

DICOM IN PATHOLOGY AND WHAT DENTIST OF J&K KNOW ABOUT IT: A QUESTIONNAIRE STUDY

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ABSTRACT

The face of dentistry is changing everyday with the incorporation of the digital communication while processing information and during X ray imaging. The digital system after getting incorporated into the dental and medical practice necessitated the development of the standards which allow reliability in image storing devices and image displaying devices. This standard is termed as DICOM i.e. the digital imaging and communications in medicine. The following article reviews DICOM briefly. The realistic understanding of its benefits and limitations allow us to effectively understand the standards.

KEYWORDS: DICOM, WSIs (whole slide images), Virtual slides

INTRODUCTION

The change in the hospital information system from closed proprietary to an open and a standard based system led the software developer to create a uniform and interoperable system. This transformation led all the patient related material available to all the personnel working in the same institution for example: pathologist and radiologist

can view radiographs and histological specimen's simultaneously¹. This transformation affected the branch of pathology leading to the growth in the market for digitization of the microscopic slides². The most widely used medical imaging standards are DICOM i.e. DIGITAL IMAGING AND COMMUNICATION IN MEDICINE, which has already become the worldwide norms of digital image acquisition, storage and display. It is applicable in³

1. Management of network image
2. Management of interpretation of network image
3. Network image print management
4. Image procedure management
5. Offline media storage management⁴

Digitization has recently made possible in pathology by a high throughput slide scanner⁵. The Digital version of the microscopic slide is called virtual slide which is regularly used as WSIs i.e whole slide image for transmitting them over the networks^{6,7}. Since 1990s virtual slides have made a mark in the education training and research but its routine use is yet to come. The review aims to give introduction to DICOM and its use in pathology².

WHAT IS DICOM

Digital imaging and communication in medicine (DICOM) is the standard within the

branch of medicine where information in terms of radiographic images is transmitted between various devices, computers software system and various equipments that are produced by different manufacturers⁸. Its image file contains series of images and patient related information selected from the library of preselected standardized term like name of the patient, identification numbers and acquisition modality. This library is continually updated to keep in par with the updating identification standards. A DICOM file is same as the image or file created in adobe Photoshop shop software or JPEG with the information embedded in metafile or data "set". DICOM was first presented for the use in year 1985. The term DICOM was coined in year 1993 to describe its original standards since that time DICOM is continually improved to meet compatibility with the digital system and with the electronic records. In the year 1996 dentistry along with the American dental association joined DICOM committee to include definitions of image objects with special categorization of the intraoral projection IO along with colour photography. Various Acquisition devices are made by the company which have built in DICOM and various devices like PACS which are developed to allow storage and retrieval of the image. DICOM is a fully encrypted at 128 bits and have a standardized format which allow for viewing of images and data over the web. It allows interoperability leading to easy communication between the dentist and their medical colleagues as long as both provide DICOM and HIPPA compliant WEB connections⁹. Revision in DICOM format was done in year 2007¹⁰. In dentistry we need both radiographic and non radiographic information to be shared between the dentists. DICOM for these dentistry needs were elucidated in year 2010. It was presented in a meeting by the name DICOM WG-22. Several important issues were considered like diagnosis by imaging, treatment guidance, treatment simulation, tissue restoration like CAD/CAM instrumentation. In this meeting it was discussed how DICOM image was ordered, acquired, processed, stored communicated and displayed for reporting. The DICOM committee elucidated the additional support WG initiatives on DICOM for implants and for support for CAD/CAM. Future work focuses on standardization of digital photographic structural

displays for intraoral and extraoral projections, templates for reports, guidelines for presentation states including overlays in dentistry. Also relate to establishing connectivity with electronic dental records etc. Conformance statement: In DICOM digital dental X ray machine is called acquisition modality which includes conformance statement. This conformance statement details how an X ray system is set up to allow communication between different products like monitor, digital record and acquisition device. It basically contains information necessary for Information technology (IT) to connect to various modalities¹¹.

