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Dentistry

ESTIMATION OF REMAINING DENTIN THICKNESS UNDER DENTIN CARIES WITH CBCT, RADIOGRAPHS AND DIGITAL CALIPER IN PERMANENT TEETH - AN INVITRO STUDY.

Dr. Ashwini Chavan	Post-graduate Student, Department of Conservative Dentistry and Endodontics, Dr. Hedgewar Smruti Rugna Seva Mandal's Dental College and Hospital, Hingoli.
Dr. Sushil Kumar Cirigiri*	Professor and HOD, Department of Conservative Dentistry and Endodontics, Dr. Hedgewar Smruti Rugna Seva Mandal's Dental College and Hospital, Hingoli*Corresponding Author
Dr. Shachi Goenka	Reader, Department of Conservative Dentistry and Endodontics, Dr. Hedgewar Smruti Rugna Seva Mandal's Dental College and Hospital, Hingoli
Dr. Mirza Aslam Baig	Senior Lecturer, Department of Conservative Dentistry and Endodontics, Dr. Hedgewar Smruti Rugna Seva Mandal's Dental College and Hospital, Hingoli
Dr. Rajiv Khode	Reader, Department of Conservative Dentistry and Endodontics, Dr. Hedgewar Smruti Rugna Seva Mandal's Dental College and Hospital, Hingoli

ABSTRACT **Background:** In order to avoid damaging the dental pulp from mechanical injury and inflammatory agents, operators are recommended to remove just infected dentin while maintaining affected and sound dentin. As a result, maximum dentin tissue must be preserved. This study aims to identify a logistic and accurate link between the amounts of actual remaining dentine thickness and the radiographic remaining dentine thickness before starting caries excavation, thereby lowering the incidences of post-operative sensitivity and direct pulpal exposure. **Material and Methodology:** In a three-stage experiment, 24 extracted human teeth were evaluated using three different techniques: digital radiography(RVG), cone beam computed tomography(CBCT), and using digital caliper after hand excavation of any remaining caries. The results were compared and statistical analysis was performed for each tooth. **Statistical analysis:** The difference among the groups was analyzed by post hoc Turkey and analysis of variance tests. A $P < 0.05$ was considered statistically significant. **Results:** The results indicated no significant difference between actual clinical (digital caliper) and CBCT measurements (P=0.054) but a significant difference was found between actual clinical and periapical radiographs. **Conclusion:** It is imprecise to estimate the remaining dentine thickness using routine periapical radiographs; a reliable and affordable method still has to be developed.

KEYWORDS : CBCT, Digital caliper, Digital radiographs, Remaining dentine thickness.

INTRODUCTION:

Dental caries is still the most common chronic disease on the globe. Being an infectious microbial disease, the frequency of its occurrence is high. To avoid damaging the dental pulp, dental caries must be eliminated as soon as possible. Delaying therapy for an extended period of time will result in the tooth lost.[1]

Operators are recommended to follow the carious lesion's shape and remove just infected dentin while maintaining affected and sound dentin, changing Black's core notion of extension for prevention to minimal intervention dentistry.[2]

It is of utmost importance for minimal invasive dentistry to emphasis on estimating the residual dentin thickness below the carious lesion.[3] The aim is tissue preservation, which implies minimizing tissue loss during therapy. As a result, maximum dentin tissue must be preserved.[3] The right distance should be determined to avoid pulp injury and ensure pulp preservation and conservative treatment.[4]

Remaining dentine thickness (RDT) is the thickness of healthy dentine between the pulpal floor and the roof of the pulp chamber.[3] The thickness must be retained because it serves as a barrier to protect the pulp from mechanical injury and inflammatory agents. According to Stanley, 2 mm of RDT helps protect teeth during dental treatments.[5] Pameijer et al demonstrated that a layer of RDT of 1 mm or more might protect the pulp tissue from the cytotoxic effects of zinc phosphate cements.[6] The quantity and size of open dentin tubules are comparable to a true pulpal exposure in very deep cavities with an RDT of 0.5 mm, according to Smith.[7] To avoid pulp damage, Murray et al[8] found that a thickness of 0.5 mm or greater is required. If the RDT falls below 1.5 mm, the pulp is more sensitive to the cytotoxic effects of dental materials.[4] The pulp's health is influenced by the quality of the surviving dentine.

Today, caries excavation is primarily based on dentists' experience of assessing cavity depths by watching colour changes in the prepared cavity with or without the use of radiography.[3] To test RDT, a number of procedures have been created, including radiography, prepometer, electrical resistance, tool maker microscope with a muffle device, and micro-computed tomography.[4] Due to their low resolution, conventional radiographs can only provide a general estimate of RDT. Digital radiography, on the other hand, use more sensitive plates and produce clearer, sharper images. If utilized properly, it is the most accessible and accurate method available to the dental practitioner.[4]

Finding a correlation between actual remaining dentine thickness and radiography remaining dentine thickness can considerably improve clinical abilities in the management of deep carious lesions.[3]

This study aims to identify a logistic and accurate link between the amounts of actual remaining dentine thickness and the radiographic remaining dentine thickness before starting caries excavation, thereby lowering the incidences of post-operative sensitivity and direct pulpal exposure.[3]

Materials and methods:

Inclusion criteria:

1. Permanent posterior teeth
2. Carious lesions not involving pulp (radiographic base)
3. Tooth extracted due to orthodontic purpose and periodontal reason having some extent of carious lesion.

