

Revised American Dental Association
Technical Report No. 1051

DICOM Requirements for Digital Imaging in Institutional Dentistry

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REVISED AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1051 FOR DICOM REQUIREMENTS FOR DIGITAL IMAGING IN INSTITUTIONAL DENTISTRY

The Council on Dental Practice of the American Dental Association has approved American Dental Association Technical Report No. 1051 for DICOM Requirements for Digital Imaging in Institutional Dentistry. Working Groups of the ADA Standards Committee on Dental Informatics (SCDI) formulate this and other specifications and technical reports for the application of information technology and other electronic technologies to dentistry's clinical and administrative operations. The ADA SCDI has representation from appropriate interests in the United States in the standardization of information technology and other electronic technologies used in dental practice. The ADA SCDI confirmed approval of ADA Technical Report No. 1051 on July 10, 2015.

The ADA Standards Committee on Dental Informatics thanks the members of Working Group 12.1 on Digital Imaging and the organizations with which they were affiliated at the time the specification was developed:

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REVISED AMERICAN DENTAL ASSOCIATION TECHNICAL REPORT NO. 1051 FOR DICOM REQUIREMENTS FOR DIGITAL IMAGING IN INSTITUTIONAL DENTISTRY

FOREWORD

(This Foreword does not form a part of Revised ADA Technical Report No. 1051 for DICOM Requirements for Digital Imaging in Institutional Dentistry).

In 1992, there was interest in the standardization of clinical information systems related to electronic technology in the dental environment. After evaluating current informatics activities, a Task Group of the ANSI Accredited Standards Committee MD156 (ASC MD156) was created by the ADA to initiate the development of technical reports, guidelines, and standards on electronic technologies used in dental practice. In 1999, the ADA established the ADA Standards Committee on Dental Informatics (SCDI). The ADA SCDI is currently the group that reviews and approves proposed American National Standards (ANSI approved) and technical reports developed by the standards committee's working groups. The ADA became an ANSI accredited standards organization in 2000.

The scope of the ADA SCDI is:

"The ADA SCDI shall develop informatics standards, specifications, technical reports and guidelines and interact with other entities involved in the development of health informatics standards aimed at implementation across the dental profession."

The ADA endorses the use of DICOM as the standard means for exchange of all digital dental images. DICOM allows providers a lossless exchange of patient images in their original diagnostic quality and enables a direct comparison between current and former examinations of the patient. In the institutional setting, dental imaging interoperability includes the ability to order, acquire, store, retrieve, archive and share DICOM radiographic and photographic images. In addition to the interoperability within and between institutions, it may be required that these images be attached to an electronic patient record. Therefore, in an institutional setting, interoperability is required functionality among various digital acquisition devices and DICOM conformant storage devices both stand alone and integrated with an electronic patient record.

These guidelines are written as guidance for the present and near-future "standards of care" relevant to imaging interoperability. It provides typical use cases and offers DICOM services to solve these interoperability scenarios. A DICOM glossary is provided to assist with terms and concepts used. ADA Technical Report No. 1051 builds upon ADA Technical Report No. 1023: Implementation Requirements for DICOM in Dentistry.¹ The final section goes into further detail into specific technical requirements that support interoperability. The complete DICOM standard provides additional details and specific explanations that are beyond the scope of this ADA technical report. The complete DICOM Standard is available on the website of the National Electrical Manufacturers Association (NEMA).²

¹American Dental Association Technical Report No. 1023: Implementation Requirements for DICOM in Dentistry. Chicago: American Dental Association, 2005

² DICOM (Digital Imaging and Communications in Medicine). Rosslyn: National Electrical Manufacturers Association (<http://medical.nema.org>)

