. The clinical assessment was performed using a William's periodontal probe (Golgran, São Caetano, SP, Brazil) (Figure 1) and the greatest distances between the limits of the cavities were considered.

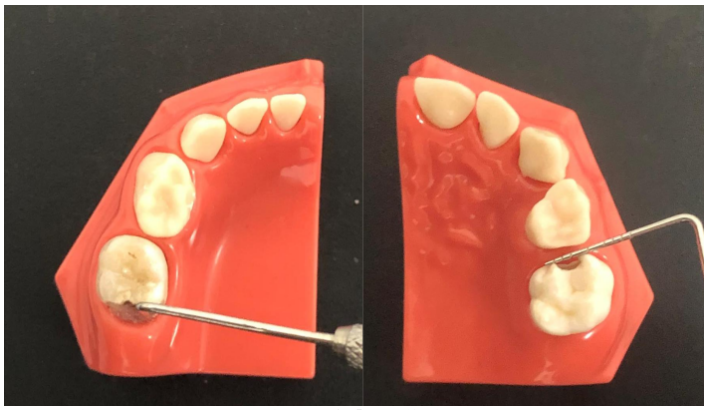

Figure 1. Illustration of the clinical measurement.

The digital measurements were done using an open-source image-processing program (ImageJ, National Institutes of Health and the Laboratory for Optical and Computational Instrumentation, The University of Wisconsin, Madison, WI, USA) (Figure 2). A line was drawn between the limits of the cavities and the program calculated the exact distances.

Two previously trained and calibrated examiners made all measurements. Initially, the training was performed by measuring the 10 cavities not included in the sample with a millimeter probe and their respective digital images. After the training, the examiners evaluated other 20 primary molars with cavitated dentin carious lesions on occlusoproximal surfaces and their respective digital images in order to obtain the interexaminer agreement. The inter-examiner agreement was excellent (Kappa: 0.91). Clinical and digital measurements were performed individually on a separate day, with an interval of two weeks, and the teeth were distributed in a random sequence to avoid bias. The cervical margin location (above or below the CEJ) was also determined in both evaluations.

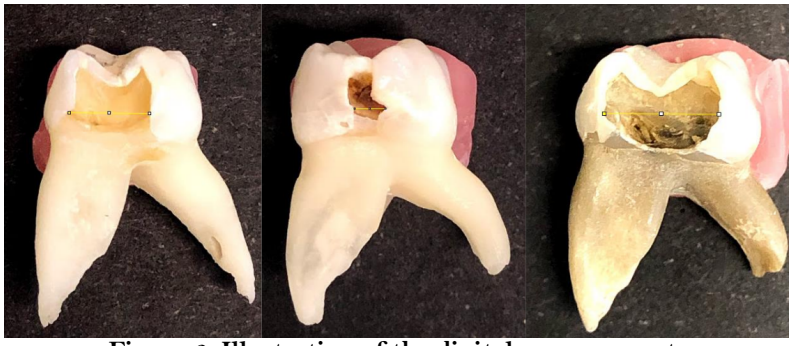

Figure 2. Illustration of the digital measurement.

Statistical Analysis

The experimental unit was the tooth. A mean of the values, in millimeters, obtained by two examiners for each assessment (clinical and digital) was considered for determining the cavity dimensions. The descriptive analysis provides the distribution summary of the sample. Pearson's correlation coefficient was used to investigate the correlation between clinical and digital measurements. The outcome was the cervical margin location (above or below the CEJ). The categorization of the thresholds (cut-off point) was determined by sensitivity, specificity, and the areas under the receiver operating characteristics curves (Az) for the two methods. The cervical-occlusal height (≤ 3.5mm or >3.5mm) and buccal-lingual/palatal width (≤ 4.5mm or >4.5mm). Logistic regression analysis was performed to evaluate the association between the thresholds and outcome in the two methods, with a 95% confidence interval and significance level at 5%. All analyses were performed using the SPSS 21.0 statistical program (SPSS, Inc. Chicago, IL, USA).

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of the Federal University of Rio Grande do Sul, Brazil (4.418.072).