ACQUISITION DEVICES

It is any device which produces a digitized image. It includes CBCT, MRI, CT, X ray machine, 3D computerised tomography, CAD/CAM system and ultrasound. New devices are DICOM competent but their interoperability with pictures archiving and communication system is not fully established. Picture archiving and communication system (PACS) is software which deals with the image acquisition, its storage, retrieval and viewing. Its use is primarily for academic centres and dental clinics where the information is transmitted between various colleagues of various departments like Radiology, Surgery, medicine, pathology, periodontics and restorative¹². In a hospital setup DICOM compliant is critical including HIPPA along with the image security which is critical when transmitted via public network on web. For the prevention of hacking and theft the 128 bit encryption is largely effective¹³. In office server: Dentist in there dental setup generally use software that comes with machine of the office server, as the dental x ray image is small which is retrieved and displayed fast when compared to CT scan and MRIs but the large files of CT, CBCT are stored on the normal hard disk storage and thus retrieval becomes slow. This problem is solved with the cloud based system which offers streamlining of processing and sharing. Cloud based system is much cheaper as they are Saas-based i.e service and customers pay for what they use and as they use. PAC'S maintenance is also costly when compared to the cloud storage especially when working in the small dental clinics^{14,15}.

TERMINOLOGY ASSOCIATED WITH DICOM

- 1) ASSOCIATION: The connection between the two DICOM applications where the information is exchanged.
- 2) ATTRIBUTES: They are the items within DICOM which describe something of DICOM. It describes information objects.
- 3) COMPOSITES: These are the objects which are defined in DICOM which corresponds to multiple or parts of multiple entity relationship models.
- 4) DATA SET: It is the formal description of entities like patients, images, equipment etc and their relation based on the information based on information-organization perspective.
- 5) DATA ELEMENT: It is the description of contents of data sets which provide characteristics of the entities in ER model.
- 6) VALUE REPRESENTATIVE (VR): In DICOM it is how the attribute value is represented ex binary data, text, patient name.
- 7) LIBRARY: It refers to the accepted terms describing patient name, date of birth, identification numbers⁹

HOW DOES DICOM WORK

Managing of the image on the network is simple; basically there is an interaction between a push mode and a pull mode. Push mode is the basic service which simply sends images to another device over a computer network. Pull mode is a two stage process allowing user to query a remote device and then retrieve the selected image.

1. IMAGE TRANSFER: Scanner initiates the routine image transfer via network. DICOM does not specify scanners behaviour; it sends images when it is ready. The image can be send as an individual image when it is completed or after some time when all the images are acquired. When the scanner gets ready it sends images one by one to the workstation. It activates DICOM for the transfer of each image. 4 steps occur between the scanner and the workstation

- I. Image query request
 - II. Image query matches
 - III. Image retrieve request
2. IMAGE QUERY REQUEST: request is entered at the workstation software, which is send to the scanner asking for the image records that value matching a set of query keys. A list of the images matching the request is sent back; the pertinent image is selected by the user at the workstation who enters a retrieve image command at the keyboard. Again a message is send from the workstation software, sending the image identification numbers and request scanner to send the images. One image at a time is send from the scanner to the workstation console store using DICOM console.
 3. IMAGE STORAGE: After sending images one by one the scanner operator sends a storage commitment request to archive .It is done in 2 steps
 - I. First step is to verify all intended images received
 - II. Second step is that, the device assumes the responsibility for keeping the images safely so that scanner detects the local copies of the images. If problem exists with any of the image or with all the procedure an "Error" message is sent to the scanner operator.
 4. NETWORK PRINTING: After the communication session with a printer is established, negotiation of the various images is done. The workstation informs the printer of the desired output so that it gets prepared with the appropriate format to receive the image. The image is then send one by one to the printer. It sends notification to workstation so that the user can monitor work in progress during the print job¹⁶.

