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Original Article

VALIDATION OF OPTICAL COHERENCE TOMOGRAPHY: A NOVEL 3- DIMENSIONAL BIOPHOTONICS IMAGING TECHNIQUE TO EXPLORE CANAL LUMEN ANATOMY APPLIED FOR CLINICAL ENDODONTIC PROCEDURES. AN IN VIVO STUDY.

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Abstract:
3-D assessing of intracanal anatomy in the clinical endodontic practice is always challenging. Although computed tomography could visualize intracanal anatomy but, they all use harmful ionized radiation and presented low sensitivity in detection of fine canal anatomy images.

Optical coherence tomography (OCT) is a high-resolution imaging technique that allows micrometer scale imaging of biologic tissues over small distances, uses infrared light waves that reflect off the internal microstructure within the biologic tissues and gives high resolution images. In studies OCT has previously been shown to be a valuable tool in assessing intracanal anatomy, cleanliness of the canal after preparation, and even perforations.

Aim: To evaluate the ability of optical coherence tomography (OCT) to image root canal walls, and to identify confounding factors in root canal treatment. Histological validation of data acquisition for root canal lumen dimensions (area and diameter) obtained from OCT scan**.**

Methodology: Maxillary incisors with poor prognosis for endodontic treatment outcome were scanned for canal lumen dimension using Intra coronary OCT probe modality. The same tooth were extracted, was sectioned to get a total number of 20 slices (n=20). Root canal lumen dimension of each slice was validated and compared histologically, double blindedly using Nikon digital microscope software (NIKON DS –Ri2) with dimensions obtained by OCT scan. The mean data acquired by OCT were correlation with histological slices using co-relation regression test.

Results: A strong correlation was found between the data acquired by using OCT and histology for area of canal lumen r (area) = 0.97, max and min diameter r= 0.95, 0.93 respectively.

Conclusion: Optical coherence tomography is a non-invasive and non-destructive technique for endodontic imaging. It proved to be suitable for analysing the anatomy and cleanliness of root canal walls, and has a high sensitivity and specificity for detection of internal anatomy of canals. OCT generates high-resolution, real-time, intra-canal microscopic images, and holds great potential for in-vivo application.

Keywords: Optical coherence tomography, intracanal imaging, biophotonics, root canal, 3D guided stent.

1. INTRODUCTION

Modern imaging techniques are clinically applied throughout root-canal treatment, however necessary info on inner canal anatomy and dentin thickness remains restricted to in vitro observations. Optical Coherence imaging (OCT) may be a comparatively recent development in diagnostic medical imaging technology that was initial introduced in 1991[1] then, it's become a regular tool in medicine and promising imaging methodology for intracoronary arterial sclerosis detection [2]. Most heart attacks are caused by fulminant ruptures of unstable blood vessel plaques that can't be detected exploitation standard imaging modalities. OCT has the potential to spot these arterial plaques and differentiate stable plaque from unstable, it is a technique for the first identification of channel malignancies, as well as the oesophagus, stomach, associate degreed colon[3]. Recently optical in vivo biopsy, providing microscope-quality pictures during which cell operate may be distinguished, is one in every of the foremost difficult fields of Oct application[4].

Oct uses infrared radiation from a supply with a brief coherence length. The sunshine is scattered by the inner microstructure within the specimen. A reflectivity profile is recorded on the scanned direction exploitation an interferometer: constructive interference happens if the lengths of sample and reference arms are adequate inside the coherence length of the source[5]. The coherence gate is scanned through the sample by dynamic the length of the reference arm. Oct achieves a depth resolution is of the order of ten µm, with associate degree in-plane resolution reckoning on the imaging optics, presumably like the optical microscope, a picture is made from the envelope of the interferogram. By scanning the probe on the imaged specimen whereas deed image lines, a two- or three-dimensional image is made up. In examination Oct imaging, near-infrared light-weight is delivered to the imaged web site (a vessel or a district of the gastro-intestinal tract) through a single-mode fiber. The imaging tip contains a lens-prism assembly to focus the beam and direct it toward the lumen wall. The imaging beam is scanned on the wall by rotating the fiber. The fiber may be backward within a tube sheath to perform a questionable "pullback," permitting the user to form a stack of cross-sections, scanning he investigated vessel lengthwise. Progressive Oct systems reach a 6-mm imaging depth, with 8-µm resolution, at over eighty frames per second Oct potential in medical specialty wasn't overlooked. Oct pictures of arduous and soft tissues within the mouth were compared with microscopic anatomy images exploitation an associate model, showing a superb match[6].