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1 SCOPE

This report provides a technical specification based on the DICOM Standard as it applies to dentistry with the goal of increasing interoperability within and between institutional digital radiographic systems. This report will illustrate through high-level interaction use cases how to achieve interoperability for typical dental imaging tasks. They are: (1) view and print images on removable media; (2) create interoperable removable media images; (3) share images among various networked multi-vendor storage and acquisition systems; (4) ability to exchange visible light photographic and endoscopic images within a dental image acquisition context; (5) create and exchange DICOM structured display objects; (6) perform scheduled workflow to integrate digital images with an electronic dental records system; (7) import and reconcile Images from outside the institution into the electronic dental records system; (8) securely transfer DICOM images via email, and; (9) access DICOM images locally via the Internet. These use cases show the DICOM requirements in context, describing them in clear relationship to the clinical tasks of the dental provider.

2 FUNCTIONAL USE CASES

The purpose of the use cases presented in this section is to identify and illustrate the DICOM functional requirements on systems used in various institutional dental settings. The figures illustrate models of dental systems and the interactions between them. They represent a desired sequence of interactions between DICOM systems. Each scenario has at least two systems sharing information, each acting together to provide DICOM services for a dental department. These sequence diagrams shows the order of events, the interactions and clearly shows who's doing what.

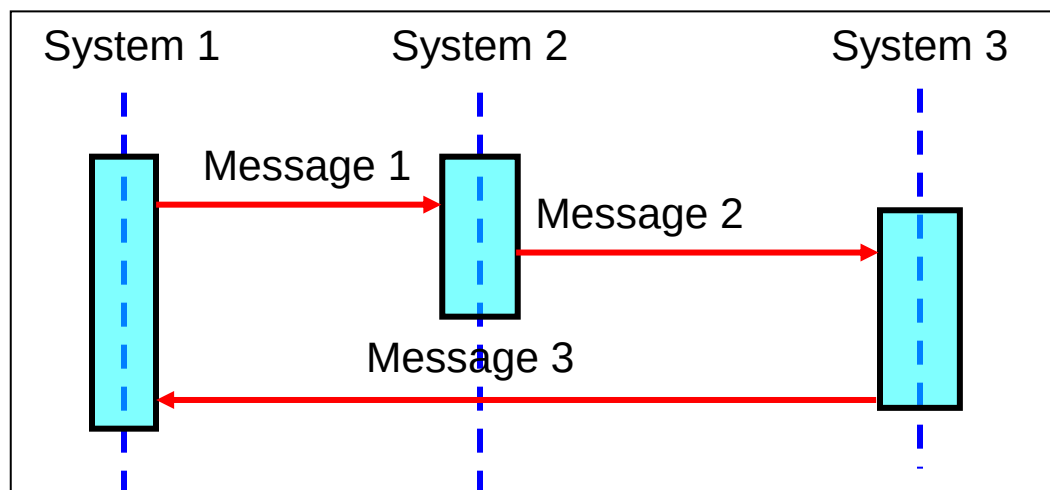


Figure 1. Modeling a use case using a sequence diagram

The convention used in these system diagrams is that the arrow indicating the direction for the transaction points from the initiator of the transaction to the destination. In this particular example, shown in Figure 1, Message 1 is sent from System 1 to System 2, then Message 2 from System 2 to System 3 and then Message 3 from System 3 to System 1. Note that an institution could implement a combination and/or mix/match any of these scenarios, systems, and messages. Before systems can act together a number of negotiated issues have to be addressed. Systems have to agree on the role each will play, have an equivalent view on the message information and select the operations that each side implements. The dental scenarios in this report trend from simplest requirements to more complex.

2.1 Viewing and Printing of DICOM images on a CD at a solo practice

This use case describes the viewing and printing of DICOM dental data on widely available removable media (i.e., CDs) for reference with or without a digital system to obtain patient data. The goal is to provide CDs that can be conveniently read and viewed anywhere. This allows the dentist to review historic examinations of the patient. The images were acquired in the past, stored in DICOM format, and will now be viewed. The dentist's office may or may not have a digital data acquisition system but has a CD reader. This use case can be extended with DICOM viewing and printing from a flash drive, USB stick or DVD removable media.