WHAT IS A VIRTUAL SLIDE?

Digitization in dentistry came as a boon with the improvement in computer processing and storing capabilities since 2 decades, before these advancement it was unthinkable. DICOM has become a digital window for pathology by means of virtual slides. A virtual slide is a digital image

which is produced by scanning a glass pathology slide at a very high resolution. These scanners use microscopic lenses and a source of light to obtain images of the desired tissue. The image is then captured electronically with a device which is similar to a digital camera called CMOS chip or CCD. The resolution of the slide scanner is .2 to .5 um pixel which is similar to that of a microscope. Two main steps of image focusing and processing are involved in producing a virtual slide.

1) Image focussing: The pathology specimens like cytopathology and histopathology are 3 dimensional and the virtual image is a focused 2D capture of a 3 dimensional object. By focusing of the image for both histopathology and cytopathology specimens, there can be various important diagnostic information which are sometimes lost in this approach. The virtual slide system adjusts the focus ten or hundred times while scanning to get a focused image in the final slide. The 3D scanning of the whole slide overcomes few drawbacks but it also causes a significant disadvantage as an already large digital image is made even larger while scanning multiple times in 3 dimensional producing a Z stack.

2) Image processing: During acquisition and after acquisition of image it undergoes variable alteration like enhanced definition of the image, colour and brightness. It is always important to remember that the image is digitally processed digital reproduction of the captured image¹⁷ which is always an enhanced version of the normal image. Thus virtual slide image differs from the image seen through the microscope in many ways to acquire it and store it.

Advantages of Virtual Slide

- It is ideal for training and teaching purpose
- It does not break and fade away
- It can be easily annotated
- It integrates easily with the laboratory
- It is easily archived and retrieved
- It allows remote consultation and tele-conferencing
- It makes laboratory workflow efficient
- It helps in image analysis, side by side image comparison and measurements

Disadvantages of Virtual Slide

- Expensive armamentarium is needed like high resolution scanners
- Safety of virtual slide is not proven yet
- Image quality may not be equivalent to the microscope
- Efficiency of slide may be less as compared to the microscope
- Significant IT infrastructure is needed to manage the data base².

Linking of WSI with DICOM: With the increasing use of whole slide images (WSI) in clinical medicine the requirement of compatibility with the DICOM standards increases but unfortunately the digitized histopathology specimen (WSIs) exceed the DICOM size limit making it difficult to exchange them and store them. Transmitting the entire DICOM image becomes ineffective for the whole slide image (WSIs) with the help of JPIP i.e JPEG 2000 interactive protocol. WSI can be easily exchanged with the DICOM over various auxiliary connections. Viewing of virtual slides: Size of microscopic specimens is 20 x 30 mm and the whole slide image (WSI) can save the uncompressed data up to 40GB¹⁸. The amount of data increases when scanning is done at a higher resolution with high optical magnification where several focus layers are scanned¹⁹. All the viewing system works on the user demand i.e only the requested area of the WSI is displayed and decoded. Thus a lossless compression image is formed and the ratio of lossy image is 10 to 30 folds²⁰. Hence a virtual microscopy needs a suitable image compression algorithm. Several scanners like SVS, NDP, Mirax have their proprietary image formats²¹. JPEG 2000 is a family of standards supervised by joint photographic expert group that has a suitable format for WSIs and this compression is computationally intensive and matches with speed of the scanner^{22,23}. The standard JPEG2000 family consists of 13 parts out of which part 1, 2 and 9 are essential for virtual microscopy. Part 1²⁴ is a core coding system which specifies jp2 file format and code stream syntax and it uses jp2 as a common file extension. Part 2²⁵ specifies extension to the first part. Part 9²⁶ is an interactivity tool, protocol and APIs which introduces JPIP i.e JPEG 2000 interactive

