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Accuracy of In Vitro Radiographs in Determining the Remaining Dentin Thickness below Deep Dentin Caries in Deciduous Molars

SUMMARY

Background/Aim: *The determination of remaining dentin thickness (RDT) is quite critical in providing appropriate treatment indications especially in deciduous molars. The aim of this study was to investigate the accuracy of in vitro pre-operative radiographs before caries removal in RDT measurement.* ***Material and Methods:*** *This in vitro study was conducted with 30 lower deciduous second molars with deep approximal dentinal caries. Following the standardized digital radiographs were obtained, RDT was measured by determining the closest distance between the carious lesion and the pulp chamber on the computer software. After caries removal, the samples were sectioned in mesio-distal direction and photographed. RDT was measured on photographs similarly to radiographic measurements. In statistical analysis, Interclass Correlation Coefficient (ICC), Wilcoxon-Signed and Bland Altman Plot (BAP) tests were performed to determine the agreement and statistically difference.* ***Results:*** *The mean RDT value in photographs was found to be 10% higher than measured on radiographs. Although, correlation coefficient was within confidence interval, both RDT values showed good but not excellent agreement (correlation coefficient= 0.812). Also, BAP test did not demonstrate strong agreement. In descriptive statistics, significant difference was found between two measurements ($p<0.05$).* ***Conclusions:*** *Pre-operative radiological examination can not alone provide reliable results regarding the accurate determination depth of caries lesions. Clinicians should also consider operative diagnostic criteria for appropriate treatment options in deciduous teeth.*

Key Words: Dentin, Diagnosis, Digital Radiography, Deciduous Teeth

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Introduction

Minimally invasive approaches are the new paradigm in health care[1]. The philosophy of modern dentistry is based on keeping the teeth structures healthy and functional. As a part of minimal intervention dentistry, minimal invasive restorations or approaches are essential. According to this modern conception, main goal is to maintain the teeth in the dental arch by providing pulpal vitality or tooth survival[1-3]. The objective is tissue preservation which means performing treatment with as little tissue loss[1]. This expresses a quite precise excision of what has to be removed, without causing any injury to adjacent dental tissues. Therefore, excessive dentin tissue removal should be avoided as possible[1,4]. New treatment concepts include that affected dentin should be left and even in some cases carious tissue could be left before sealing the cavity[3]. Starting from this point, the remaining dentin thickness (RDT) below the deep carious lesion is quite critical for the appropriate treatment decision, and it is stated that RDT is the most valuable predictor of status of the pulp[5,6].

Up to the present, it would appear that only caries lesion depth, and not site, has been investigated as a indicator of pulpal status and reactions[7]. It is reported that RDT influences underlying pulp tissue vitality in permanent

premolar teeth. As RDT decreases, the inflammatory mediators in the pulp tissue increase and the pulpal reactions initiate. In caries lesion with a RDT of <0.25 mm, the number of odontoblast cells are significantly reduced in pulp-dentin complex[8]. In this case, although the increase of odontoblast-like cells, only the reparative dentin produced by these cells can not provide a sufficient defensive response against possible pulpal damage in deep cavities[8]. Berbari *et al.*[5] also reported that RDT is an important clinical factor that should be assessed in decision making for pulpotomy indication in deciduous molars. Therefore, since RDT is directly effective in protective pulpal reactions and treatment decision, it should be determined as accurately as possible prior to the treatment procedures[8,9].

Radiographic techniques are the most easily accessible determination methods for the clinicians[10]. However, two-dimensional radiographs are inadequate in determining the exact extent of caries lesions, although well indicate the localization especially in deep cavities[6,11]. Therefore, it is quite important to determine how reliable the radiographs in understanding the localization and depth of caries lesions[6,9].

The objective of this study is to assess the measurement accuracy of radiographs in determining RDT between the carious lesion and the pulp tissue in deciduous molar teeth prior to caries excavation.

Material and Methods

Ethical Approval

This study has followed the CRIS guidelines for *in vitro* studies as discussed in the 2014 concept note. The study protocol was approved by the Ethics Committee of Ankara University, Faculty of Dentistry (approval number: 03/14). All the procedures of the study were performed based on the Declaration of Helsinki. In addition, the written informed consent forms were signed by the parents of the patients whose previously extracted teeth were used.