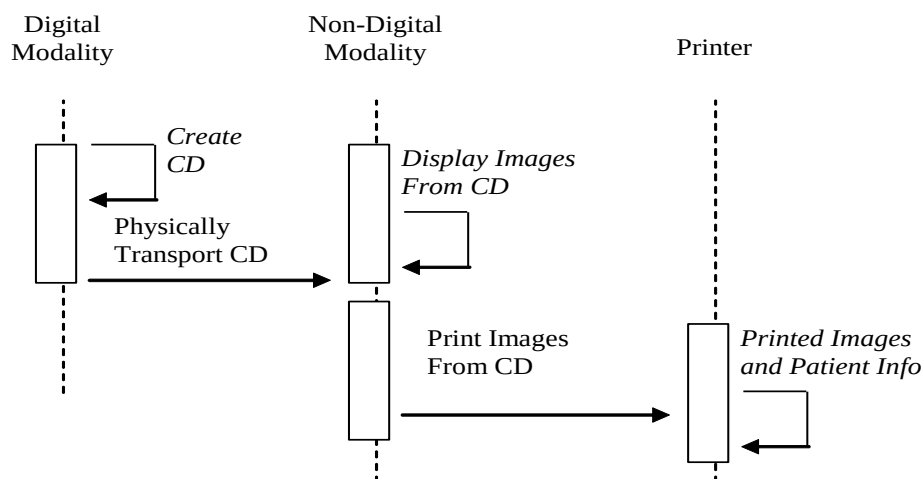


Figure 2. Solo practice, DICOM viewing and printing.

- A** A new patient arrives with a CD containing images and documents from a previous dental examination. The images are in DICOM format and a basic DICOM viewer is included on the disk.
- B** The Basic DICOM viewer on the CD is operating system compatible and at least contains basic functionality such as zoom, pan, window/level, display of patient demographics, etc. From now on, the Basic DICOM viewer will just be called a viewer.
- C** The dentist's computer reads the CD, starts the viewer and is able to display patient data. The dentist also has the ability to view and confirm the patient's metadata information, manipulate the images and perform an interpretation and diagnosis.
- D** The dentist requires the ability to print the images from the CD. This print capability does not require a diagnostic quality printer and could be accomplished by a plain paper printer. The CD viewer is required to support the ability to print the images with patient demographic information included.
- E** The dentist may optionally acquire additional DICOM images before treating the patient.
- F** The dentist may optionally import the data provided on the CD to be included in the patient's record for reference.
- G** The dentist returns the CD back to the patient or disposes of the CD of patient data securely.

2.2 Creation of interoperable CDs

This use case describes the interchange of dental digital imaging data on removable media with a DICOM modality /workstation. The goal is to create CDs that can be read anywhere. A dentist's office has a digital modality system with PC based DICOM workstation capabilities. There is also a local image archive with a CD burner.

