Digital Imaging and Communications in Medicine (DICOM)

Supplement 197: Ophthalmic Optical Coherence Tomography for Angiographic Imaging Storage SOP Classes

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Table of Contents

Scope and Field of Application

This Supplement defines Storage SOP Classes to support en face images acquired using ophthalmic optical coherence computed tomography (OCT) technology.

En Face angiography images are derived from images obtained using OCT technology (i.e., structural OCT volume images plus angiographic flow volume information). With special image acquisition sequences and post hoc image processing algorithms, OCT angiography detects the motion of the blood cells in the vessels to produce images of blood flow in the retina and choroid with capillary-level resolution. The resultant en face angiography images are similar to images obtained in retinal angiography with contrast dye administered intravenously, though clear differences are observed when comparing these two modalities. OCT angiography technology enables a high resolution visualization of the retinal and choroidal vascular network to detect the growth of abnormal blood vessels, and to provide additional insights in diagnosing and managing a variety of retinal diseases including diabetic retinopathy, neovascular age-related macular degeneration, retinal vein occlusion, and others.

This supplement:

- Updates the Ophthalmic Tomography IOD to identify that the SOP Instance is suitable for volumetric analysis, by requiring attributes related to defining spatial relationship (e.g., Pixel Measures, Plane Orientation, Plane Positions, etc.)
- Adds a CID to identify the Retinal Segmentation Surfaces used when generating a Surface Segmentation SOP Instance (e.g., capturing OPT surface mesh information).
- Adds a SOP Class to encode the OCT B-scan volume analysis information (such as angiographic flow volume information)
- Adds a SOP Class to encode derived en face image(s). En face images may be based on structural OCT volumes and surface mesh only or structural OCT volumes, surface mesh plus angiographic flow volume information.

Changes to NEMA Standards Publication PS 3.2

Digital Imaging and Communications in Medicine (DICOM)
Part 2: Conformance

Item: Add to table A.1-2 categorizing SOP Classes:

The SOP Classes are categorized as follows:

Table A.1-2
UID VALUES

UID Value	UID NAME	Category
…	…	…
1.2.840.10008.5.1.4.1.1.77.1.5.7	**Ophthalmic Optical Coherence Tomography En Face Image Storage**	**Transfer**
1.2.840.10008.5.1.4.1.1.77.1.5.8	**Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage**	**Transfer**
…	…	…

Changes to NEMA Standards Publication PS 3.3

Digital Imaging and Communications in Medicine (DICOM)

Part 3: Information Object Definitions

Modify PS3.3 Table A.1-1 to add new IODs for OCT En Face Image and OCT B-scan Volume Analysis

IODs Modules	…	OCT ENF	OCT BSV
Patient		M	M
Clinical Trial Subject		U	U
General Study		M	M
Patient Study		U	U
Clinical Trial Study		U	U
General Series		M	M
Clinical Trial Series		U	U
Segmentation Series			
Whole Slide Microscopy Series			
Intravascular OCT Series			
Ophthalmic Thickness Map Series			
Corneal Topography Map Series			
Ophthalmic Tomography Series		M	M
Frame of Reference		M	M
Synchronization			
Cardiac Synchronization			
General Equipment		M	M

Enhanced General Equipment		**M**	**M**
General Image		**M**	
Image Pixel		**M**	**M**
Palette Color Lookup Table		**C**	
Supplemental Palette Color Lookup Table			
Enhanced Contrast/Bolus			
Cine			
Multi-frame			
Multi-frame Functional Groups			**M**
Multi-frame Dimension			**M**
Bitmap Display Shutter			
Device			
Specimen			
VL Image			
Slide Coordinates			
Whole Slide Microscopy Image			
Optical Path			
Multi-Resolution Navigation			
Slide Label			
Ophthalmic Photography Image			
Wide Field Ophthalmic Photography Stereographic Projection			
Wide Field Ophthalmic Photography 3D Coordinates			
Wide Field Ophthalmic Photography			

Quality Rating			
Ocular Region Imaged		**M**	
Ophthalmic Photography Acquisition Parameters			
Ophthalmic Photographic Parameters			
Ophthalmic Tomography Image			
Ophthalmic Tomography Parameters			
Ophthalmic Tomography Acquisition Parameters			
Ophthalmic Thickness Map			
Ophthalmic Thickness Map Quality Rating			
Corneal Topography Map Image			
Corneal Topography Map Analysis			
Intravascular OCT Image			
Intravascular OCT Acquisition Parameters			
Intravascular OCT Processing Parameters			
Intravascular Image Acquisition Parameters			
Ophthalmic OCT En Face Image		**M**	
Ophthalmic OCT B-scan Volume Analysis			**M**
Ophthalmic OCT En Face Image		**C**	

Quality Rating			
Segmentation Image			
Overlay Plane			
Common Instance Reference		**U**	**U**
Acquisition Context			
ICC Profile		**U**	
SOP Common		**M**	**M**
Frame Extraction			**C**

Modify PS3.3 Annex A to update Ophthalmic Tomography IOD to require Frame of Reference and Functional Marcos when Ophthalmic Tomography SOP Instance supports volumetric properties

A.52.3 Ophthalmic Tomography Image IOD Modules

Table A.52.3-1. Ophthalmic Tomography Image IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	Ophthalmic Tomography Series	C.8.17.6	M
Frame of Reference	Frame of Reference	C.7.4.1	C – Required if Ophthalmic Photography Reference Image available **or if Ophthalmic Volumetric Properties Flag (0022,1622) is YES. May be present otherwise.**
	Synchronization	C.7.4.2	C – Required if Ophthalmic Photography Reference Image available
Equipment	General Equipment	C.7.5.1	M

IE	Module	Reference	Usage
	Enhanced General Equipment	C.7.5.2	M
Image	Image Pixel	C.7.6.3	M
	Enhanced Contrast/Bolus	C.7.6.4b	C – Required if contrast was administered
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Acquisition Context	C.7.6.14	M
	Cardiac Synchronization	C.7.6.18.1	C – Required if cardiac synchronization was used
	Ophthalmic Tomography Image	C.8.17.7	M
	Ophthalmic Tomography Acquisition Parameters	C.8.17.8	M
	Ophthalmic Tomography Parameters	C.8.17.9	M
	Ocular Region Imaged	C.8.17.5	M
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	U
	Frame Extraction	C.12.3	C – Required if the SOP Instance was created in response to a Frame-Level retrieve request

A.52.4.3 Ophthalmic Tomography Image Functional Group Macros

Table A.52.4.3-1 specifies the use of the Functional Group Macros used in the Multi-frame Functional Groups Module for the Ophthalmic Tomography Image IOD.

Table A.52.4.3-1. Ophthalmic Tomography Functional Group Macros

Functional Group Macro	Section	Usage
….	…..	…..
Plane Position (Patient)	C.7.6.16.2.3	C - Required if no Ophthalmic Photography Reference Image **is** available **or if Ophthalmic Volumetric Properties Flag (0022,1622) is YES**; May be present otherwise
Plane Orientation (Patient)	C.7.6.16.2.4	C - Required if no Ophthalmic Photography Reference Image **is** available **or if Ophthalmic Volumetric Properties Flag (0022,1622) is YES**; May be present otherwise

Modify PS3.3 Plane Position, Plane Orientation Macros and Pixel Measures to be required when an Ophthalmic Tomography encodes volumetric properties and for OCT B-scan Volume Analysis

C.7.6.16.2.3 Plane Position (Patient) Macro

Table C.7.6.16-4 specifies the attributes of the Plane Position (Patient) Functional Group Macro.

Table C.7.6.16-4. Plane Position (Patient) Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Plane Position Sequence	(0020,9113)	1	Identifies the position of the plane of this frame. Only a single Item shall be included in this Sequence.
>Image Position (Patient)	(0020,0032)	1C	The x, y, and z coordinates of the upper left hand corner (center of the first voxel transmitted) of the frame, in mm. See Section C.7.6.2.1.1 and Section C.7.6.16.2.3.1 for further explanation. Note In the case of CT images with an Acquisition Type (0018,9302) of CONSTANT_ANGLE the image plane is defined to pass through the data collection center and be normal to the central ray of the diverging X-Ray beam. Required if ~~either~~: • Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Volumetric Properties (0008,9206) of this frame is other than DISTORTED**, or** • SOP Class UID is Segmentation Storage ("1.2.840.10008.5.1.4.1.1.66.4") and Frame of Reference UID (0020,0052) is present**, or** • **SOP Class UID is Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4") and Ophthalmic Volumetric Properties Flag (0022,1622) is YES, or** • **SOP Class UID is Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.8")** May be present otherwise.