Results

Table 1 summarizes the characteristics of the sample. The majority of the cavitated dentin carious lesions presented buccal-lingual/palatal dimension until 4.5 mm and cervical-occlusal height higher than 3.5 mm. Moreover, most lesions (60.5%) presented the cervical margins above the CEJ.

Table 1. Descriptive analysis of the sample according to the clinical and digital assessments and cervical margin location (N=200).

Characteristics of the Sample	N (%)
Clinical Dimensions	
Buccal-Lingual/Palatal	
≤ 4.5	146 (73.0)
> 4.5	54 (27.0)
Cervical-Occlusal	
≤ 3.5	107 (53.5)
> 3.5	93 (46.5)
Digital Measurement	
Buccal-Lingual/Palatal	
≤ 4.5	105 (52.5)
> 4.5	95 (47.5)

Cervical-Occlusal	
≤ 3.5	74 (37.0)
> 3.5	126 (63.0)
Cervical Limit	
Above the CEJ	121 (60.5)
Below the CEJ	79 (39.5)

There was a strong correlation between clinical and digital methods for all measurements (cervical-occlusal height: r=0.90, buccal-lingual/palatal width: r=0.95; p=0.000). The thresholds for each method were shown by the best sensibility, specificity, and Az values (Table 2).

Table 2. Cut-off points of the clinical and digital assessments.

Cervical Margin Location	Cut-off Points	Sensitivity	Specificity	Az[a]
Clinical Assessment				
Vestibular-Lingual/Palatal	4.5	0.962	0.636	0.923
Cervical-Occlusal	3.5	0.975	0.686	0.946
Digital Assessment				
Buccal-Lingual/Palatal	4.5	0.100	0.554	0.948
Cervical-Occlusal	3.5	0.987	0.587	0.946

[a]Az: area under ROC curve.

Regression analysis results are shown in Table 3. Cavitated dentin carious lesions with buccal-lingual/palatal width higher than 4.5 mm and cervical-occlusal height higher than 3.5 mm had a lower chance of presenting the cervical limit above the CEJ, irrespective of the measurement method.

The statistical power of the study was calculated through differences in the mean of probe and image method between the outcome categories: cervical limit above the CEJ (mean 3.95, DP 1.31, n=121) and below the CEJ (mean 6.37, DP 0.89, n=79), through a 95% confidence interval. Statistical power was 100%.

Table 3. Regression analysis to identify possible associated factors with outcome.

Variables	Above the CEJ Unadjusted		Above the CEJ Adjusted	
	OR[a] (95% CI[b])	p-value	OR (95% CI)	p-value
Clinical Assessment				
Buccal-Lingual/Palatal		0.000		0.011
≤ 4.5	1		1	
> 4.5	0.02 (0.00-0.06)		0.11 (0.02-0.60)	
Cervical-Occlusal		0.000		0.009
≤ 3.5	1		1	
> 3.5	0.02 (0.01-0.06)		0.19 (0.06-0.66)	
Image Method				
Buccal-Lingual/Palatal		0.000		0.000
≤ 4.5	1		1	
> 4.5	0.02 (0.00-0.05)		0.06 (0.02-0.21)	
Cervical-Occlusal		0.000		0.004
≤ 3.5	1		1	
> 3.5	0.01 (0.00-0.06)		0.03 (0.00-0.34)	

[a]OR: Odds Ratio; [b]CI: Confidence Interval.

Discussion

Controlling approximal caries lesions is a challenge in the paediatric clinic, especially due to the difficulty of the mechanical control of biofilm on such surfaces. In addition, the greater susceptibility to caries experience of the proximal surface [4] linked to the faster progression rate for enamel to reach the dentin in

primary teeth results in a high prevalence of cavitated dentin caries lesions [18]. Thus, restorative procedures are commonly needed to arrest these lesions and re-establish the anatomy.