Otis et al[7] mentioned the clear depiction of odontology tissue contour, sulcular depth, animal tissue attachment, and marginal adaptation of restorative materials to dentin, closing that Oct may be a powerful methodology for generating high-resolution, cross-sectional pictures of oral structures. Amaechi et al.[8] and Baumgartner et al.[9] delineate the popularity of decay with OCT. The technique may give dentists with an unprecedented level of image resolution to help within the analysis of periodontal disease, dental restorations, and in the detection of caries.

2. MATERIALS AND METHODS

2.1 In vivo OCT scan of root canal lumen:

In vivo chair side OCT scan was made in tooth indicated for extraction irt 11, 21 with vertical root fracture and endodontic treated tooth with infected root canal, using intra coronary OCT machine with pullback speed was 1 mm/second, and video files were generated at a rate of 10 frames per second FIG 1.

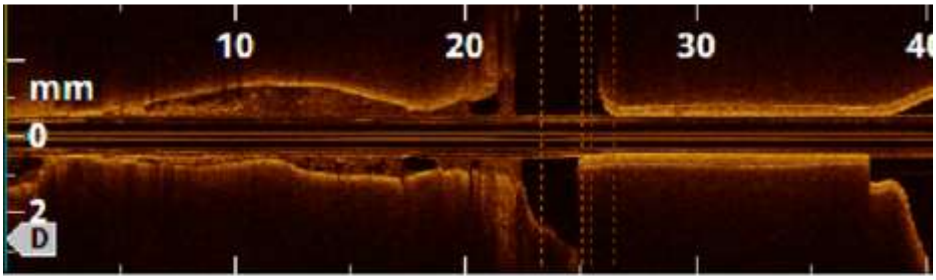

Figure 1: Oct Scan Of 11

2.2 OCT Data Acquisition:

Scanned canal lumen along with dimension for area and maximum and minimum length were obtained at different canal length as shown in FIG 2

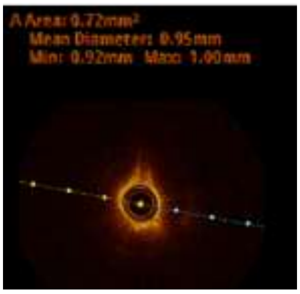

Figure 2: Data Acquisition For Mean Area And Length Of Canal Lumen

2.3 Preparation of tooth section and canal lumen measurement.

20 Section out of two scanned extracted maxillary central incisor were made at different length and data acquisition for length and area measurement was made for histological sections using Nikon DS-Ri2 digital microscope at 5X magnification, as shown in FIG 3, 4 and 5.