C.7.6.16.2.4 Plane Orientation (Patient) Macro

Table C.7.6.16-5 specifies the attributes of the Plane Orientation (Patient) Functional Group Macro.

Table C.7.6.16-5. Plane Orientation (Patient) Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Plane Orientation Sequence	(0020,9116)	1	Identifies orientation of the plane of this frame. Only a single Item shall be included in this Sequence.

Attribute Name	Tag	Type	Attribute Description
>Image Orientation (Patient)	(0020,0037)	1C	The direction cosines of the first row and the first column with respect to the patient. See Section C.7.6.2.1.1 and Section C.7.6.16.2.3.1 for further explanation. Required if ~~either~~: • Frame Type (0008,9007) Value 1 of this frame is ORIGINAL and Volumetric Properties (0008,9206) of this frame is other than DISTORTED**, or** • SOP Class UID is Segmentation Storage ("1.2.840.10008.5.1.4.1.1.66.4") and Frame of Reference UID (0020,0052) is present**, or** • **SOP Class UID is Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4") and Ophthalmic Volumetric Properties Flag (0022,1622) is YES, or** • **SOP Class UID is Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.8")** May be present otherwise.

70

C.7.6.16.2.1 Pixel Measures Macro

Table C.7.6.16-2 specifies the attributes of the Pixel Measures Functional Group Macro.

Table C.7.6.16-2. Pixel Measures Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Pixel Measures Sequence	(0028,9110)	1	Identifies the physical characteristics of the pixels of this frame. Only a single Item shall be included in this Sequence.
>Pixel Spacing	(0028,0030)	1C	Physical distance in the imaging target (patient, specimen, or phantom) between the centers of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm. See Section 10.7.1.3 for further explanation of the value order. Note In the case of CT images with an Acquisition Type (0018,9302) of CONSTANT_ANGLE, the pixel spacing is that in a plane normal to the central ray of the diverging X-Ray beam as it passes through the data collection center. Required if ~~either~~: • Volumetric Properties (0008,9206) is other than DISTORTED or SAMPLED**, or** • SOP Class UID is Segmentation Storage ("1.2.840.10008.5.1.4.1.1.66.4") and Frame of Reference UID (0020,0052) is present**, or** • **SOP Class UID is Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4") and Ophthalmic Volumetric Properties Flag (0022,1622) is YES, or** • **SOP Class UID is Ophthalmic Optical Coherence Tomography B-scan**

Attribute Name	Tag	Type	Attribute Description
			Volume Analysis Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.8") May be present otherwise.
>Slice Thickness	(0018,0050)	1C	Nominal reconstructed slice thickness (for tomographic imaging) or depth of field (for optical non-tomographic imaging), in mm. See Section C.7.6.16.2.3.1 for further explanation. Note Depth of field may be an extended depth of field created by focus stacking (see Section C.8.12.4). Required if ~~**either**~~: • Volumetric Properties (0008,9206) is VOLUME or SAMPLED, or • SOP Class UID is Segmentation Storage ("1.2.840.10008.5.1.4.1.1.66.4") and Frame of Reference UID (0020,0052) is present**, or** • **SOP Class UID is Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4") and Ophthalmic Volumetric Properties Flag (0022,1622) is YES, or** • **SOP Class UID is Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.8")** May be present otherwise.
>Spacing Between Slices	(0018,0088)	3	Spacing between adjacent slices, in mm. The spacing is measured from the center-to-center of each slice, and if present shall not be negative.

Modify PS3.3 Annex A to Surface Segmentation IOD to add a note that explains Laterality is not a modifier for retinal segmentation in the Segment Description Macro

C.8.20.4.1 Segment Description Macro

Table C.8.20-4 specifies the attributes of the Segment Description Macro.

Table C.8.20-4. Segment Description Macro Attributes

Attribute Name	Tag	Type	Attribute Description
…..	……	….	…..
Include Table 10-7 "General Anatomy Optional Macro Attributes"			May not be necessary if the anatomy is implicit in the Segmented Property Type Code Sequence.
Segmented Property Category Code Sequence	(0062,0003)	1	Sequence defining the general category of this segment. Only a single Item shall be included in this Sequence.

Attribute Name	Tag	Type	Attribute Description
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*Baseline CID 7150 "Segmentation Property Categories".*
Segmented Property Type Code Sequence	(0062,000F)	1	Sequence defining the specific property type of this segment. Only a single Item shall be included in this Sequence.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*Baseline CID 7151 "Segmentation Property Types"*
>Segmented Property Type Modifier Code Sequence	(0062,0011)	3	Sequence defining the modifier of the property type of this segment. One or more Items are permitted in this Sequence.
>>Include Table 8.8-1 "Code Sequence Macro Attributes"			*Baseline CID 244 "Laterality".* **Note** **For Retinal Segmentation Surfaces, laterality is not typically specified.**

Modify PS3.3 Annex A to add new IODs

A.aa Ophthalmic Optical Coherence Tomography En Face Image Information Object Definition

This Section defines an Information Object to be used with several types of en face images that are derived from volumetric images obtained using OCT technology. En face images may be based upon structural OCT volumes and surface mesh information only or structural OCT volumes, surface mesh information and angiographic flow volume information.

A.aa.1 Ophthalmic Optical Coherence Tomography En Face Image IOD Description

The Ophthalmic Optical Coherence Tomography En Face Image IOD specifies a single-frame image derived from images obtained using OCT technology. This IOD encodes a single derived en face image.

A.aa.2 Ophthalmic Optical Coherence Tomography En Face Image IOD Entity-Relationship Model

The Ophthalmic Optical Coherence Tomography En Face Image IOD uses the DICOM Composite Instance IOD Entity-Relationship Information Model defined in Section A.1.2. The Series IE contains only an Image IE.

A.aa.3 Ophthalmic Optical Coherence Tomography En Face Image IOD Modules

Table A.aa-1 specifies the Modules of the Ophthalmic Optical Coherence Tomography En Face Image IOD.

Table A.aa-1
Ophthalmic Optical Coherence Tomography En Face Image IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U

Series	General Series	C.7.3.1	M
	Ophthalmic Tomography Series	C.8.17.6	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Image	General Image	C.7.6.1	M
	Image Pixel	C.7.6.3	M
	Palette Color Lookup Table	C.7.9	C – Required if Photometric Interpretation (0028,0004) has a value of PALETTE COLOR
	Ophthalmic OCT En Face Image	C.8.xx.2	M
	Ocular Region Imaged	C.8.17.5	M
	Ophthalmic OCT En Face Image Quality Rating	C.8.xx.3	C – Required if device calculates quality rating
	ICC Profile	C.11.15	U
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	U

A.aa.4 Ophthalmic Optical Coherence Tomography En Face Image Image IOD Content Constraints

The following constraints on Series and Image attributes take precedence over the descriptions given in the Module Attribute Tables.

A.aa.4.1 Frame of Reference UID

The value for the Frame of Reference UID (0020,0052) in this SOP Instance shall convey the same value as the Frame of Reference UID (0020,0052) of the SOP Instance(s) referenced in Attribute Source Image Sequence (0008,2112).

Modify PS3.3 Annex A to update Ophthalmic Tomography OCT B-scan Volume Analysis IOD

A.bb Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Information Object Definition

This Section defines an Information Object to be used for multi-frame images obtained from the volumetric analysis of ophthalmic tomography B-scans (e.g., ophthalmic tomography angiographic (blood flow) volume information).

A.bb.1 Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD Description

The Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD specifies a multi-frame image conveying ophthalmic optical coherence tomography volumetric B-scan volume analysis information (e.g., angiographic (blood flow) volume information).

A.bb.2 Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD Entity-Relationship Model

The Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD uses the DICOM Composite Instance IOD Entity-Relationship Information Model defined in Section A.1.2.

A.bb.3 Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD Modules

Table A.bb-1 specifies the Modules of the Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD.

Table A.bb-1
Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Ophthalmic Tomography Series	C.8.17.6	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Image	Image Pixel	C.7.6.3	M
	Ophthalmic OCT B-scan Volume Analysis	C.8.yy.2	M
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	U
	Frame Extraction	C.12.3	C – Required if the SOP Instance was created in response to a Frame-Level retrieve request

A.bb.3.1 Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Constraints

The General Image Module, Overlay Plane Module, Modality LUT Module and VOI LUT Module shall not be used in a Standard Extended SOP Class of the Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Class.

Note

In order to annotate a B-scan Volume Analysis, SOP Instances of the Grayscale Softcopy Presentation State Storage or the Structured Report Storage SOP Classes that reference the SOP Instance may be used.