The decision-making process involves clinical and radiographic examinations to determine the occlusoproximal cavitated carious lesions' extension and depth. Anatomical particularities of the primary molars, such as greater mesial-distal diameter than the cervical-occlusal dimension that results in shorter clinical crowns heights and broad and flattened contact areas, make the restorative procedures challenging [9]. Moreover, carious lesions are frequently extended to or below the CEJ, leaving little or no enamel at the cervical margin. In this study, it was assumed that establishing clinical parameters to predict the CEJ location might help the professional in the decision-making when treating occlusoproximal cavitated carious lesions in primary teeth. This is the first study that evaluated the relationship between the cavity dimensions in dentin carious lesions on occlusoproximal surfaces of primary teeth with the cervical limit location using a periodontal millimeter probe. Digital assessment of the cavities dimensions with a digital image-processing program was used as a reference standard to validate the clinical method.

The categorization of the thresholds (cut-off point) for buccal-lingual/palatal width and cervical-occlusal height was determined by sensitivity, specificity, and the areas under the receiver operating characteristics curves (Az) for the two methods. Also, the correlation between clinical and digital methods for all measurements was strong. The results showed that cavitated dentin carious lesions with buccal-lingual/palatal width higher than 4.5 mm and cervical-occlusal height higher than 3.5 mm had a lower chance of presenting the cervical limit above the CEJ irrespective of the measurement method.

Although the restorative procedures success depends on several factors, such as the number of restored surfaces [19], operator skills [20], individual caries risk [19,21] and child behaviour [21] during dental care, considering occluso-proximal composite resin restorations factors related to cavity morphology are also important [22].

Secondary caries lesions are commonly located at the gingival margin of these restorations, probably because not only of the easy plaque accumulation in this area but also for technical reasons such as hard visibility and moisture control, proper bonding procedures and composite resin application [22]. According to the results of this study, in cavitated carious lesions presenting buccal-lingual/palatal width higher than 4.5 mm or cervical-occlusal height higher than 3.5mm, the chance of the cervical limit being below the CEJ, i.e., positioned subgingivally is high, probably increasing the chances of restorative failures.

Even different restoratives approaches are available such as conventional restoration with resin composite, compomer or resin-modified glass ionomer cement, atraumatic restorative treatment (ART) using high-viscous glass ionomer cement, or use of preformed crowns, a higher success rate has been shown when using the Hall technique for treating occlusoproximal carious lesions in primary teeth than conventional restorative treatment [16]. This management strategy slows caries progression only via cavity sealing, explaining the positive performance on the occlusoproximal cavities. Moreover, as the crowns extend slightly subgingivally, the cervical limit would not be as critical to treatment success as when performing conventional restorative procedures. Thus, considering the obtained results, clinicians should opt to use preformed metal crowns or even tooth extraction when cavity dimensions are greater than 4.5 mm in buccal-lingual/palatal width or than 3.5mm in cervical-occlusal height.

Finally, it is relevant to emphasize the limitations of the present study. Extracted primary molars presenting cavitated dentin carious lesions were selected from a human teeth pool and the evaluations may not reflect exactly the clinical conditions. However, in an attempt to simulate the clinical condition, we included the

teeth in a dental arch model for evaluation with a millimeter probe. Photographs were taken considering direct visualization of the carious lesions to validate the cavity dimensions by digital measurement. In addition, some teeth could be having pulp involvement due to carious lesions' dimensions, being endodontic treatment needed before restorative approaches. However, we assumed that any restorative approach would be necessary, irrespective of the pulp involvement. Further clinical studies evaluating the relationship of these clinical measurement cut-off points with the decision to treat occlusoproximal carious lesions in primary teeth are necessary to determine an assistant clinical parameter for restorative decision-making.

Conclusion

The cervical-occlusal and buccal-lingual/palatal dimensions of cavitated dentin carious lesions in occlusoproximal surfaces of primary teeth could be used to predict the location of CEJ.

Authors' Contributions

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JCPI	https://orcid.org/0000-0002-1990-2851	Conceptualization, Writing - Review and Editing.
ROR	https://orcid.org/0000-0001-7737-2257	Writing - Review and Editing.
FRO	https://orcid.org/0000-0003-0759-9661	Formal Analysis, Writing - Review and Editing.
TLL	https://orcid.org/0000-0003-3568-5217	Conceptualization, Methodology, Investigation, Data Curation, Writing - Review and Editing, Supervision.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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