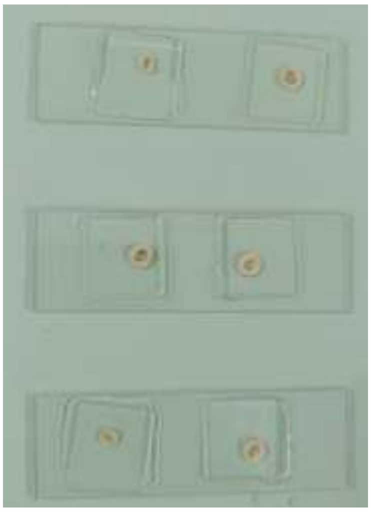

Figure 3: Sectioned Tooth For Histological Examination

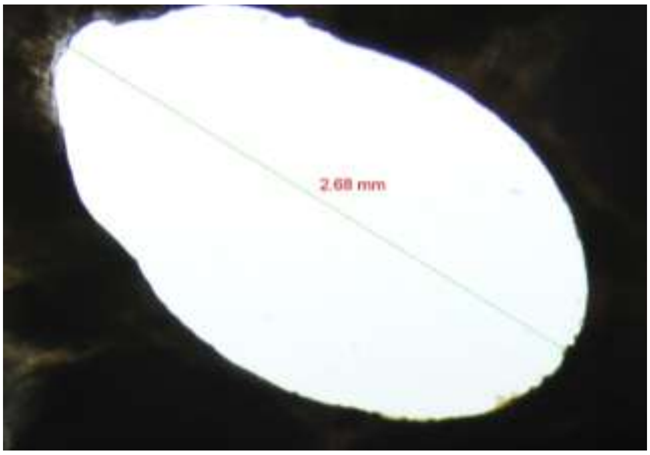

Figure 4: Histological Length Measurement Of Canal Lumen

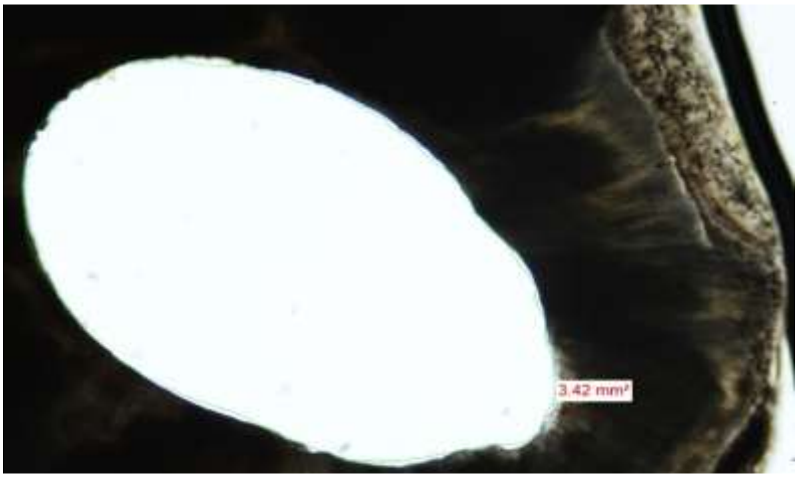

Figure 5: Histological Area Measurement Of Canal Lumen

Correlation of data for root canal lumen measurement for area and length obtained by OCT with histological sections:

Data validation for measurement of length and area with OCT section and histological section was observed for co-relation as shown FIG 6, FIG 7.

Histological canal lumen traced diameter 2.68mm

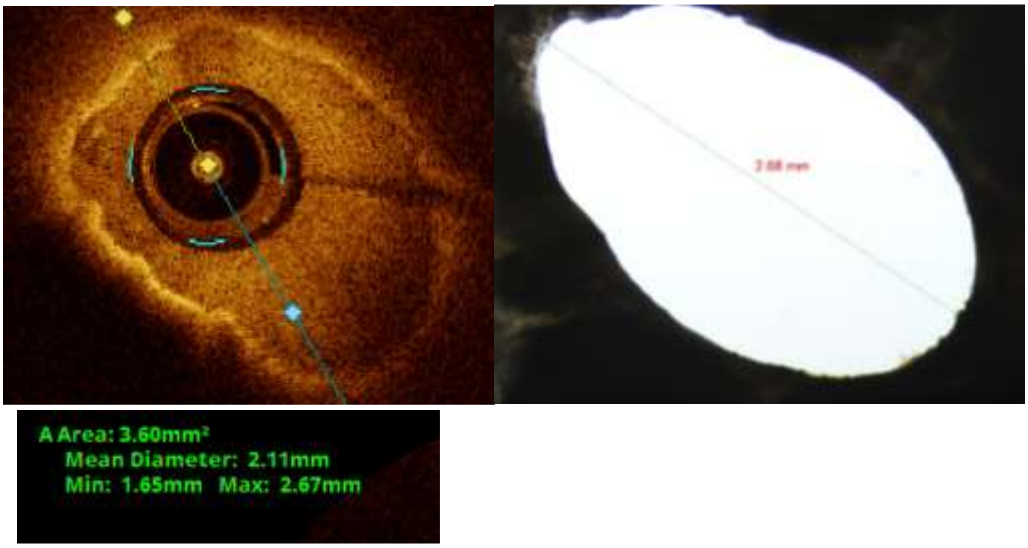

Figure 6: Corelation Of Data For Root Canal Lumen Measurement For Area And Length