Pseudo-color presentation information may be applied through the use of separate Pseudo-color Softcopy Presentation State SOP Instances.

No standard mechanism is provided for inclusion of annotations within the image SOP Instance itself and implementers are discouraged from using private extensions to circumvent this restriction.

A.bb.3.2 Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Functional Group Macros

Table A.bb.3.2-1 specifies the use of the Functional Group Macros used in the Multi-frame Functional Groups Module for the Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD.

Table A.bb.3.2-1. Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Functional Group Macros

Functional Group Macro	Section	Usage
Pixel Measures	C.7.6.16.2.1	M
Plane Orientation (Patient)	C.7.6.16.2.4	M
Plane Position (Patient)	C.7.6.16.2.3	M
Frame Content	C.7.6.16.2.2	M – May not be used as a Shared Functional Group.
Referenced Image	C.7.6.16.2.5	M
Derivation Image	C.7.6.16.2.6	M – May not be used as a Shared Functional Group (see A.bb.3.2.1.1 for specialization).
Frame Anatomy	C.7.6.16.2.8	M
Frame VOI LUT With LUT Macro	C.7.6.16.2.10b	M
Real World Value Mapping	C.7.6.16.2.11	U

A.bb.3.2.1 Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD Content Constraints

This source for an Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance is one or more multi-frame Ophthalmic Tomography SOP Instance(s). The correlation is encoded at the Frame Level and conveyed in the Derivation Image Macro (see C.8.xx.2.1.7 for examples).

A.bb.3.2.1.1 Derivation Image Functional Group

The following constraints to the Derivation Image Macro shall apply:

1. Derivation Image Sequence (0008,9124) shall be Type 1
2. The value for Derivation Code Sequence (0008,9215) shall be (*128303, DCM, "OCT B-scan analysis")*
3. Source Image Sequence (0008,2112) shall be Type 1 and contain one Item. The referenced SOP Instance shall have the same value for Frame of Reference UID (0020,0052) as this SOP Instance
4. The value for Referenced SOP Class UID (0008,1150) shall be Ophthalmic Tomography Image Storage ("1.2.840.10008.5.1.4.1.1.77.1.5.4")
5. The value for Purpose of Reference Code Sequence (0040,A170) shall be (*128250, DCM, "Structural image for imaging processing"*)
6. The value for Spatial Locations Preserved (0028,135A) shall be YES

Modify C.8.17.7-1 to generate condition flag for OCT Volumetric Properties

Table C.8.17.7-1. Ophthalmic Tomography Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
……	…..	..	…….
Ophthalmic Volumetric Properties Flag	**(0022,1622)**	**1C**	**Whether this SOP Instance is suitable for OCT volumetric processing.** **Required if this SOP Instance is suitable for OCT volumetric processing. May be present otherwise.** **Enumerated Values:** **YES** **NO**
…….	**…..**	**….**	**……**
In-concatenation Total Number	(0020,9163)	1	The number of SOP Instances sharing the same Concatenation UID (0020,9161). **See C.8.yy.2.3 for further explanation.** Enumerated Values: **1**

The value constraints on Concatenation Frame Offset Number (0020,9228), In-concatenation Number (0020,9162), and In-concatenation Total Number (0020,9163) have the effect of requiring the entire image to be in one concatenation.

The Attribute Ophthalmic Volumetric Properties Flag (0022,1622) is YES when the Ophthalmic Tomography Image Storage SOP Instance encodes volumetric spatial information (e.g. Frame of Reference, Pixel Measures, Plane Orientation, Plane Position, etc.). For example, ophthalmic tomography volumetric information is required when implementations encode Surface Segmentation SOP Instance(s) (e.g., surface segmentation is applied to the structural OCT volume to delineate the anatomical boundaries) and/or an Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage SOP Instance (e.g., angiographic (blood flow) volume information) based upon the volumetric Ophthalmic Tomography Image Storage SOP Instance.

Modify C.8.17.5 to enable the capture of Anatomic Reference Points for OP, OPT and en face images.

C.8.17.5 Ocular Region Imaged Module

Table C.8.17.5-1 contains IOD Attributes that describe the anatomy ~~**contained**~~ **imaged** in an Ophthalmic Photography or Ophthalmic Tomography **Image Storage SOP Instance**.

Table C.8.17.5-1. Ocular Region Imaged Module Attributes

Attribute Name	Tag	Type	Attribute Description
……	…..	….	….
Relative Image Position Code Sequence	(0022,001D)	~~3~~**2C**	The position of this image on the retina (as defined by a specified nomenclature; the nomenclature is implicit in the code used). Only a single Item is permitted in this Sequence. **Required if Ophthalmic Volumetric Properties Flag (0022,1622) is set to YES and Attributes Ophthalmic Anatomic Reference Point X-Coordinate (0022,1624) and Ophthalmic Anatomic Reference Point Y-Coordinate (0022,1626) do not contain a value, May be present otherwise.** **Note** **This Attribute is used to provide the user with a general reference point when viewing the image. If the implementation is able to identify a precise anatomic location, it will convey that information in Attributes Ophthalmic Anatomic Reference Point X-Coordinate (0022,1624) and Ophthalmic Anatomic Reference Point Y-Coordinate (0022,1626).**
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*Baseline CID 4207 "Ophthalmic Image Position".*
Ophthalmic Anatomic Reference Point X-Coordinate	**(0022,1624)**	**2C**	**The horizontal offset location (column) of the anatomic reference point identified by Attribute Primary Anatomic Region Sequence (0008,2228). See Section C.8.17.5.1 for further explanation.** **Image relative position specified with sub-pixel resolution such that the origin at the Top Left Hand Corner (TLHC) of the TLHC pixel is 0.0\0.0, the Bottom Right Hand Corner (BRHC) of the TLHC pixel is 1.0\1.0, and the BRHC of the BRHC pixel is Columns\Rows (see figure C.10.5-1). The value must be within the range 0\0 to Columns.** **Required if Ophthalmic Volumetric Properties Flag (0022,1622) is set to YES. May be present otherwise.**
Ophthalmic Anatomic Reference Point Y-Coordinate	**(0022,1626)**	**2C**	**The vertical offset location (row) of the anatomic reference point identified by Attribute Primary Anatomic Region Sequence (0008,2228). See Section C.8.17.5.1 for further explanation.** **Image relative position specified with sub-pixel resolution such that the origin at the Top Left Hand Corner (TLHC) of the TLHC pixel is 0.0\0.0, the Bottom Right Hand Corner (BRHC) of the TLHC pixel is 1.0\1.0, and the BRHC of the BRHC pixel is Columns\Rows (see figure C.10.5-1). The value must be within the range 0\0 to Rows.**

Attribute Name	Tag	Type	Attribute Description
			Required if Ophthalmic Volumetric Properties Flag (0022,1622) is set to YES. May be present otherwise.
Include Table 10-5 "General Anatomy Mandatory Macro Attributes"			*Defined CID 4209 "Ophthalmic Anatomic Structure Imaged" for Anatomic Region Sequence* ***In this Module Primary Anatomic Structure Sequence (0008,2228) is Type 1C.*** ***Required if Attributes Ophthalmic Anatomic Reference Point X-Coordinate (0022,0024) and Ophthalmic Anatomic Reference Point Y-Coordinate (0022,0026) contain a value. May be present otherwise.*** ***Defined CID 4266 "Ophthalmic Anatomic Structure Reference Point" for Primary Anatomic Structure Sequence***

Add section C.8.17.5.1

C.8.17.5.1 Ocular Region Imaged Module Attribute Descriptions

C.8.17.5.1.1 Ophthalmic Anatomic Reference Point Location

The Attributes Ophthalmic Anatomic Reference Point X-Coordinate (0022,1624) and Ophthalmic Anatomic Reference Point Y-Coordinate (0022,1626) are used when an Ophthalmic Tomography Image Storage SOP Instance contains attributes to convey volumetric properties (such as when using the Ophthalmic Tomography image for angiography). These Attributes identify the location of the anatomic region conveyed in Attribute Primary Anatomic Region Sequence (0008,2228). The most common anatomic regions identified for an OCT angiography are the fovea centralis and optic nerve head.

Note

The Anatomic Region Sequence (0008,2218) is typically set to *(T-AA000, SRT, "Eye").*

Figure C.8.17.5-1 shows an Ophthalmic Tomography image displaying the fovea centralis. The image Row/Column is defined as 245 x 245 and the location of the fovea centralis is horizontal row = 194 and vertical row = 132. Therefore, Attribute Ophthalmic Anatomic Reference Point X-Coordinate (0022,0024) is equal to 194 and Attribute Ophthalmic Anatomic Reference Point Y-Coordinate (0022,0026) is equal to 132.