Exclusion criteria:

1. Fractured tooth
2. Deep carious lesions reaching the pulp (Radiographic base)

Methodology:

24 extracted permanent human teeth including premolars and molars were collected from the oral surgery department of institute.

They were decontaminated prior to storage in a solution of 1:10

sodium hypochlorite for 30 minutes according to the safety guidelines of disease and infection control of CDC. Then the extracted teeth were stored in 0.9% saline solution before the study procedures.

Digital Radiography (RVG) measurement:
Digital images were taken for each tooth using Carestream Sensor and Carestream software at 90-degree angulation with an exposure time of 0.16ms and 70kv in buccolingual dimension using Parallel angle technique through standardization by using parallel ring holder with maintaining a distance of 10 cm between ring holder and cone. Radiographs are measured in Carestream software from the deepest point of the remaining dentine on the floor of the lesion to the pulp dentine border of the nearest (Figure 1)

Fig 1: Digital radiograph measuring RDT of the tooth through specialized software is 1.1 mm

Cone beam computed tomography (CBCT) measurement:
Teeth were mounted in modeling wax to the level of the cement-enamel junction and for reference purpose teeth were encoded with a number over modeling wax. All the teeth were scanned by using Carestream CS9600 (Carestream Dental, USA) CBCT machine using a field of (10 x 10) cm and 25 µsv. Each mould was secured to the chin support horizontally so that the occlusal plane is parallel to the plate. CBCT images through Carestream software were measured from the deepest point of the remaining dentine on the floor of the lesion to the pulp dentine border (Figure 2).

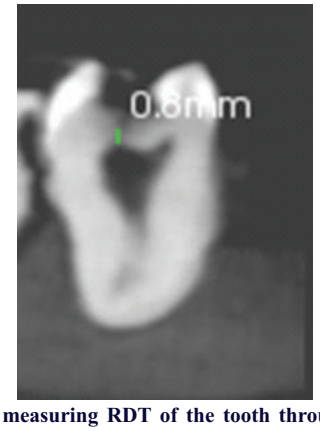

Fig 2: CBCT measuring RDT of the tooth through specialized software is 0.8 mm

Digital caliper measurement-
Before the actual clinical measurement, the infected soft dentin was completely excavated with small and medium size hand excavators to the point which was firm to moderate for excavation force application and clinically accepted by the operator. For actual clinical measurement, a diamond cutting disc (Skill-bond, High Wycombe, UK, Sintered Diamond Disc, size 400, 1/10 mm set 638R1) was used to slice the tooth in the mesiodistal plane (Figure 3). After every fifth tooth, the disc was replaced. Water from the 3-way syringe was continuously used as a coolant. The actual remaining dentine thickness was measured directly on the sectioned tooth using a digital caliper.

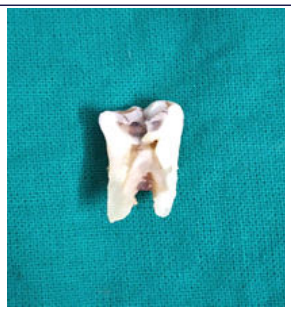

Fig 3: Tooth after sectioning in Mesiodistal plane and hand excavation of infected dentine

Statistical analysis:
All the obtained data was collected, tabulated, and entered in MS excel and analyzed by using SPSS version 25.0 software 2017. One-way Analysis Variance was used to assess intergroup comparison. Post hoc Tukey's test was used for statistical analysis.

Results:
This study consisted of 24 extracted permanent human teeth including; carious lesion distributed on different surfaces which consist of 11 occlusal surface and 13 smooth surface caries samples.

For each tooth, three Measurements were taken that include actual clinical evaluation, digital radiographs (RVG), and CBCT (Table 1). The mean measurement for RVG was 0.48 mm with a standard deviation of 0.19 mm and a range of 0.20 mm - 0.90 mm. The mean measurement for CBCT was 0.42 mm with a standard deviation of 0.18 mm, and a range of 0.15mm – 0.80 mm. The mean measurement for digital caliper was 0.41 mm with a standard deviation of 0.17 mm and a range of 0.15 mm – 0.75 mm. Within the limitation of this study, according to descriptive statistical test results,

1) The mean RDT value of digital caliper was found to be lower than the measured on the CBCT and Digital radiographs.

2) The results indicated no significant difference between actual clinical (digital caliper) measurement and CBCT measurements (P=0.054) but a significant

Table 1: Descriptive Statistics of different groups

Descriptive Statistics					
Method	N	Minimum	Maximum	Mean	Std. Deviation
RVG	24	0.20	0.90	0.48	0.19
CBCT	24	0.15	0.80	0.42	0.18
Digital calliper	24	0.15	0.75	0.41	0.17

Table 2: Pairwise multiple Intergroup comparison of RDT between different groups

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	P value
RVG	CBCT	0.05625	0.05369	0.050*
	Digital cal	0.07042	0.05369	0.030*
CBCT	RVG	-0.05625	0.05369	0.050*
	Digital cal	0.01417	0.05369	0.054
Digital caliper	RVG	-0.07042	0.05369	0.030*
	CBCT	-0.01417	0.05369	0.054

Post hoc tukey test; * Indicates significant difference at p≤0.05

difference was found between actual clinical measurement and RVG measurement (p=0.030) and between CBCT and RVG measurement (p=0.050) (Table 2).

