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DICOM Awareness of Oral and Maxillofacial Radiologists in India

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Since the late 1970's, diagnostic images have been increasingly in digital form creating a need for digital interoperability, something that was hithertofore universally achieved for analog images using transmitted light from a view box. The picture archiving and communications system (PACS) helped digital image management at a department or hospital level [1–6]. To have interoperability between devices, a single formatting standard was desirable, though initially a hardware solution had been sought.

Digital imaging and communications in medicine (DICOM) is the International Organization for Standardization (ISO)-referenced standard for communication of diagnostic images and associated data. It is the internationally accepted format in which radiologic images are sent from scanners and digital X-ray devices, as well as the protocol used to send, archive, and retrieve them. DICOM has its roots in the USA from the American College of Radiology/National Electrical Manufacturers Association (ACR/NEMA) standard versions 1 and 2, developed in the 1980's, that were replaced in the early 1990's by DICOM "version 3," the only version that has ever existed in DICOM [7]. In the mid 1990's, the DICOM Standards Committee was expanded from NEMA and ACR to include several dozen vendors, user groups, and interested parties.

It had often not been possible to display digital images made using one proprietary system with another vendor's display software. Even different generations of the same manufacturer's imaging system have demonstrated incompatibility. This may well be the reason why full implementation of the filmless oral and maxillofacial radiology department or imaging center lagged behind initially, especially. While the American Dental Association (ADA) joined the DICOM Standards Committee in 1996, a working group specific to dentistry (WG 22) was only initiated in 2003. Indeed, the ADA only accepted DICOM as the means for interchange of images by resolution in year 2000. The ADA has now been joined by the American Academy of Oral and Maxillofacial Radiology and the American Association of Orthodontics giving dentistry three votes at the DICOM table. To protect the oral and maxillofacial radiologists' investment in equipment and the patient's investment of time, money, and radiation exposure, it is desirable to use a standard that will make digital radiographic images at least as durable and portable as their analog predecessors [8].

Though the adoption of the DICOM standard is voluntary, its use is international in scope [9]. DICOM has been adopted as a worldwide standard by such bodies as the ISO, as well as the European Committee for Normalization CEN TC 251 (CEN Technical Committee) for the European Standard MEDICOM. The Japanese Industry Association for Radiation Apparatus standard, Medical Imaging Processing System, is also based on DICOM. [10] However, the Indian Society of Oral Medicine and Radiology has not yet adopted DICOM as the standard for imaging.

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In the oral and maxillofacial radiology setting, patient diagnostic images typically include intraoral radiographs (periapicals and bitewings), panoramic radiographs, cone beam computed tomography (CBCT) scans, multi-slice computed tomographic (MSCT) scans, magnetic resonance images (MRI), nuclear medicine scans, and ultrasound. Oral and maxillofacial radiologists often refer images to their counterparts nationally and internationally for second opinions and also receive images from their colleagues and non-specialists to interpret. Digital image communication is unlikely if two practitioners use divergent imaging system or software or both without using a compatible format, namely, DICOM. The same problem can also be encountered within a single office using digital image acquisition systems from different vendors or even just different generations of detectors or software from a single vendor. Most manufacturers of digital dental imaging equipment are now seeking to become DICOM conformant; however, progress in this direction is less advanced in India. With the continual introduction of many new image acquisition systems, a standard for exchange is becoming even more important for portability and accessibility of dental diagnostic images. Though DICOM is not absolutely needed for interoperability, given the fact that DICOM standard that has already been developed, it would be unreasonable to redevelop a separate standard for digital dental imaging systems [8].

There are presently 1,332 oral and maxillofacial radiologists registered with the Indian Academy of Oral Medicine and Radiology, most working in oral maxillofacial radiology units of dental schools, with others working in private practice, largely in imaging centers [11]. The oral and maxillofacial radiology practice in India generates substantial numbers of radiographic images and can benefit from use of the DICOM standard as a means of promoting interoperability as these images are usually made for referred patients, with the images needing to be sent to the referring practitioners.

In spite of the known effectiveness of the DICOM standard and the increasing availability in India of X-ray equipments using DICOM, there are still misunderstandings on the benefits of DICOM and the real impact of DICOM on the images [7]. In view of the current confusion in the use of DICOM in the practice of oral and maxillofacial radiology and the relative dearth of literature on the awareness of DICOM by Indian oral and maxillofacial radiologists, it was decided to assess the use, awareness, and knowledge of DICOM by this group.

Material and Methods

This survey instrument was institutional review board approved. The questionnaire was developed and validated for reproducibility before using it for collecting study data. The survey instrument was circulated to oral and maxillofacial radiologists from all regions of India. The residents of oral and maxillofacial radiology (OMR), the faculty of OMR, private practitioners with a master's degree in OMR, and currently practicing OMRs were the targeted population. The inclusion criteria for the respondents therefore were: resident in OMR or faculty in OMR or a private practitioner with a master's degree in OMR and currently practicing OMR.