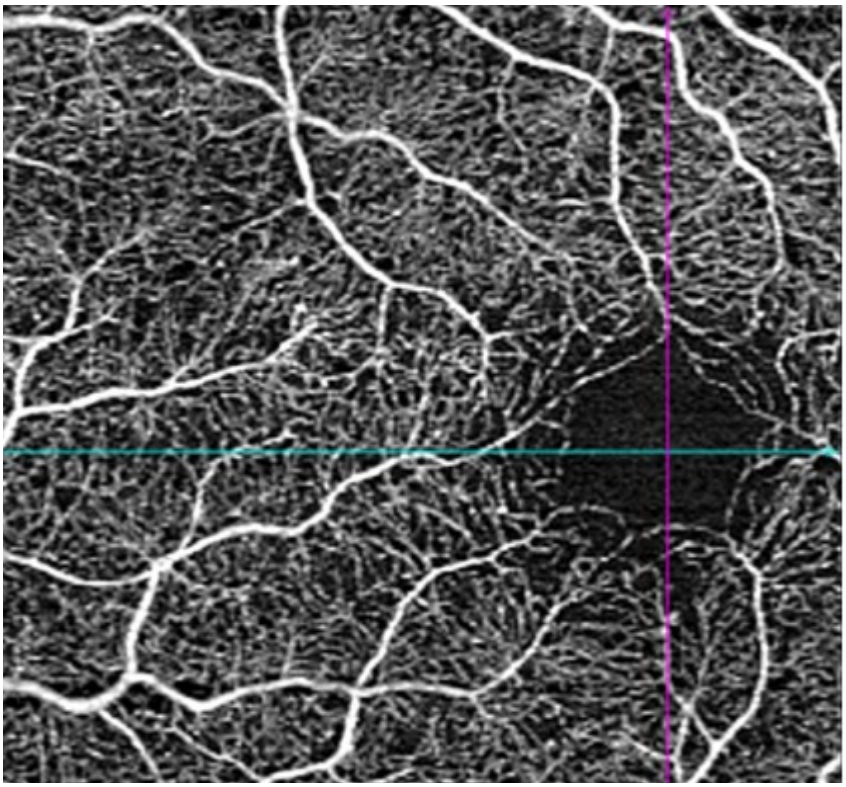


Figure C.8.17.5-1: En face Image – Ophthalmic Anatomic Reference Point Location Example

C.8.xx.2 Ophthalmic OCT (Optical Coherence Tomography) En Face Image Module

220 Table C.8.xx.2-1 specifies the Attributes that describe the Ophthalmic OCT En Face Image Module.

Table C.8.xx.2-1
Ophthalmic OCT En Face Image Module Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. See Section C.8.xx.2.1.5 for specialization.
Instance Number	(0020,0013)	1	A number that identifies this SOP Instance.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. See Section C.8.xx.2.1.6 for specialization.
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. See Section C.8.xx.2.1.6 for specialization.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Shall be one less than the value in Bits Stored (0028,0101). See Section C.8.xx.2.1.6 for specialization.
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image.

Attribute Name	Tag	Type	Attribute Description
			Enumerated Value: **1**
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. See Section C.8.xx.2.1.4 for specialization.
Pixel Representation	(0028,0103)	1	Data representation of pixel samples. Enumerated Values: **0**
Pixel Spacing	(0028,0030)	1	Nominal physical distance at the focal plane (in the retina) between the center of each pixel, specified by a numeric pair – adjacent row spacing (delimiter) adjacent column spacing in mm. See Section 10.7.1.3 for further explanation of the value order. Note Since a patient's retina is curved and the image representation is planar, there can be an error in using Pixel Spacing (0028,0030) for measurements in the periphery of the image. En face imaging does not support wide field measurements.
Content Time	(0008,0033)	1	The time the image pixel data creation started.
Content Date	(0008,0023)	1	The date the image pixel data creation started.
Source Image Sequence	(0008,2112)	1	A Sequence that identifies the Images that were used to derive this Image. One or more Items shall be included in this sequence. See Section C.7.6.1.1.4 and C.8.xx.2.1.1 for further explanation.
>Include Table 10-3 "Image SOP Instance Reference Macro Attributes"			
>Purpose of Reference Code Sequence	(0040,A170)	1	Describes the purpose for which the reference is made, that is what role the source image or frame(s) played in the derivation of this image. Only a single Item shall be included in this Sequence.
>>Include Table 8.8-1 "Code Sequence Macro Attributes".			*Defined CID 7202 "Source Image Purposes of Reference".* *If the derived en face image is based upon OPT structure information, the concept code shall be*

Attribute Name	Tag	Type	Attribute Description
			(128250, DCM, "Structural image for image processing"). *If the derived en face image is based upon OPT flow information, the concept code shall be (128251, DCM, "Flow image for image processing").*
Derivation Algorithm Sequence	(0022,1612)	1	Software algorithm that performed the derivation. Only a single Item shall be included in this Sequence.
>Include Table 10-19 "Algorithm Identification Macro Attributes"			*Defined Context ID 4270 "OCT-A Processing Algorithm Families" shall be used for Algorithm Family Code Sequence (0066,002F)*
Ophthalmic Image Type Code Sequence	(0022,1615)	1	En face image type used to identify this SOP Instance Only a single Item shall be included in this Sequence. See Section C.8.xx.2.1.3 for further explanation.
>Include Table 8.8-1 "Code Sequence Macro Attributes".			*Defined CID is 4271 "En Face Image Types"*
Ophthalmic Image Type Description	(0022,1616)	3	Description of the en face image type.
Window Center	(0028,1050)	1	Window Center for display. See Section C.11.2.1.2 for further explanation. Note When Bits Allocated (0028,0100) is 8, the value is typically always set to 127 or 128.
Window Width	(0028,1051)	1	Window Width for display. See Section C.11.2.1.2 for further explanation. Note When Bits Allocated (0028,0100) is 8, the value is typically always set to 256.
Ophthalmic FOV	(0022,1517)	3	The horizontal field of view used to capture the ophthalmic image, in degrees. The field of view is the maximum image size displayed on the image plane, expressed as the angle subtended at the exit pupil of the eye by the maximum dimension 2r (where r equals the radius).
Referenced Surface Mesh Identification Sequence	(0022,1620)	1	Reference to the surface mesh(s) used in the creation of this SOP Instance. One or more Items shall be included in this sequence. See Section C.8.xx.2.1.2 for further explanation.

Attribute Name	Tag	Type	Attribute Description
>Referenced SOP Instance UID	(0008,1155)	1	Referenced SOP Instance that contains the surface segmentation used in the creation of this SOP Instance.
>Referenced Surface Number	(0066,002C)	1	Reference to a Surface Number (0066,0003) present in Surface Sequence (0066,0002).
>Segmented Property Type Code Sequence	(0062,000F)	1	Sequence defining the specific property the surface represents. Only a single Item is permitted in this Sequence Note "Property" is used in the sense of meaning "what the surface represents", whether it be a physical or biological object, be real or conceptual, having spatial, temporal or functional extent or not. I.e., it is what the segment "is" (as opposed to some feature, attribute, quality, or characteristic of it, like color or shape or size).
>>*Include Table 8.8-1 "Code Sequence Macro Attributes"*			*Baseline CID 4273 "Retinal Segmentation Surfaces".*
>Surface Mesh Z-Pixel Offset	(0022,1658)	1	Offset in number of pixels along the z axis by which the mesh data has been shifted when generating this SOP Instance. The mesh data is the Attribute Point Coordinates Data (0066,0016) of the surface mesh referenced by Attribute Referenced SOP Instance UID (0008,1155). Note If no offset is used the value is set to 0.
Ophthalmic Axial Length	(0022,1019)	3	The axial length measurement, in mm.
Ophthalmic Axial Length Method	(0022,1515)	3	The method used to obtain the Ophthalmic Axial Length. Enumerated values: MEASURED = Measured axial length. ESTIMATED = An estimated value based upon performing the examination (i.e. based upon surrogate markers of axial length). POPULATION = A length that represents a population norm (i.e. not based upon a measured axial length or surrogate markers of axial length).
Lossy Image Compression	(0028,2110)	1	Specifies whether an Image has undergone lossy compression (at a point in its lifetime). Enumerated Values: **00** Image has NOT been subjected to lossy