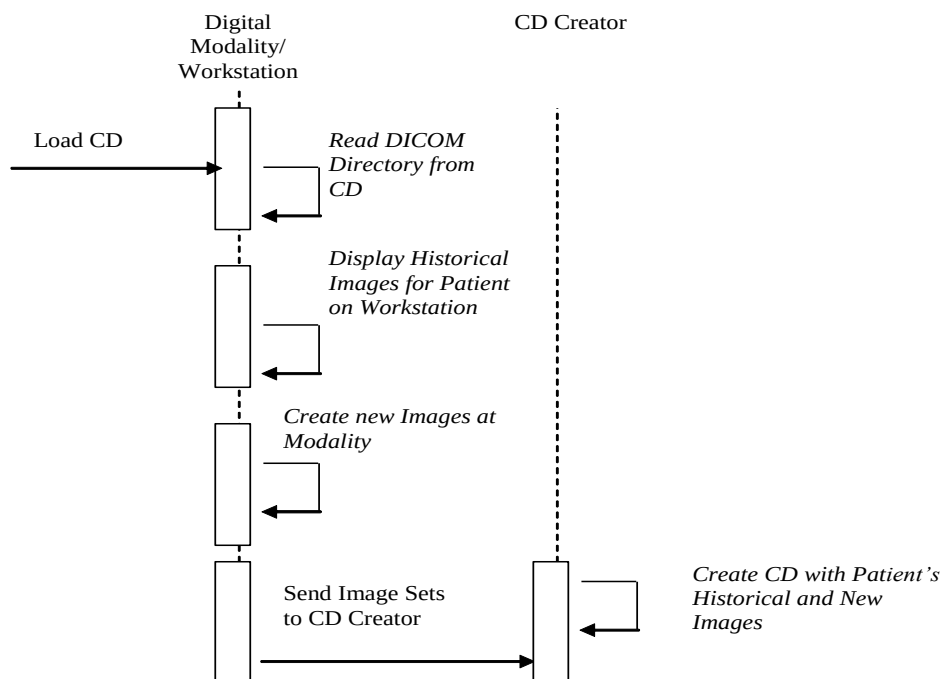


Figure 3. Solo practice, DICOM modality/workstation & CD creator

- A A new patient arrives with a CD containing viewable patient data. The CD contains DICOM images that were obtained using a digital system from either the same or a different vendor. There are several intra-oral (IO) images as well as a panoramic radiograph image (PX).
- B At this modality/workstation, the dentist views the images using the CD viewer to see the patient's images contained on the CD and to potentially acquire additional x-ray images to complement the original images.
- C This viewer is required to at least support basic DICOM functionality such as zoom, pan, window/level, display of patient demographics data, etc. The viewer shall have the ability to print the images with patient demographic information included.
- D This media application interchange requirement assumes that the dentist's system support of DICOM, PS. 3.11 2014b, Annex K, the Dental Application Profile as a File Set Reader (FSR).
- E The dentist returns the original CD back to the patient or disposes of the patient data securely.
- F After viewing the historically relevant patient data, the dentist decides to obtain additional images on the digital DICOM modality system.
- G The dentist compares the previous images with the newly acquired images and archives the both the historical and new images on the local image archive.

- H At the local archive, a new CD for this patient is created. Patient information is verified to be accurate. The new DICOM CD with the image sets is generated for the patient to take for future usage. This newly generated CD has a basic DICOM viewer on it. This media application interchange requirement assumes that the dentist's system support of DICOM, PS. 3.11 2014b, Annex K, the Dental Application Profile as a File Set Creator (FSC).
- I Using the print capabilities of the digital system, the dentist may print images using a high quality printer for the patient to take for referral.

2.3 Solo practice, network exchange of data between multi-vendor digital systems

This use case describes the simple network interchange of dental digital imaging data utilizing DICOM networking services or its workflow. A dental practice has multiple digital acquisition systems that may be from different vendors or they may be from the same vendor. A panoramic modality system from Vendor 1 also has a viewing workstation capability. An intraoral camera system from Vendor 2 may also have a image server that contains a database of historical images.