The respondents were contacted during various continuing dental education (CDE) programs, a residents' meeting, and the annual Indian OMR congress. The CDEs, residents meeting, and the annual OMR congress did not have any lecture or demonstration on DICOM. All these programs were held in different parts of the country. The survey tool was circulated by volunteers. The questionnaire was collected by the same volunteers within 15 to 20 min of circulation. This was done to avoid any collusion biasing answers to the survey.

The survey instrument (Fig. 1) had questions on the respondent's current use of DICOM, duration of use, various modalities for which DICOM was used, and the mode of transfer and receiving DICOM images in the respondent's practice. The survey instrument also questioned the preferred mode for receiving DICOM images. The demographic details of the respondents were also documented.

A total number of 500 survey instruments were circulated and 318 responses were received. Sixteen responses were rejected due to being incomplete. The total responses evaluated were representative of approximately 22.7 % of the total Indian OMRs' population. The results of this survey were digitized on an Excel file (Windows Office 2007 version) which made further descriptive statistical analysis of the data possible using the Statistical Package for Social Sciences version 14 software.

Results

Of the 500 survey instruments circulated, a total of 302 were finally evaluated in this study. Hence, a total of 60.4 % of the survey instruments circulated were completed and returned. An almost equal number of men (50.4 %) and women (49.6 %) responded to the survey. Regarding age demographics, 78.8 % of the respondents were between 20 to 39 years of age, 18.8 % between 40 to 49 years of age, 1.9 % between 50 to 59 years in age, and 0.3 % of respondents were over 60 years of age. Of the 302 respondents, 86.1 % were DICOM users and 13.9 % were not DICOM users.

The results presented from hereon are for the 260 DICOM users who responded to the survey. Of these,

Fig. 1 The survey instrument used in this study

Do you use DICOM in your practice?
Yes ☐ No ☐

If yes, how do you receive or send DICOM images?
In removable media (e.g. CD/DVD/flash) ☐
Via dedicated LAN/WAN ☐
Via Internet ☐
Via webservices ☐

Are you satisfied with your mode of transfer?
Yes ☐ No ☐

If no, please briefly explain:_____

Would you like to change your mode of transfer?
Yes ☐ No ☐

If yes which other mode of transfer would you prefer?
CD ☐ LAN/WAN ☐ internet ☐ webservices ☐

How long have you been using DICOM?
< 2 years ☐ 2-5 years ☐ 5- 10 years ☐ >10 years ☐

For which of the following modalities have you been using DICOM? (Check all that is applicable)
CBCT ☐ MSCT/MDCT ☐ MRI ☐ Ultrasound ☐
Panoramic radiogrph ☐ Periapical ☐ Others, please specify_____

Do you store images at your workstation in DICOM format?
Yes ☐ No ☐

What viewing software do you use to view your image?
DICOM compatible software (specify_____) ☐
Non-DICOM software (Specify_____) ☐

Do you transfer image to your colleagues (national or international) in DICOM format?
Yes ☐ No ☐

Age (years): 20-29 ☐ ; 30-39 ☐ ; 40-49 ☐ ; 50-59 ☐ ; 60+ ☐

Sex: Male ☐ Female ☐

56.1 % had used DICOM for less than 2 years, 40.8 % between 2 to 5 years, and 3.1 % for 6 to 10 years. Removable media in the form of compact disc (CD), digital video disc (DVD), or flash memory (thumb drives) were used for receiving images by 156 DICOM users, 89 either used a local area network (LAN) or a wide area network (WAN), 38 used internet for receiving images, and 1 used web services (Table 1). Of the DICOM users, 65.4 % (150) were satisfied with the mode in which they received DICOM images. The remaining 34.6 % (90) specified not being satisfied with the mode used to receive DICOM images. Nevertheless, 84.2 % (219) of the DICOM users either wanted to change their mode or would like to add to their existing mode. This exceeds the total number of non-satisfied users because some DICOM users satisfied with their current mode of use would like to add additional modes. Of the 219 wishing to use a different or additional modes for DICOM image interchange, 71 wanted to shift to, or add, LAN/WAN, 149 wanted to either shift to, or add, internet, while 3 wanted to either add, or change to, CD/DVD/flash removable memory. None indicated a wish to use web services. Totals for these categories exceed the number of DICOM users opting for change or addition as some users indicated a desire to move to, or add, multiple new modes of image delivery.

MSCT images were received in DICOM format by 73 DICOM users, CBCT by 26, MRI by 49, periapicals by 51, and panoramic radiographs by 165. The total is more than the total number of DICOM users because some individuals are included in more than one category (Table 2).