Attribute Name	Tag	Type	Attribute Description
			compression. **01** Image has been subjected to lossy compression. Once this value has been set to 01 it shall not be reset. See Section C.7.6.1.1.5.
Lossy Image Compression Ratio	(0028,2112)	1C	Describes the approximate lossy compression ratio(s) that have been applied to this image. See Section C.7.6.1.1.5.2. Required if Lossy Image Compression (0028,2110) is “01”.
Lossy Image Compression Method	(0028,2114)	1C	A label for the lossy compression method(s) that have been applied to this image. See Section C.7.6.1.1.5.1. Required if Lossy Image Compression (0028,2110) is “01”.
Presentation LUT Shape	(2050,0020)	1C	Specifies an identity transformation for the Presentation LUT, such that the output of all grayscale transformations defined in the IOD containing this Module are defined to be P-Values. Enumerated Values: **IDENTITY** output is in P-Values. Required if Photometric Interpretation (0028,0004) is MONOCHROME2
Calibration Image	(0050,0004)	3	Indicates whether a reference object (phantom) of known size is present in the image and was used for calibration. Enumerated Values: **YES** **NO**
Burned In Annotation	(0028,0301)	1	Indicates whether or not image contains sufficient burned in annotation to identify the patient and date the image was acquired. Enumerated Values: **YES** **NO**
Recognizable Visual Features	(0028,0302)	1	Indicates whether or not the image contains sufficiently recognizable visual features to allow the image or a reconstruction from a set of images to identify the patient. Enumerated Values:

Attribute Name	Tag	Type	Attribute Description
			YES **NO**

C.8.xx.2.1 Ophthalmic OCT En Face Image Module Attribute Descriptions

C.8.xx.2.1.1 Source Image Sequence

An OCT en face image is derived from images obtained using OCT technology. The Source Image Sequence (0008,2112) shall convey the SOP Instances used to derive this en face SOP Instance.

If Attribute Purpose of Reference Code Sequence (0040,A170) is set to (*128250, DCM, "Structural image for image processing"),* the Source Image Sequence will reference an Ophthalmic Tomography SOP Instance.

If Attribute Purpose of Reference Code Sequence (0040,A170) is set to (*128251, DCM, "Flow image for image processing"),* the Source Image Sequence will reference an Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance.

A typical example of the image processing stages performed to generate en face images is shown in Figure C.8.xx-1.

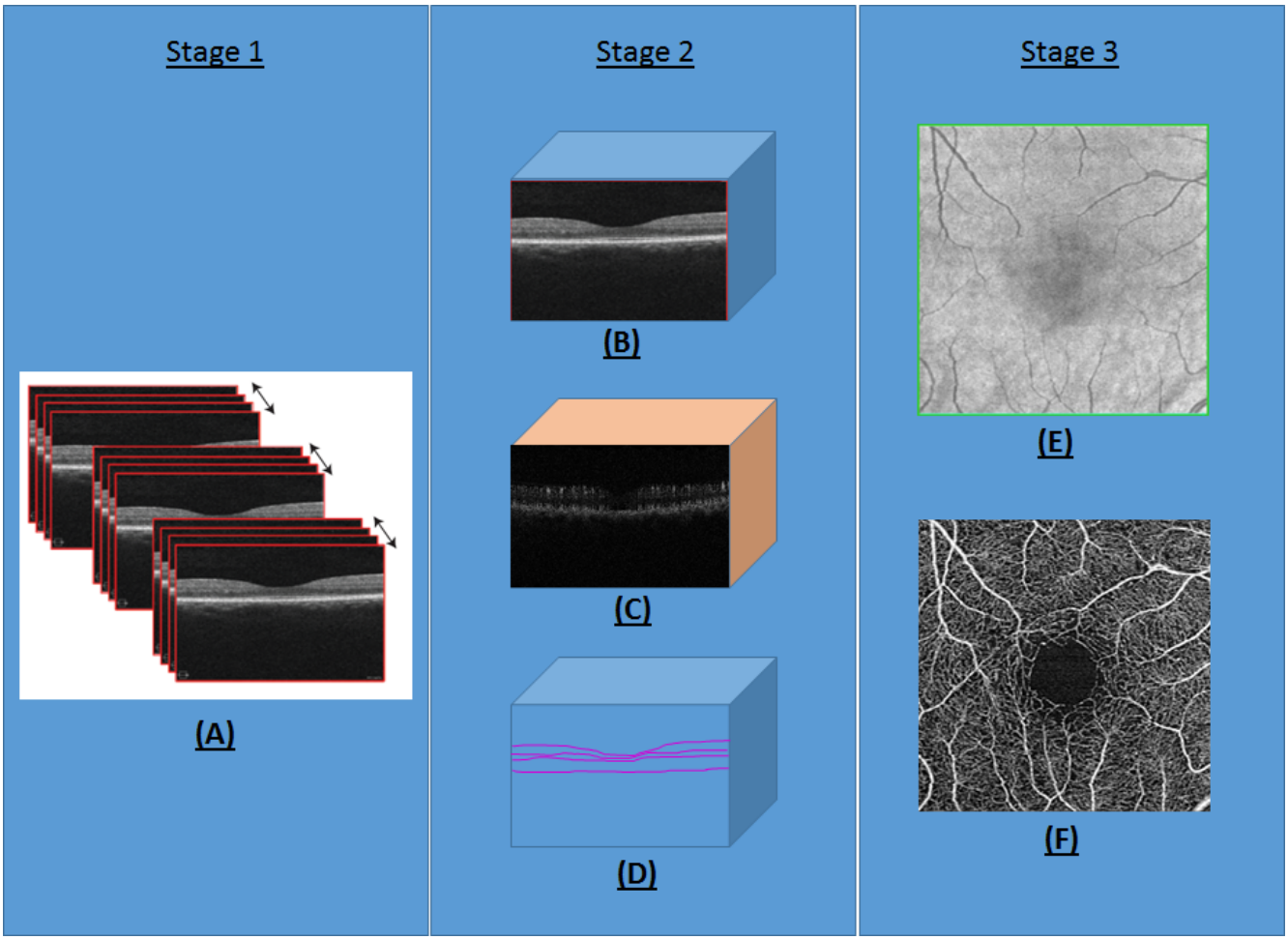


Figure C.8.xx-1: Example of the Image Process Performed to Generate En Face Images

Figure Legend:

A = OCT proprietary B-scan data (possibly a DICOM Raw Data Instance)
B = Volumetric structural ophthalmic tomography image (Ophthalmic Tomography Image Instance)
C = OCT angiographic flow volume information (Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Instance)
D = OCT surface mesh (Surface Segmentation Instance)
E = Structural en face image (Ophthalmic Optical Coherence Tomography En Face Image Instance)
F = En Face angiographic flow image (Ophthalmic Optical Coherence Tomography En Face Image Instance)

Stage 1: OCT technology is used to acquire a volumetric dataset from a retinal region of interest. This volumetric dataset (A) consists of multiple B-scans in a raster pattern, and multiple frames are acquired at each B-scan location. The B-scans are acquired in the manufacturer's proprietary format for analysis and storage. If this information is stored in DICOM, it can use the Raw Data Storage SOP Class.

Stage 2: The OCT proprietary B-scan data (A) (or DICOM Raw Data SOP Instance) is then analyzed to derive the volumetric structural ophthalmic tomography image (B). From (B) one or more OCT surface meshes (D) are generated to delineate the anatomical boundaries. The difference in signal between the frames of each individual B-scan is analyzed to produce the OCT angiographic flow volume information (C).