Sample Size Determination and Tooth Selection Criteria

The power analysis was performed to determine the sample size. To determine the differences between the radiographic and photographic measurements, a power calculation (effect size: 0.55) indicated that a minimum of 28 deciduous molar teeth were required to detect a significant difference between both measurements (80% power and 5% type I error). Therefore, the present study was performed by using 30 lower second deciduous molar teeth that were previously extracted due to any indications. The including criteria for deciduous molar teeth were in the following: with deep approximal dentinal caries, with no pulpal exposure and previously had not been restored. However, teeth with caries on lingual or buccal surfaces in addition to aproximal surfaces and teeth with pulpal exposure during caries excavation were excluded from the study.

Procedure

The extracted deciduous molars were stored in 0.9% physiological saline solution before the study procedures. After that, teeth were immersed in 2.5% sodium hypochlorite solution for 48 h to remove periodontal ligament residues and organic tissue remnants and washed under tapping water. In the preparation of the samples, the teeth were embedded in acrylic blocks to position the crowns at a certain distance from the cone of X-ray device (Belmont, Phot-x II, Takara Company, Canada). The samples were placed on a table at 22 cm distance from the cone of X-ray device. In obtaining digital radiographic images phosphor plates size #1 (Gendex Dental Systems, Zurich, Switzerland) were used and the exposure time was 0.15 sec for all the samples. Additionally, metal ring (inner and outer diameter were 3 and 6 mm, respectively) was included in the images in order to calibrate and standardize the measurements.

Digital radiographic images were transferred to a computer software (Digimizer, MedCalc Software Ltd, Belgium) for measurements. In radiographic RDT measurement, the closest distance between the carious lesion and the pulp chamber was measured. This measurement was performed by marking the deepest point of the caries lesion and the closest point of the pulp to caries and determining the distance between the two mentioned points on the computer software. After this procedure, the measured values were recorded as RDT (Figure 1). Following that, carious lesion was removed with a sharp dental excavator to affected and hard dentin based on the tactile sensation by the same operator. The teeth were sectioned into two halves using a dental separator in the mesio-distal direction passing through the deepest point of the cavity. The photographic images of the divided tooth halves were captured with a digital single reflex camera (Canon EOS 1200D, Tokyo, Japan) with a macro lens (Sigma 105 mm. F2.8 EX DG OS Macro HSM, Tokyo, Japan) and the images were transferred to the software for RDT measurements. Similar to obtaining radiographic images, previously mentioned metal ring was included in the images. Photographic measurements were performed by determining the closest distance between the carious lesion and the pulp chamber similarly to radiographic measurements (Figures 2a and 2b). Finally, the photographic RDT values were recorded for the statistical analysis.



Figure 1: Radiographic measurement of RDT on digital radiograph.

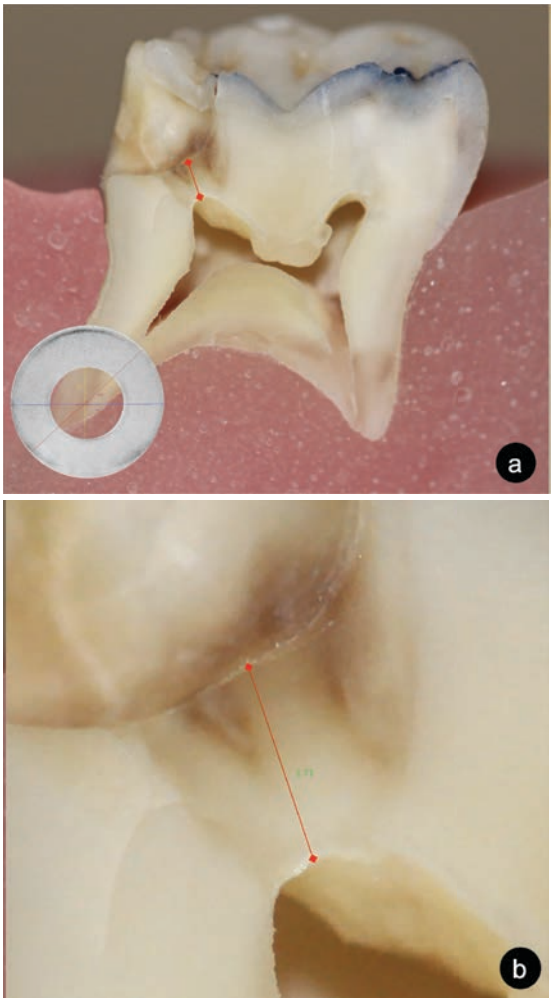


Figure 2: Photographic measurement of RDT on macro photograph (a) and magnification image of RDT (b).