Histological canal lumen traced area 3.42 mm^2

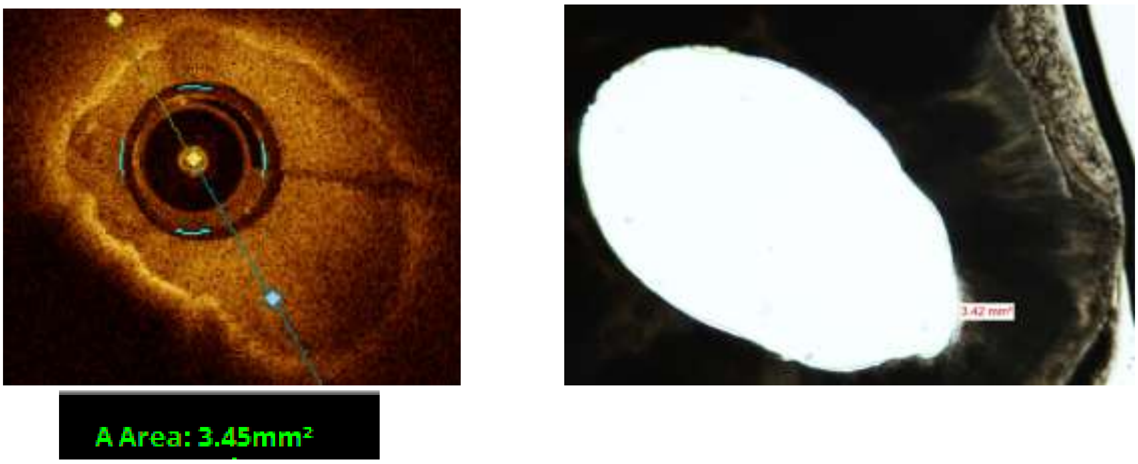

Figure 7: Corelation Of Data For Root Canal Lumen (Area)

Statistical Analysis:

The statistical analysis was performed by using the SPSS software package. The data were analysed by using descriptive statistics including means and standard deviations. The correlation for root canal lumen for maximum and minimum length and area for OCT section and the histological scan was evaluated by using the Pearson linear correlation coefficient.

Results:

Comparison of the measurements for root canal area for the OCT scan and histological showed a strong correlation between the values obtained by OCT and those from the histologic sections Fig. 8: r (area) = 0.97 and values for maximum and minimum length showed a strong correlation between the values obtained by OCT and those from the histologic sections Fig 9 r = 0.95 (max length) and Fig 10 r = 0.93 (min length) respectively.