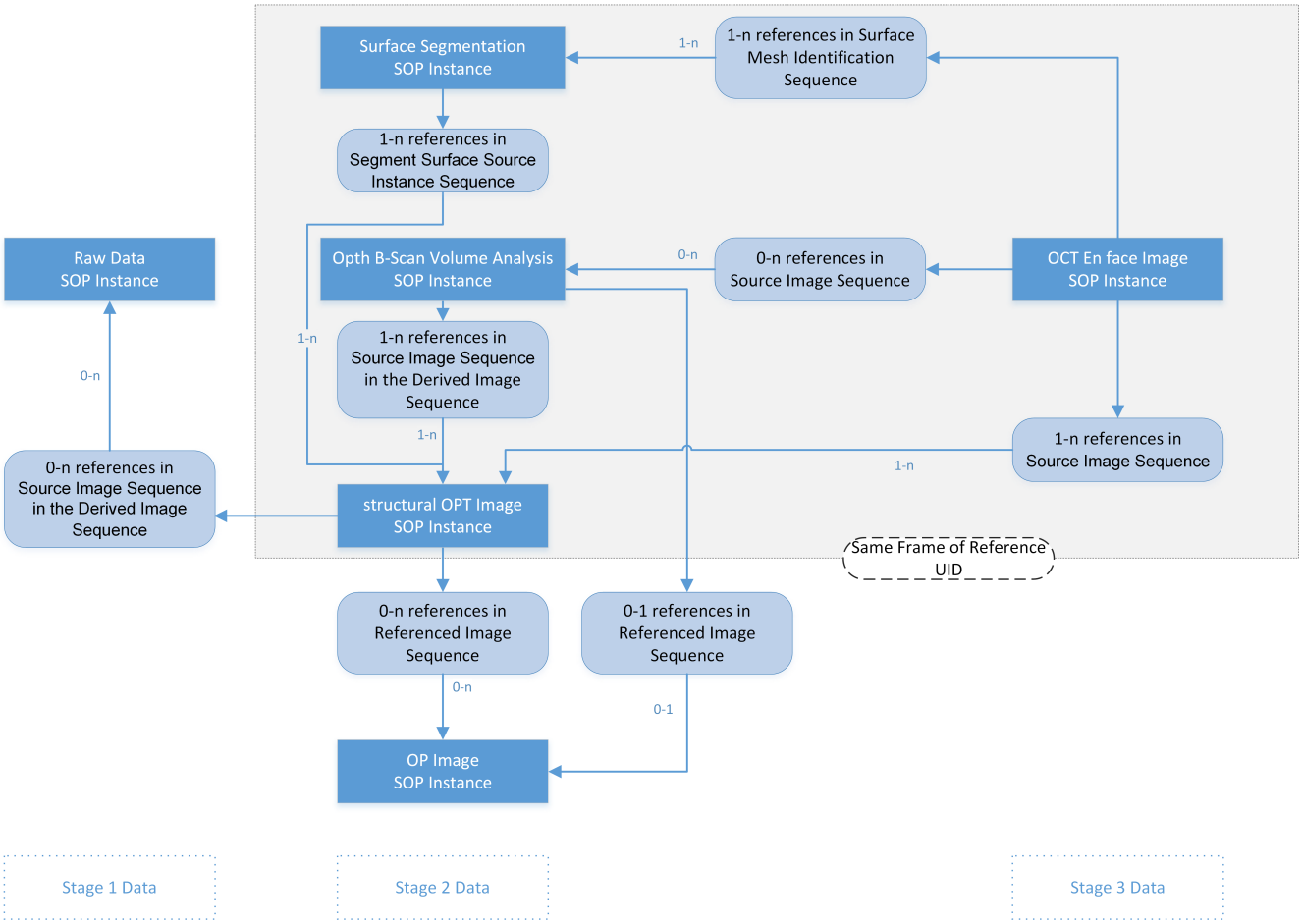
Stage 3: Clinicians typically make their assessment based upon two types of OCT en face images. The structural OCT en face image (E) is derived by using pixel information in (B) and two surface meshes (C). The vascular OCT en face image (F) may be derived using the volumetric structural ophthalmic tomography image (B), the OCT surface mesh (D) and the OCT angiographic flow volume information (C).

En face images are typically derived by the acquisition modality that generated the Ophthalmic Tomography Image, Surface Segmentation and Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instances or by image workstations that received the respective Ophthalmic Image, Surface Segmentation and Ophthalmic Optical Tomography B-scan Volume Analysis SOP Instances via DICOM Storage.

Note

Image workstations receiving ophthalmic tomography images may choose to evaluate the structural ophthalmic tomography image and generate a different set of segmented surfaces than defined by an acquisition device. The surface segmentation information can be stored in a separate Surface Segmentation SOP Instance.

The Ophthalmic Tomography Image, Surface Segmentation, Ophthalmic Optical Coherence Tomography B-scan Volume Analysis and the Ophthalmic Optical Coherence Tomography En Face Image SOP Instances all reside in different DICOM series. They share the same spatial Frame of Reference which is identified in Attribute Frame of Reference UID (0020,0052) (i.e., the value of Frame of Reference UID (0020,0052) is the same in each SOP Instance). Figure C.8.xx-2 illustrates the relationships between the OCT angiography based SOP Instances.



275

Figure C.8.xx-2: Relationships Between OCT-A Based SOP Instances

C.8.xx.2.1.2 Referenced Surface Mesh Identification Sequence

Referenced Surface Mesh Identification Sequence (0022,1620) identifies one or more segmentation surfaces used to
280 generate the derived en face image. The segmented surfaces are described in the SOP Instance identified by Referenced SOP Instance UID (0008,1155) (e.g., Surface Segmentation Storage SOP Instance).

C.8.xx.2.1.3 Ophthalmic Image Type Code Sequence

Implementations may generate many different types of derived en face images. Figure C.8.xx-3 illustrates various derived enface image types. The Ophthalmic Image Type Code Sequence (0022,1615) is used to identify the type of derived en face image.

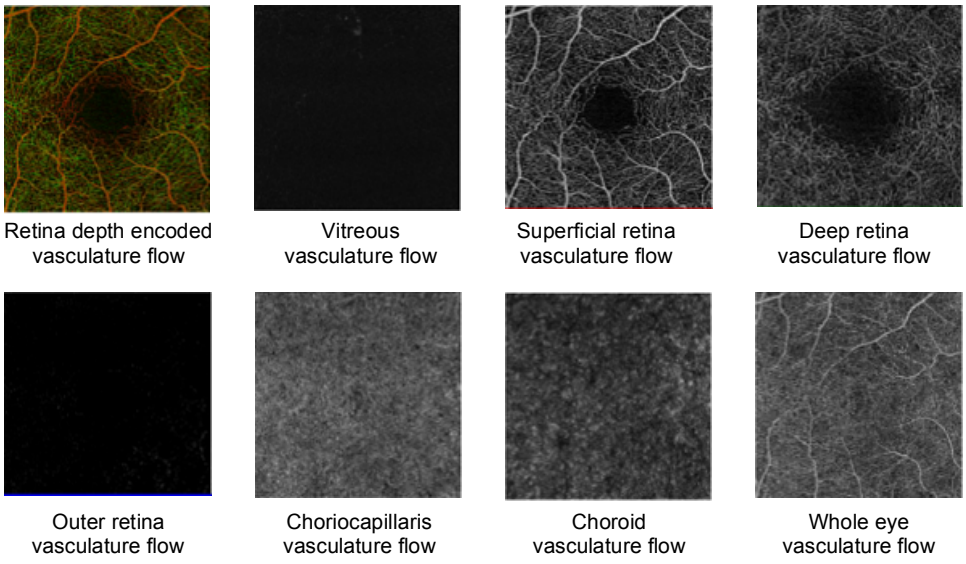


Figure C.8.xx-3: Examples of En Face Images Types

C.8.xx.2.1.4 Photometric Interpretation

Specifies the intended interpretation of the pixel data.

Enumerated Values:

MONOCHROME2
PALETTE COLOR

C.8.xx.2.1.5 Image Type

The Image Type attribute (0008,0008) (General Image Module, Section C.7.6.1) identifies important image characteristics in a multiple valued data element. For the Ophthalmic Optical Tomography En Face Image IOD, Image Type is specified as a Type 1 attribute and further specialized as follows:

a. Value 1 shall identify the Pixel Data Characteristics in accordance with Section C.7.6.1.1.2.

   Enumerated Values:
   DERIVED identifies a Derived Image

b. Value 2 shall identify the Patient Examination Characteristics in accordance with Section C.7.6.1.1.2

   Enumerated Values:
   PRIMARY identifies a Primary Image

c. Value 3 shall identify any Image IOD specific specialization in accordance with Section C.7.6.1.1.2 (optional)

   Defined Terms:
   MONTAGE identifies a Montage Image

d. Other Values that are implementation specific in accordance with Section C.7.6.1.1.2 (optional)

Note

A Montage Image is constructed out of several individual images, which also can be exchanged separately. The images used to create the montage image will be included in the source image sequence if those images are also exchanged. A Montage Image is identified as Image Type DERIVED\PRIMARY\MONTAGE.

C.8.xx.2.1.6 Image Bits Allocated, Bits Stored, and High Bit Type

These Attributes shall be determined based upon the Photometric Interpretation (0028,0004):

Photometric Interpretation (0028,0004)	Bits Allocated (0028,0100)	Bits Stored (0028,0101)	High Bit (0028,0102)
MONOCHROME2 PALETTE COLOR	8	8	7
	16	12	11
	16	16	15

C.8.xx.2.1.7 Relationship Between Ophthalmic Tomography Image and Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IODs

When generating an angiographic en face Image SOP Instance implementations need to understand the relationship between the Ophthalmic Tomography Image SOP Instance(s) and the Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance.

The Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance, which is a multi-frame SOP Instance, references one or more Ophthalmic Tomography Image SOP Instances using the Derivation Image Macro. The Derivation Image Macro defines Attributes at the Frame Level (i.e. each frame in the Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance, references an Ophthalmic Tomography Image SOP Instance and the Ophthalmic Tomography Image SOP Instance frame number that was used to generate the specific Ophthalmic Optical Coherence Tomography B-scan Volume Analysis frame).

Below is a typical example.

- Ophthalmic Tomography Image SOP Instance UID is “1.2.3.4.5” and contains five frames.
- Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance encodes five frames (e.g., one frame for each ophthalmic tomography frame).
- References are encoded via the Per-frame Functional Groups Sequence (5200,9230) using Attributes Derivation Image Sequence (0008,9124) and Source Image Sequence (0008,2112).

Name	Tag	Value	Comment
…..	….	…	
Per-frame Functional Groups Sequence	(5200,9230)		
Item 1 (Frame 1 in OCT B-scan Volume)			
…..			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 1)			

Name		Tag	Value	Comment
	>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
	>>> Referenced SOP Instance UID	(0008,1155)	“1.2.3.4.5”	
	>>>Referenced Frame Number	(0008,1160)	1	
	…			
Item 2 (Frame 2 in OCT B-scan Volume)				
…..				
> Derivation Image Sequence		(0008,9124)		
>>……		……	……	
>>Source Image Sequence		(0008,2112)		
	Item 1 (for Frame 2)			
	>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
	>>> Referenced SOP Instance UID	(0008,1155)	“1.2.3.4.5”	
	>>>Referenced Frame Number	(0008,1160)	2	
	…			
Item 3 (Frame 3 in OCT B-scan Volume)				
…..				
> Derivation Image Sequence		(0008,9124)		
>>……		……	……	
>>Source Image Sequence		(0008,2112)		
	Item 1 (for Frame 3)			
	>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
	>>> Referenced SOP Instance UID	(0008,1155)	“1.2.3.4.5”	
	>>>Referenced Frame Number	(0008,1160)	3	
	…			
Item 4 (Frame 4 in OCT B-scan Volume)				

Name	Tag	Value	Comment
…..			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 4)			
>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
>>> Referenced SOP Instance UID	(0008,1155)	“1.2.3.4.5”	
>>>Referenced Frame Number	(0008,1160)	4	
…			
Item 5 (Frame 5 in OCT B-scan Volume)			
…..			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 5)			
>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
>>> Referenced SOP Instance UID	(0008,1155)	“1.2.3.4.5”	
>>>Referenced Frame Number	(0008,1160)	5	
…			

Below is a more complex example.

- Ophthalmic Tomography Image SOP Instance UID is “2.3.4.5” and contains 3 frames.
- Ophthalmic Tomography Image SOP Instance UID is “1.6.7.8.9” and contains 2 frames.
- Ophthalmic Optical Coherence Tomography B-scan Volume Analysis SOP Instance encodes five frames (e.g., one frame for each Ophthalmic Tomography Frame from the two Ophthalmic Tomography Image SOP Instances).

Name	Tag	Value	Comment
…..	….	…	

Name	Tag	Value	Comment
Per-frame Functional Groups Sequence	(5200,9230)		
Item 1 (Frame 1 in OCT B-scan Volume)			
…..			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 1)			
>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
>>> Referenced SOP Instance UID	(0008,1155)	“2.3.4.5”	
>>>Referenced Frame Number	(0008,1160)	1	
…			
Item 2 (Frame 2 in OCT B-scan Volume)			
…..			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 2)			
>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
>>> Referenced SOP Instance UID	(0008,1155)	“2.3.4.5”	
>>>Referenced Frame Number	(0008,1160)	2	
…			
Item 3 (Frame 3 in OCT B-scan Volume)			
….			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	

Name	Tag	Value	Comment
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 3)			
>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
>>> Referenced SOP Instance UID	(0008,1155)	“2.3.4.5”	
>>>Referenced Frame Number	(0008,1160)	3	
…			
Item 4 (Frame 4 in OCT B-scan Volume)			
…..			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 4)			
>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
>>> Referenced SOP Instance UID	(0008,1155)	“1.6.7.8.9”	
>>>Referenced Frame Number	(0008,1160)	1	
…			
Item 5 (Frame 5 in OCT B-scan Volume)			
…..			
> Derivation Image Sequence	(0008,9124)		
>>……	……	……	
>>Source Image Sequence	(0008,2112)		
Item 1 (for Frame 5)			
>>> Referenced SOP Class UID	(0008,1150)	“1.2.840.10008.5.1.4.1.1.77.1.5.4”	Ophthalmic Tomography Image
>>> Referenced SOP Instance UID	(0008,1155)	“1.6.7.8.9”	
>>>Referenced Frame Number	(0008,1160)	2	

Name	Tag	Value	Comment
…			

C.8.xx.3 Ophthalmic OCT (Optical Coherence Tomography) En Face Image Quality Rating Module

Table C.8.xx.3-1 specifies the Attributes for evaluating the quality of the derived en face image.

Table C.8.xx.3-1
Ophthalmic OCT En Face Image Quality Rating Module Attributes

Attribute Name	Tag	Type	Attribute Description
Ophthalmic En Face Image Quality Rating Sequence	(0022,1628)	1	Evaluation of the quality of the en face image. Only a single Item shall be included in this sequence.
>Include 'Numeric Value Macro' Table 10-26			*Defined Context ID 4243 shall be used for Concept Name Code Sequence (0040,A043)*
>Quality Threshold	(0022,1630)	1	Threshold for the quality value. If the Numeric Value (0040,A30A) of the Numeric Value Macro is equal or above the threshold, it is considered acceptable by the algorithm. The units of this Attribute shall be the same as defined in Measurement Units Code Sequence (0040,08EA) of the Numeric Value Macro.
>Include 'Algorithm Identification Macro' Table 10-19			

Modify PS3.3 to add B-scan Volume Analysis image module

C.8.yy.2 Ophthalmic OCT (Optical Coherence Tomography) B-scan Volume Analysis Image Module

Table C.8.yy.2-1 specifies the Attributes that describe the Ophthalmic OCT B-scan Volume Analysis Image Module.

Table C.8.yy.2-1
Ophthalmic OCT B-scan Volume Analysis Module Image Attributes

Attribute Name	Tag	Type	Attribute Description
Image Type	(0008,0008)	1	Image identification characteristics. Enumerated Values for Value 1: **ORGINAL** Enumerated Values for Value 2: **PRIMARY**

Instance Number	(0020,0013)	1	A number that identifies this SOP Instance.
Content Time	(0008,0033)	1	The time the image pixel data creation started.
Content Date	(0008,0023)	1	The date the image pixel data creation started.
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Enumerated Values: 8 16
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample.
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Shall be one less than the value in Bits Stored (0028,0101).
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image. Enumerated Value: 1
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. Enumerated Value: MONOCHOME2
Pixel Representation	(0028,0103)	1	Data representation of pixel samples. Enumerated Values: **1**
Presentation LUT Shape	(2050,0020)	1	Specifies an identity transformation for the Presentation LUT such that the output of all grayscale transformations are defined to be in P-Values. Enumerated Values: **IDENTITY** output is in P-Values.
Lossy Image Compression	(0028,2110)	1	Specifies whether an Image has undergone lossy compression (at a point in its lifetime), or is derived from lossy compressed images. Enumerated Values: **00** Image has NOT been subjected to lossy compression. **01** Image has been subjected to lossy compression. Once this value has been set to 01 it shall not be reset. See Section C.8.32.2.1 and Section C.7.6.1.1.5.