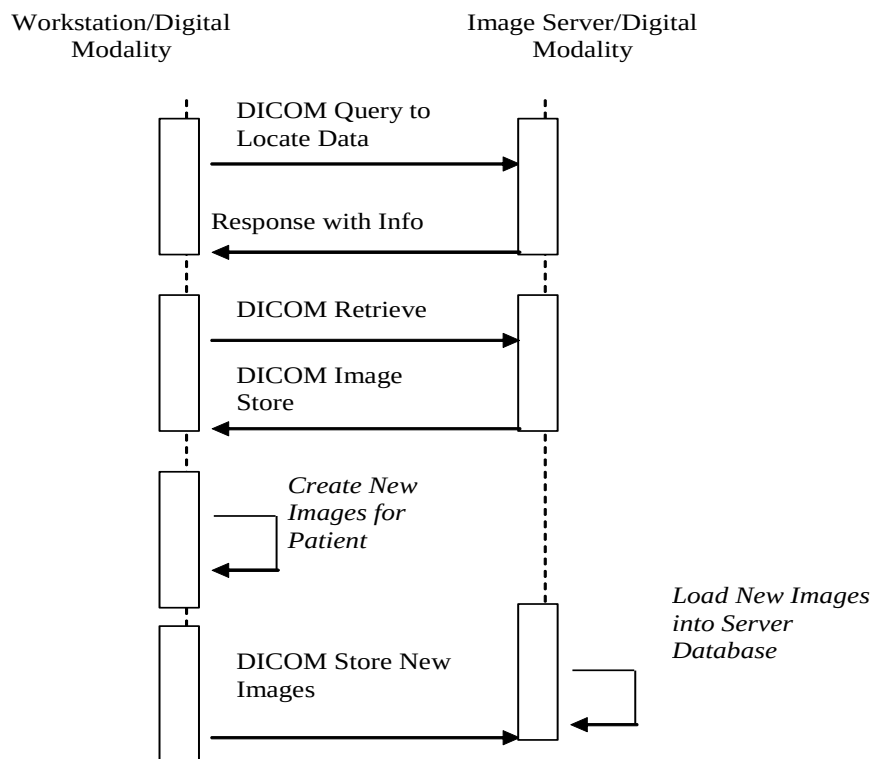


Figure 4. Solo practice, network exchange of data between multi-vendor digital systems

- A The dentist's office is configured such that the dental modality systems communicate with each other via DICOM network services, such as verification, store, query and retrieve. All the systems support the Verification SOP class as both an SCU and SCP.
- B A patient arrives who has been seen before at this location/facility. On the workstation, the dentist performs a DICOM Query (FIND SCU) to locate the appropriate historically relevant images on this patient from the other

digital device functioning as an image server. The dentist's workstation supports the DICOM Query "Study Root" SOP class as an SCU.

- C The imaging server system matches the dentist's query and provides the dentist with a list of retrievable images of patient information. The archive supports the DICOM Retrieve "Study Root" SOP class as an SCP.
- D From the list, the dentist then uses DICOM Retrieve (MOVE SCU; STORE SCP) at the workstation and views selected images using the built-in DICOM viewing applications. The intraoral system, which functions as the "server," supports DICOM Query SCP and Move SCP.
- E After viewing the historical images, the dentist acquires additional panoramic (PX) images.
- F The new images are stored from the digital panoramic system to the local intraoral server (STORE SCU).

Note: If there were no system that supports the server role on the network, a "poor-man" solution for this use case would be for the dentist to rely on an other system "pushing" the images using a DICOM Store, not requiring Query-Retrieve support but rather the Storage SCP.

2.4 Visible Light (VL) photographic images (XC and ES)

A dental provider utilizes Visible Light (color) DICOM images for both photographic and endoscopic aspects of the patient's dentition. In these cases, precision and consistency of color reproduction is critical to achieve correct clinical decisions.³ The provider acquires a series of photographs for the patient's orthodontic record. Throughout the examination, the acquisition perspective, patient perspective and patient subject state was captured as image notes. The anatomic information was captured utilizing standard code sequence based on ISO 3950-2010 Dentistry - Designation system for teeth and areas of the oral cavity.⁴ The provider creates and stores numerous DICOM images intraorally (ES) and extraorally (XC) for clinical applications.

XC images are acquired with a camera outside the mouth and can be of the head and neck or of the intraoral area, but the orientation of the acquisition device to the patient is always "outside to inside", as is the x-ray beam for IO. ES images are acquired with the camera inside the mouth and the orientation of the camera with respect to the patient can be either "outside to inside" (e.g. buccal view of teeth) or "inside to outside" (e.g., lingual view of teeth).