The radiographic and photographic measurements were made by the same operator two times at 1 h intervals and the higher measurement value was recorded. Intra-examiner validity for the measurements was verified by a kappa test and test values ranged from 0.8 or above, demonstrating good reliability.

Statistical Analysis

Since it was considered that photographic RDT measurements reflect more realistic and actual values, the correlation and agreement tests would yield more reliable analysis in order to determine the consistence between both measurements. In this regard, InterClass Correlation Coefficient and Bland Altman Plot tests were done to analyze the agreement between both measurements Additionally, Wilcoxon Signed Rank Test was performed to determine statistically significant differences between both RDT measurements.

Results

In the present study, according to agreement analysis results between both measurement groups, the confidence intervals were found as shown in Figure 3. Although the most measurements were within the confidence interval, the presence of measurement values out of the confidence interval showed that there was no strong agreement in Bland-Altman test. Similarly, Interclass Correlation Coefficient test presented good but not excellent agreement between two measurements (Table 1).

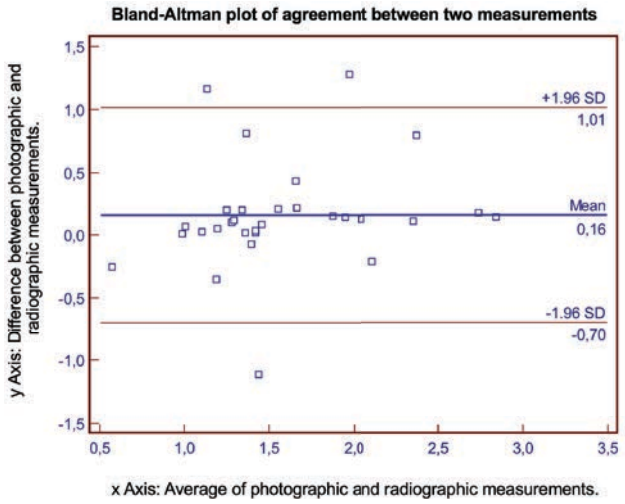


Figure 3: Confidence interval for agreement analysis (Bland Altman Plot test) for radiographic and photographic measurements (x axis: the average of photographic and radiographic measurements, y axis: the difference between photographic and radiographic measurements, SD: standart deviation).

Table 1. Confidence interval and correlation coefficient (ICC test) value for both measurements

	Interclass Correlation Coefficient	95% Confidence Interval	
		Lower Limit	Upper Limit
Radiographic and photographic measurements	0.812	0.609	0.910

According to the results of the descriptive statistics test (Wilcoxon-Signed Rank test) between both measurements, the mean RDT value in photographic measurements was found to be higher than the measured on the radiographs. Statistically significant difference was found between the two measurement techniques ($p<0.05$) (Table 2).

Table 2. Descriptive statistic analysis for both measurements.

	Photographic Measurements (n=30) mm	Radiographic Measurements (n=30) mm	Difference	p value
Mean	1.66	1.50	0.15	
Std. Deviation	0.61	0.53	0.43	
Median	1.47	1.40	0.11	**0.008***
Minimum	0.45	0.55	1.11	
Maximum	2.91	2.77	1.28	

*$p<0.05$ indicates statistically significant difference.

Discussion

Accurate and timely diagnosis of dental caries is quite critical in decision making the appropriate treatment planning and technique[12,13]. The detection of the extension of the aproximal caries is challenging, especially due to limitations of the direct clinical examination in posterior teeth[14]. In this respect, radiographic examination is essential in determining the localization and extent of the caries lesions and estimating the proximity of caries to the pulp tissue, especially in deep lesions[6].