protocol for the remote serving and viewing of JPEG 2000 images. According to Della Mea et. al. DICOM standards include basic parts of JPEG 2000 IN SUPPLEMENTS 61 AND 105. Supplement 106 describes two JPEG 2000 interactive protocol based transfer syntaxes as a method to deliver image data²⁷. When using JPIP transfer syntaxes in DICOM based PACS i.e picture archiving and communication a DICOM server first sends a uniform resource locator (URL) string which refers to WSI pixel data provider along with image name which is arbitrary and unrelated to the patient data. On receiving the data, client DICOM uses a built in JPIP viewer or uses an external JPIP viewer for retrieving WSI from the specified JPIP server. All network messaging between client and PACS is done solely according to DICOM protocol except that the JPIP transmission which is performed on the top (HTTP/1.1) i.e Hypertext transfer protocol for the compatibility with existing web infrastructure, it can be done with TCP i.e transmission control protocol. JPIPs image serving performances is demonstrated to be excellent²⁸.

METHODOLOGY

Inclusion Criteria

1. Dentist should be from Jammu and Kashmir only
2. Dentist should have qualified atleast BDS degree from any recognized institution.

Exclusion Criteria

1. Dentist outside Jammu and Kashmir
2. Dental students who are still pursuing their studies .

A questionnaire study was carried out between 300 dentist to get an idea how much they know about DICOM or any related stuff. These questions were put forth the dentist. After this a thorough discussion was made with all of the participants and all their doubts were targeted.

RESULTS

After the questionnaire study we found that a very small number of people knew about the DICOM and after explaining it to them they were interested in using it on daily basis.

QUESTION	ANSWER
Do you know what DICOM is	Only 20% dentist knew about it
Have you ever discussed treatment plan on phone with your colleagues	All dentist has done it
Have you used any electronic media for discussing patient treatment	All the dentist have discussed their patients treatment plan over electronic media
Will you ever use such inventory for proper treatment planning for the patient	Every dentist said yes to for such addition to inventory
Will you ever invest money in such inventory	It is priced at high price so only 10% dentist said yes for its addition in their clinic
Do you think if it is priced for less you will use it and add it in your inventory	If price gets lower 40% dentist showed their interest in adding DICOM in their practice
Do you think with digitization of India more dentist will add it in their inventory	70% dentist said that with digitization of India on the upfront the rates of DICOM inventory may drop down leading to more and more dentist adopting its usage
Do you think DICOM has any role in pathology	100 Percent dentist said Yes definitely there is main role of DICOM in pathology
Is DICOM worth investing in	Yes 100 percent

DISCUSSION

The uses in education is with the growing increase in the number of medical school away from the proper microscope based labs, there is an increased risk that basic pathology teaching will suffer. Several e-learning approaches are newly developed for teaching microscopy like web-path site but with these the interaction with microscope and facility decreases immensely but the advantage of learning from virtual slide is area of interest which can be easily an noted to the students and these slide can be easily integrated into e-learning material and online questionnaire^{29,30,31}. In the post graduate training the access to the desired study material is a problem and this problem can be easily solved

with the virtual slides as there is the limited number of department and personnel study material. As the material can be easily integrated into vast ES-resources of image for learning purpose¹⁷. There are two important advances in DICOM images which include online image transfer and use of mobile phones and tablets as viewers. DICOM images are fully encrypted thus can be transferred via the internet^{32,33,34}. The possibility of error is reduced which is associated with saving it into compact disc and the image is transferred to the provider in real time. Consultation and immediate feedback with dentist from different fields is made easy via DICOM based imaging survey which is HIPPA compliant. Newer advances in gadgets add another layer of internet communication possibility of DICOM³⁵.

CONCLUSION

Other than the significant investment which is required for the establishment of the IT infrastructure along with the cost of computers, computer storage devices, virtual microscopy along with DICOM are boon for dentistry still there is enormous work which is to be done.

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