In the near term, the acquisition perspective, patient perspective and patient subject state will have to be captured as image notes. In the near future, these attributes should be captured as their own unique attributes within the Acquisition Context Group for Dentistry.

Before saving an image, the dentist may use the DICOM "Image Comments" to annotate text. Such text comments stored in the DICOM "Image Comments" section are captured in DICOM and saved with the image. In the short term, for images acquired with the use of a mirror, the end user will need to be trained to adjust the mirrored image to a direct image view.

³ Badano, Revie, Casertano, et.al, Consistency and Standardization of Color in Medical Imaging: a Consensus Report, JDI, July 2014 for additional use case discussion.

⁴ DICOM, CP 375.

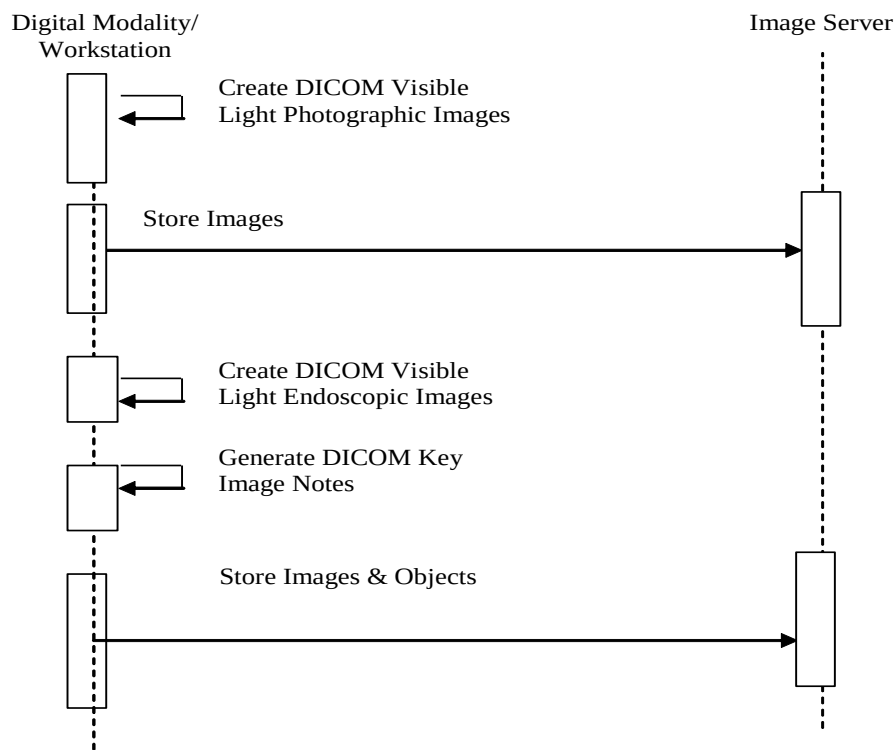


Figure 5. Solo practice, exchange of Visible Light (VL) photographic images multi-vendor shared digital systems

Several consultants (within and outside of the institutions) could receive the images on referral and read the accompanying annotations provided by the DICOM "Image Comments." Image presentation integrity is assured in that the visible light images look the same independent of the method used to present the images. After placing the images in the proper acquisition context, the consultants could either independently and/or collaboratively comment on the initial treatment recommended by the referring dentist.

The ability to use and save either a DICOM Presentation State is assumed, as is the presence of DICOM Query-Retrieve. It is assumed that other graphics or text notes may be available to supplement the image comments in the dental viewer software. Separate graphics may be referenced within the image comments or stored as a presentation state or a secondary capture image.

Note: A controlled patient image server preserves authorized access on patient information and limits disclosure. See NIST Special Publication 800-53 Revision 4, Security Controls of Federal Information Systems and Organizations, for additional guidance.