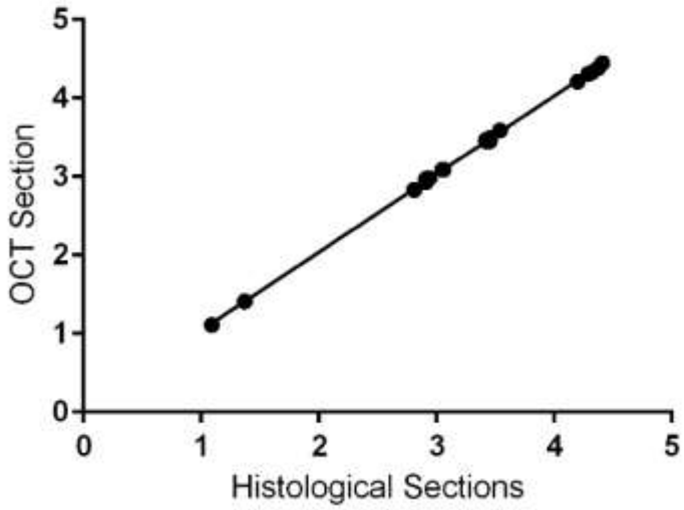

FIGURE8 : r (area) = 0.97

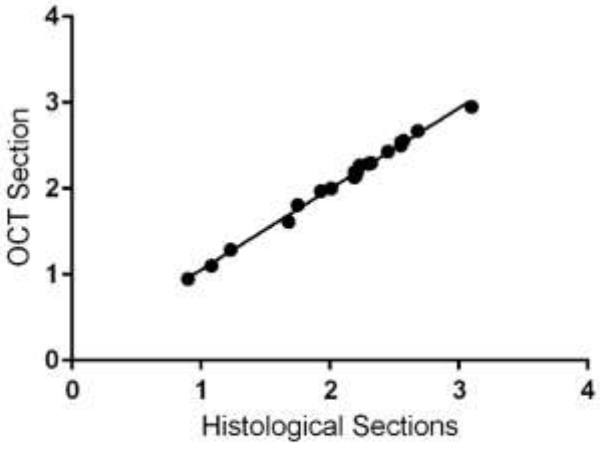

FIGURE 9: r (Max length) = 0.95

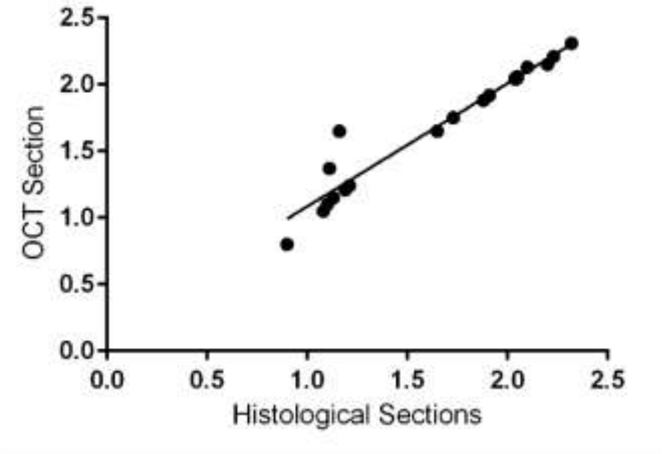

FIGURE 10: r (Min length) = 0.93

DISCUSSION:

The use of novel imaging techniques is gaining a lot of attention in the field of endodontics. New computed tomography (CT) methods prove to be more accurate in the evaluation of bone lesions than conventional radiography[10]. These methods use ionizing radiation which could be harmful at higher doses when used in-vivo, two major disadvantages are limiting the successful application of these methods for intracanal imaging: First, the resolution is usually not suitable for microscopic level imaging. Digital dental radiography systems have a pixel size approaching 100 µm. Second, the probe size is usually much bigger than a root canal. These methods are also time consuming and often require the interpretation of thousands of images.

In contrast, OCT combines a very thin optical catheter measuring 0.5 mm in diameter, with high resolution capacities, enabling imaging of objects measuring a few micrometers and does not involve ionizing radiation. The imaging wire can be deployed independently or integrated straightforwardly into existing therapeutic or imaging catheters. Furthermore it can easily fit into a prepared root canal, and is flexible, allowing penetration through curvatures. Fiberoptic endoscopy was previously described as a method for intracanal visualization[11].

In this system, a 0.7 mm probe is inserted into a dry canal, to image the inner anatomy, this system is based on a camera which produces a digital image and not on microscopic level characterization or light propagation as observed by the OCT.

In this study the correlation data showed strong relationship of data measured for area and length calculation of root canal lumen dimension with histological sections with r value of 97% and 95% respectively.

CONCLUSION:

Optical coherence tomography is a non-invasive and non-destructive technique for endodontic imaging. It proved to be suitable for analyzing the anatomy and cleanliness of root canal walls, and has a high sensitivity and specificity for detection of internal anatomy of canals. OCT generates high-resolution, real time, intra-canal microscopic images, and holds great potential for in-vivo application.

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