Of the DICOM users, 65.4 % stored images in DICOM format. The remaining 34.6 % did not store images in

Table 1 Modes for receiving DICOM images

Mode of receiving images	Number of respondents
CD, DVD, flash	156
LAN, WAN	89
Internet	38
Web services	1
Total	284

Total exceeds 260 DICOM users as multiple users have been included in individual categories

DICOM format. This was a survey that questioned the storage of files in DICOM format on a level understandable to users rather than greater technical detail. By definition, when DICOM storage is used, it must comply with part 10 6.2.3.1 and storage directory specific object pair classes as defined in PS 3.3, 3.4, and 3.5 of the DICOM standard. The storage classes used were not questioned in the instrument as this was considered beyond the comprehension of most of the respondents.

DICOM compatible software was used internally by 90.8 % of DICOM users, while 8.5 % used non-DICOM compatible software and 0.8 % used both DICOM compatible and non-DICOM internally. The total here exceeds 100 % because the users of both DICOM compatible and non-DICOM compliant software have also been added to their respective individual categories. Of the DICOM users, 83.1 % transferred images to outside practitioners in DICOM format.

Discussion

The development and acceptance of the DICOM standard has become a basic requirement for the implementation of electronic imaging in radiology. DICOM is now also evolving to provide a standard for electronic communication between radiology and other parts of the hospital enterprise. In a completely integrated filmless radiology department, there are three core computer systems, the PACS, the hospital or radiology information system (HIS and RIS), and the acquisition modality. Ideally, each would have bidirectional communication with the other two systems. The PACS must be able to receive and acknowledge receipt of image and demographic data from the modalities. Similarly, the modalities must also be able to send images and demographic data to the PACS [12]. DICOM communication protocols for query or retrieval, storage, and print classes have now been established through both conformance statements and inter-vendor testing. It should always be remembered that DICOM conformance does not absolutely guarantee system interoperability. Perhaps no written statement could ever do so. The final test for interoperability will always be demonstration, hence the introduction of interoperability demonstration at some of the earlier annual ADA congresses to educate the general dental practitioner. This testing is also done through the Imaging the Healthcare Enterprise connectathons.

Table 2 Imaging modalities where DICOM was employed

Imaging modalities	Number of respondents
MSCT	73
CBCT	26
MRI	49
Ultrasonography	0
Periapicals	51
Panoramic	105
Total	364

Total exceeds 260 DICOM users as multiple users have been included in individual categories

It was encouraging that 86.1 % of the respondents were using DICOM. The reason for 13.9 % of the respondents not using DICOM was given as either not being aware of DICOM or being inadequately trained to use DICOM. For this reason, it is perhaps beneficial that the 5th International DICOM Congress is scheduled to be held in Bangalore, India on March 2013.

Most of the respondents of this study were using DICOM for a short duration of less than 5 years. It needs to be mentioned that using DICOM for a shorter duration does not necessarily mean a novice user. Further, maxillofacial radiologists may have used DICOM for a longer duration without making an optimum use. CD, DVD, or flash was the most popular means of receiving DICOM images followed by LAN or WAN. Only 6.5 % of the DICOM users used more than one mode of receiving DICOM images. The reason stated for CD, DVD, or flash being more popular was that other modes like the internet or web services were not readily available at most of these practices.

Since 1995, all of the major diagnostic imaging modalities have been included under the DICOM umbrella. This includes digital radiography (flat panels and computed radiography systems), CT scan, MRI, ultrasonography, and nuclear medicine scan [13]. In this study, panoramic radiographs and periapicals were the most popular modalities in which DICOM was used. This could be because panoramic and periapical radiographs have been available in digital form in India for some time now, while CBCT has only recently made inroads in India. It is believed that with increasing use of CBCT, it will also become a popular imaging modality for use of DICOM. The Indian OMRs need to be educated that even ultrasonography as a modality could be viewed in DICOM format. Ultrasonographic images were not used in DICOM form by the respondents from India though ultrasonography is a frequently used modality in OMR practice.

Transfer of images to outside practitioners or colleagues for second opinion in DICOM format is vital for increasing

the knowledge base for interpretation of images. Of the respondents, 83.1 % transferred images to outside practitioners in DICOM format. This result seems incongruous with the 260 respondents using DICOM unless they are printing images for outside practitioners or using proprietary formats for this purpose. The way of transferring images to their counterparts or outside practitioner was again not a part of the survey tool. OMRs from India need to be made further aware of the advantages of transferring images in DICOM format.

In conclusion, there is still much work to be done to ensure optimal use of DICOM by Indian OMRs. This is an issue that the Indian Association of Oral Medicine and Radiology needs to address in concert with the international DICOM Standards Committee.

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