2.5 Exchanging DICOM Structured Displays

This use case describes the exchange of DICOM structured display objects. A dental practice (solo or a group at one or more locations) has a digital system in each operatory. Each system can generate panoramic (PX), intra-oral (IO), and color photography (VL) images and has local viewing capabilities. The shared server has a database/archive and could possibly be another dental system. Each of the systems is made by a different vendor.

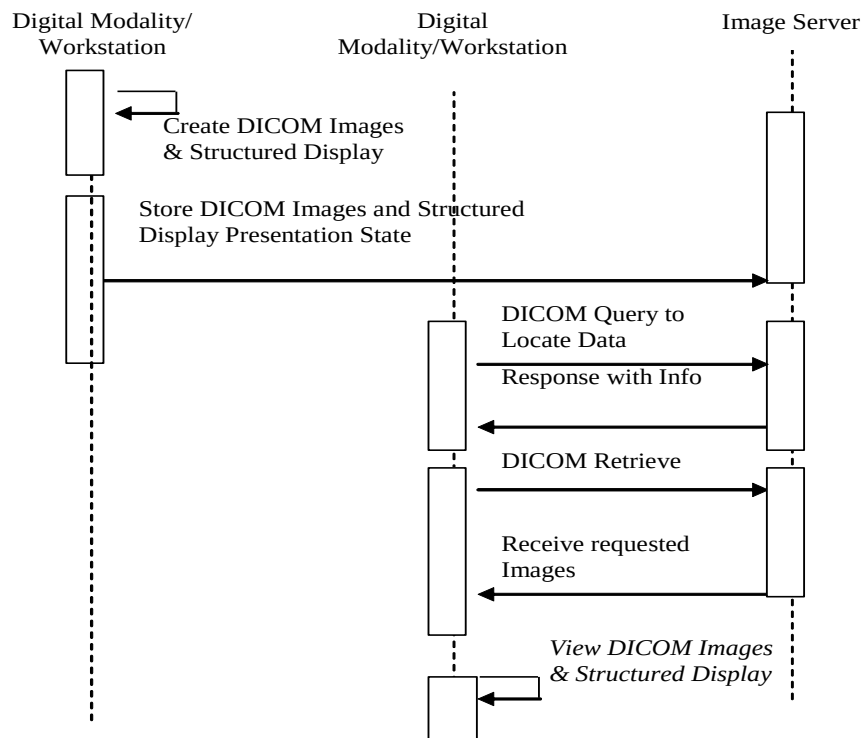


Figure 6. Exchanging DICOM Structured Displays

- A** A new patient arrives at a dental facility for a full mouth examination. A set of Intra-oral (IO) images are created by the dentist at a digital modality. The images and structured display Presentation Display are stored in the patient folder in the image server.
- B** In another area of the facility on another vendor's system, a specialist is referred to view the images based on the bone loss noted by the dentist. The specialist performs a DICOM Query (FIND SCU) and retrieves the appropriate images from the imaging server using DICOM Retrieve (MOVE SCU; STORE SCP).
- C** The specialist views the images and structured display presentation states. The specialist consults with the dentist regarding the patient's data. Although they are using different vendors systems, they are both able to observe the same examination showing the images on each other's display using the exact same layout.

Note: The contents of this use case also apply to the dental practice where all equipment and software are provided by the same vendor.

2.6 Dental practice, multi-vendor digital systems, scheduled workflow with a Dental Information System

This use case highlights clinic workflow to initiate the DICOM dental digital imaging process when interfacing with HL7 information systems. In a hospital or large dental clinic, these systems are commonly known as Hospital Information System (HIS) and Dental Information Systems. In typical dental clinics, they are commonly known as front office – Patient Scheduling and Registration Systems and back office – Patient Management Systems. No matter the size of the clinic, this functionality of Admit, Discharge and Transfer (ADT), Patient Demographics, Patient Registration, Order Placer and Department System Scheduler/ Order Filler, are typically found in HL7 based Information Systems. This is needed by the

DICOM Systems, Dental Acquisition Modality and Picture Archive and Communications System (PACS) to link the digital image to the patient's Electronic Health Record (EHR).