The Intraclass Correlation Coefficient test presented good but not an excellent agreement between the two measurements.

Discussion:
The ability to make an accurate and timely diagnosis of dental caries is crucial in determining the best treatment plan and technique.[9] In this regard, radiographic assessment is essential for evaluating the location and extent of caries lesions, as well as calculating the distance between

caries and pulp tissue, particularly in deep lesions.[10] Once dentine is involved, caries spreads quickly and approaches the pulp chamber. As a result, radiographic detection of RDT is critical in the differential diagnosis for restorative or endodontic treatment decisions in carious teeth before treatment planning. Berbari et al. reported that although RDT alone cannot offer significant information on the immuno-bacteriological status of the pulp tissue, it has been observed that inflammatory responses begin in the pulp-dentin complex when the RDT drops to less than 0.3 mm.[11] RDT also serves as a barrier to keep unpleasant and harmful elements out of the pulp tissue.[11] RDT determination should be conducted for effective caries removal, and dental students would benefit from learning the consistent correlation between radiographic RDT and actual RDT measurement. Because RDT is thought to be so important in maintaining pulp vitality and determining the best treatment decision, the goal of this study was to see if there was a link between RDT observed in in-vitro radiographic technique and sound RDT following caries removal.

Because of the quick exposure time, convenience of use, and benefits of delivering digital measurements through computer software, digital radiographic procedures have grown more common than traditional/analog radiography. Therefore, in this study, digital radiography such as radiovisiography (RVG) was preferred. Different methods have been proposed in measuring the remaining dentine in the carious lesion. In order to evaluate the depth of proximal lesions, Everett and Fixott[12] and Krithika et al[13] suggested projecting a millimeter grid onto the film, and Russell and Pitts[14] created a five-point radiographic grading scale based on the degree of the dental tissues' radiolucency. In order to better accurately quantify the depth of breakdown, Valizadeh et al.[15] set out to develop software. Yet there are greater difficulties when attempting to gauge the magnitude of the lesion.

According to Lancaster, Craddock, and Carmichael's (2011) study, a standard digital periapical radiograph cannot accurately predict the size of the RDT.[16] In this investigation, cone beam computed tomography was used as it is effective for localization and characterization of root canals, treatment planning of periapical surgery, and identification of root fractures in extracted teeth.[17]

A digital caliper commonly referred to as a digital vernier caliper, is a very accurate measuring tool that may be used to measure both interior and external distances. A screen with a liquid crystal display is used to read measurements.[4] For actual clinical measurement, the measurements were taken from the pulp dentine border to the thinnest point of remaining dentine on the lesion's floor.

There are two distinct layers in carious dentin: a soft, bacterial-infected layer and a partially demineralized infected hard dentin layer with remineralization potential.[18] For successful caries removal, caries detection dyes can be employed to distinguish between these two dentin layers. However, when the dyes are used, the dentin tissue, which should not be removed, is tinted light pink. Because it is not always evident when to stop excavating there are no objective clinical markers in the use of caries detection dyes. As a result, diseased and soft dentin was removed using a sharp dental excavator based on the tactile sensation concept by the same operator in the current investigation.

After analyzing the results, we discovered that, as periapical radiographs are the most commonly used method for judging the depth of lesions, they are not reliable in determining the extent of caries; however, CBCT measurements were more in line with the actual clinical measurements. Although it may not be practical to take CBCT for each case in our daily routine to aid in our diagnosis and decision makings, it appears to be a more valuable adjunct to our clinical judgments. Rozhyna Peshraw Kamal,[3] et al examined remaining dentine thickness after caries excavation by digital radiography, cone beam computed tomography, and microscopically after hand excavation of remaining caries where they evaluated that actual clinical measurements and CBCT measurements did not differ significantly from one another (P=0.98); however, actual clinical measurements and periapical radiographs did differ significantly.

AL Jhany et al,[4] in 2019 compared the radiographic remaining dentine thickness with the actual thickness below the deep carious lesions on the posterior teeth, where they concluded that a statistically significant difference in the mean values of the radiographic and actual dentine thickness was observed (P<0.05).

Conclusion:

For most dental professionals, from students to specialists, deciding whether to excavate residual caries in mild to deep carious cavities is a daily struggle. According to the investigations, radiographs the method most frequently used to estimate remaining dentine thickness, have been shown to be inaccurate; however, CBCT appears to be more promising in providing accurate measurements, but its not the best choice due to its lower accessibility and higher cost compared to digital radiography. Upcoming developments and technology might make it easier and more convenient for dental specialists to precisely determine the amount of remaining dentin in a way that is quicker and less expensive.

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