Dental tissue thicknesses such as enamel and dentin in deciduous teeth are thinner and more porous than the permanent teeth, and the closer proximity of the pulp chambers to the outer surface causes the dental caries to progress rapidly. Therefore, before the treatment planning, radiographical detection of RDT is crucial in differential diagnosis for restorative or endodontic treatment decision in carious deciduous teeth[9,12]. Although, Berbari *et al*.[5] reported that RDT alone can not provide sufficient information regarding the immuno-bacteriological status of the pulp tissue, when the RDT reduces to less than 0.3 mm, it has been reported that the inflammatory responses begin in the pulp-dentin complex[8]. RDT also acts as a protective barrier to prevent the noxious and toxic materials into the pulp tissue[8]. Al Jhany *et al*.[9] reported that in their study conducted on posterior permanent teeth, RDT determination should be performed for efficient caries removal and it would be beneficial for dental students to determine the constant relationship between radiographic RDT and actual RDT measurement. Since RDT was reported to be so critical in maintaining the pulp vitality and making the appropriate treatment decision, in this study it was planned to investigate the correlation between RDT detected in *in vitro* periapical radiographs and the sound RDT after caries removal.

In the present study, extracted lower second deciduous molar teeth including approximal deep dentin caries were used to ensure standardization. Kassa *et al*.[7] reported that deciduous molars with approximal cavities extending more than a half through dentine layer appear to have more inflammatory changes than occlusal lesions with a similar depth. As authors, we preferred deciduous molar teeth with approximal caries in the present study, considering that RDT determination is more critical in especially approximal lesions. On the other hand, it is clear that digital radiographic techniques have become more popular than conventional/analog radiography because of short exposure time, ease of use and the advantages of providing digital measurements by a computer software[6,14]. Therefore, in this study, digital radiography was preferred to measure RDT with the minimum error on *in-vitro* radiographs.

To date, RDT measurements on radiography have been performed with several various methods[6]. These include the use of millimeter grids superimposed on the radiographic images, scales with different scores, ultrasonic micrometers, direct calipers, electrical methods and the computer-aided systems[15-20]. In this study, digital radiographs were transferred to the computer software to obtain more precise measurements.

In carious dentin, there are two layers with different structure; soft and bacterial-infected layer and partially demineralized affected hard dentin layer which has remineralization potential[21]. While the infected dentin is the outer and bacterial-infected surface of carious lesion[22], affected dentin tissue is partially demineralized and intertubular dentin contains porosity because of the loss of mineral contents[23]. Caries detection dyes may be used to differentiate these two different dentin layers for effective caries removal[24,25]. However, when using the dyes, the dentin tissue -that should not be removed- is also stained with light pink appearance. It has been stated that there are no objective clinical markers in the use of caries detection dyes, because it is not always clear to know at which point to stop excavation[25]. Hosoya *et al.*[24] emphasized that these dyes should not be used in deciduous teeth. Therefore, in the present study, infected and soft dentin was removed using a sharp dental excavator based on the tactile sensation principle by the same operator.

In statistical analysis, instead of only descriptive analysis, the agreement analysis were also applied between both measurement groups. According to the results obtained in the present study, the mean RDT values for photographic measurements were higher than radiographic ones. The significant difference in the descriptive statistics tests ($p<0.05$) and the lack of excellent agreement between two measurement groups confirm these findings. In RDT measurements, the present results showed that an average of approximately 10% of radiographs underestimation compared with the macrophotographs. Our findings coincide with the study of Berbari *et al*.[6]. Similarly, the authors stated that RDT measured in radiographs was less than photographic measurements. It was also reported that this difference occurred due to the misinterpretation because of the radiograhic projection of the demineralized dentin walls and the bottom areas of the carious cavity, and the radiographic depth of the cavity was perceived in greater amounts than the photographic images. However, in a study of Al Jhany *et al*.[9] on permanent premolars and molars, in comparison of RDT measurements between the pre-excavation radiography and after excavation photography, in contrast to our study, the mean radiographic RDT value was found higher than actual mean RDT value on photographic measurements. The authors stated that, determining a constant relationship between radiographic RDT and actual RDT measurements still remain a challenge.

Conclusions

The fact that the pulp chamber is close proximity to the outer surface in deciduous teeth may result pulp exposure especially in deep approximal caries lesions. Therefore, in cases where it is difficult to make a treatment decision between restorative and endodontic procedures, clinicians should not decide based only on the radiological examination. Otherwise, excessive dentin tissue removal or unnecessary endodontic treatments and loss of pulp vitality may be encountered. As authors, we suggest that operative diagnostic data should be considered in addition to radiological examination and the clinicians should be precautionary regarding making a treatment decision. In addition, further studies are required for obtaining reliability of RDT measurements.

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