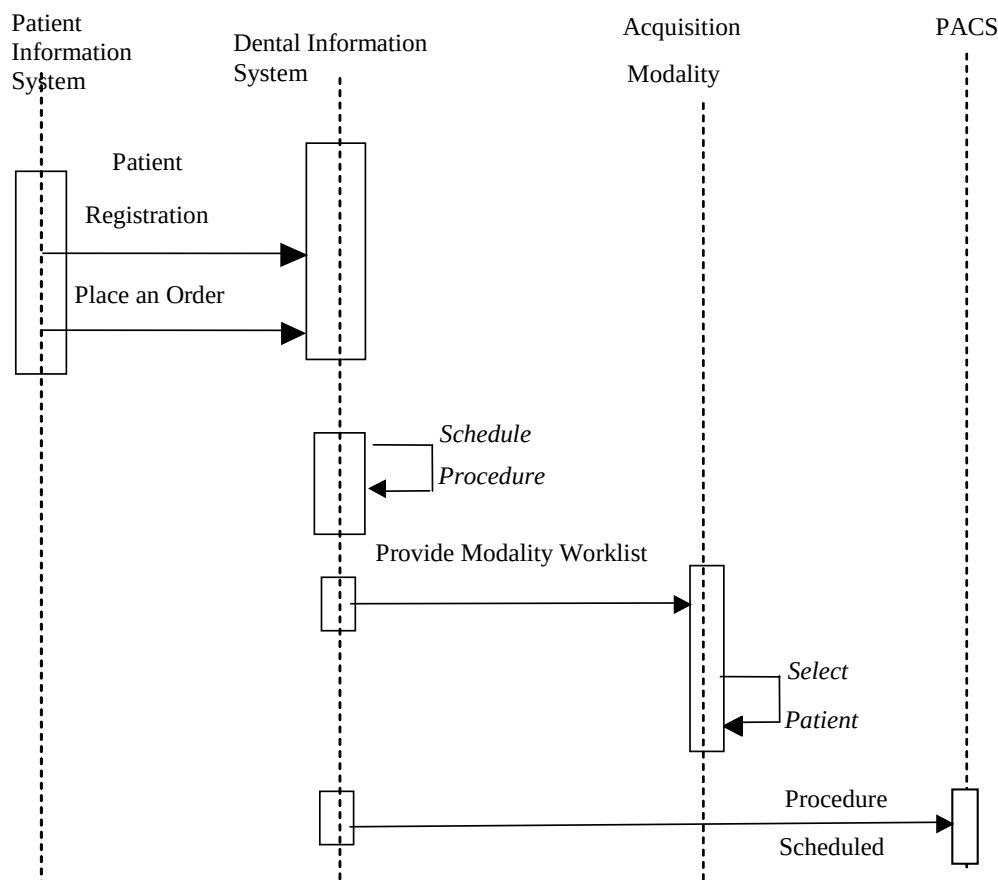


Figure 7a. Scheduled workflow with the Dental Record System

- A** The patient is registered in the front office patient information system. The provider can view applicable patient information such as patient history, allergies and previous exams.
- B** Within a preliminary dental examination, the provider creates new dental order. A dental imaging procedure is scheduled from a modality list that may include a complete survey of the patient's dentition such as panoramic, bitewings, full mouth series and ceph. This patient order and procedure will be made available to imaging modalities located in the dental radiology service area and to the PACS.
- C** At the dental radiology service area, the provider retrieves the patient and procedure information utilizing DICOM Modality Worklist at the modality. By utilizing MWL, patient and procedure information will remain forever with the image pixel information.