Lossy Image Compression Ratio	(0028,2112)	1C	Describes the approximate lossy compression ratio(s) that have been applied to this image. See Section C.7.6.1.1.5.2. Required if present in the source images or this IOD instance has been compressed.
Lossy Image Compression Method	(0028,2114)	1C	A label for the lossy compression method(s) that have been applied to this image. See Section C.7.6.1.1.5.1. Required if present in the source images or this IOD instance has been compressed. See Section C.8.32.2.1.
Burned In Annotation	(0028,0301)	1	Indicates whether or not image contains sufficient burned in annotation to identify the patient and date the image was acquired. Enumerated Values: **NO**
Recognizable Visual Features	(0028,0302)	1	Indicates whether or not the image contains sufficiently recognizable visual features to allow the image or a reconstruction from a set of images to identify the patient. Enumerated Values: **YES** **NO**
Acquisition Method Algorithm Sequence	(0022,1423)	1	Software algorithm used by the acquisition method. Only a single Item shall be included in this Sequence.
>Include Table 10-19 "Algorithm Identification Macro Attributes"			*For Algorithm Family Code Sequence (0066,002F) Baseline CID 4270 "OCT-A Processing Algorithm Families".*
OCT B-scan Analysis Acquisition Parameters Sequence	(0022,1640)	1	Conveys raw data parameters captured during the B-scan acquisition process. One or more Items are permitted in this Sequence. More than one Item indicates that multiple scan patterns have been used to acquire the raw data. See Section C.8.yy.2.2 for further explanation.
>Scan Pattern Type Code Sequence	(0022,1618)	1	The scan pattern type used to generate this SOP Instance. Only a single Item shall be included in this Sequence.
>>Include Table 8.8-1 "Code Sequence Macro Attributes"			*Defined CID is 4272 OPT Scan Pattern Types*

>Number Of B-scans Per Frame	(0022,1642)	1	The number of B-scans performed at the same spatial location (B-scan slab). See Section C.8.yy.2.2 for further explanation.
>B-scan Slab Thickness	(0022,1643)	1	Nominal thickness of each B-scan slab, in mm. See Section C.8.yy.2.2 for further explanation.
>Distance Between B-scan Slabs	(0022,1644)	1	Nominal distance between adjacent B-scan slabs, in mm. See Section C.8.yy.2.2 for further explanation.
>B-scan Cycle Time	(0022,1645)	1C	Nominal time (in msec) between individual B-scans. See Section C.8.yy.2.1.1 for further explanation. Required if B-scan Cycle Time Vector (0022,1646) is absent.
>B-scan Cycle Time Vector	(0022,1646)	1C	An array that contains the real time increments (in msec) between B-scans. See Section C.8.yy.2.1.1 for further explanation. Required if B-scan Cycle Time (0022,1645) is absent. Note: scan time + latency between B-scans
>A-scan Rate	(0022,1649)	3	Frequency, in kHz, of the A-scan used to acquire the raw image data.
>B-scan Rate	(0022,1650)	3	Frequency, in Hz, of the B-scan used to acquire the raw image data.
Concatenation Frame Offset Number	(0020,9228)	1	Offset of the first frame in a multi-frame image of a concatenation. Enumerated Values: 0
In-concatenation Number	(0020,9162)	1	Identifier for one SOP Instance belonging to a concatenation. Enumerated Values: 1
In-concatenation Total Number	(0020,9163)	1	The number of SOP Instances sharing the same Concatenation UID (0020,9161). See C.8.yy.2.3 for further explanation. Enumerated Values: 1
Image Comments	(0020,4000)	3	User-defined comments about the image

C.8.yy.2.1 Opthalmic Optical Coherence Tomography B-scan Volume Analysis Image Module Attribute Descriptions

C.8.yy.2.1.1 B-scan Cycle Time and B-scan Cycle Time Vector

The B-scan Cycle Time (0022,1645) is the nominal scan time (in milliseconds) plus the latency between the individual repeats of the B-scan at the same location. The B-scan Cycle Time Vector can be used if the time for the repeats are not uniform. Either the B-scan Cycle Time (0022,1645) or the B-scan Cycle Time Vector (0022,1646) are required.

B-scan Cycle Time shall be used in the following manner to calculate 'the relative time' for each B-scan:

B-scan Cycle 'Relative Time' (n) = B-scan Cycle Delay + B-scan Cycle Time * (n-1)

where: n = number of B-scan cycles within the frame and the first B-scan number is one

Note

When there is only one B-scan present, B-scan Cycle Time (0022,1645) may have either a value of 0, or a nominal value that would apply if there were multiple B-scans.

B-scan Cycle Time Vector (0022,1646) is an array that contains the time increments (in milliseconds) between the nth B-scan cycle and the previous B-scan cycle for a frame. The first B-scan cycle always has a time increment of 0. The B-scan Cycle Time Vector shall be used in the following manner to calculate 'relative time' *T(n)* for B-scan Cycle *n*:

$$T(n) = \sum_{i=1}^{n} \Delta t_i$$

where Δt_i is the i^{th} B-scan Cycle Time Vector component.

C.8.yy.2.2 Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Acquisition Parameters Expected Use

The acquisition technique of ophthalmic tomography B-scan volume analysis (e.g., OCT angiography blood flow information) is based on the same mechanism as used for ophthalmic tomography images. Therefore, B-scans are used for individual image frames of the acquired volume. The frames of the resulting volume are calculated based on a number of repeated B-scans at the same spatial location. So the frame of an Ophthalmic Tomography B-scan Volume Analysis SOP Instance is not a B-scan, but a data aggregation of B-scans from the raw data of the acquisition.

To convey the information about the acquisition of the raw data, which are not typically in the scope of DICOM, the OCT B-scan Analysis Acquisition Parameters Sequence (0022,1640) is used. The parameters are provided for the user to assess the quality of the resulting B-scan volume analysis as well as to provide a means to compare volumes created by different devices. Furthermore the user is able to identify if a vendor-recommended protocol has been used to acquire the raw data.

The OCT B-scan Analysis Acquisition Parameters Sequence contains at least one item. It can contain more than one if multiple scan patterns have been used to acquire the raw data and are used to calculate the volume data.

Number of B-scans Per Frame (0022,1642) can be used to provide an indication about the resulting image quality. In principal, the more B-scans averaged the better but as a high number of scans slows down the acquisition process, the resulting data becomes prone to noise introduced by eye movements, which are not related to blood flow. Furthermore, the number of B-scans averaged can be used to determine whether the acquisition was based on a vendor-specific protocol, or if the user changed the protocol.

The B-scan Slab Thickness (0022,1643) and Distance Between B-scan Slabs (0022,1644) provide information about the density of the sampling pattern used to acquire the volume data. The calculation of the volume (Ophthalmic Tomography B-scan Volume Analysis SOP Instance) is based on this information.

C.8.yy.2.3 Data Subsets

Applications may find it useful to break up an OPT image or B-scan volume into multiple data subsets. There are two mechanisms in DICOM to achieve this: Concatenation and Multiple SOP Instances.

Concatenations are not permitted in the Ophthalmic Tomography Image and Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IODs.

However, an OPT image or a B-scan volume can be encoded in multiple SOP instances. For example:

1. All frames of the volume are collected and transmitted in one multi-frame SOP instance (e.g., one SOP Instance with 30 frames).

2. Each frame of the volume is transmitted in one SOP instance where the number of frames is equal to one (e.g., 30 SOP Instances with 1 frame each).

3. The frames in the volume are transmitted in multiple SOP Instances (e.g., 3 SOP Instances with 10 frames each).

Changes to NEMA Standards Publication PS 3.4

Digital Imaging and Communications in Medicine (DICOM)
Part 4: Service Class Specifications

Add to PS3.4 Annex B.5.

B.5 Standard SOP Classes

Table B.5-1
STANDARD SOP CLASSES

SOP Class Name	SOP Class UID	IOD (See PS 3.3)
…		
Ophthalmic Optical Coherence Tomography En Face Image Storage	**1.2.840.10008.5.1.4.1.1.77.1.5.7**	**Ophthalmic Optical Coherence Tomography En Face Image IOD**
Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage	**1.2.840.10008.5.1.4.1.1.77.1.5.8**	**Ophthalmic Optical Coherence Tomography B-scan Volume Analysis IOD**

Changes to NEMA Standards Publication PS 3.6

Digital Imaging and Communications in Medicine (DICOM)
Part 6: Data Dictionary

450 *Add to PS3.6 Annex A*

UID Value	UID NAME	UID TYPE	Part
…			
1.2.840.10008.5.1.4.1.1.77.1.5.7	**Ophthalmic Optical Coherence Tomography En Face Image Storage**	**SOP Class**	**PS 3.4**
1.2.840.10008.5.1.4.1.1.77.1.5.8	**Ophthalmic Optical Coherence Tomography B-scan Volume Analysis Storage**	**SOP Class**	**PS 3.4**

Add to PS3.6 the following Data Elements to Section 6, Registry of DICOM data elements:

Tag	Name	Keyword	VR	VM
(0022,1612)	Derivation Algorithm Sequence	DerivationAlgorithmSequence	SQ	1
(0022,1615)	Ophthalmic Image Type Code Sequence	OphthalmicImageTypeCodeSequence	SQ	1
(0022,1616)	Ophthalmic Image Type Description	OphthalmicImageTypeDescription	LO	1
(0022,1618)	Scan Pattern Type Code Sequence	ScanPatternTypeCodeSequence	SQ	1
(0022,1620)	Referenced Surface Mesh Identification Sequence	ReferencedSurfaceMeshIdentificationSequence	SQ	1
(0022,1622)	Ophthalmic Volumetric Properties Flag	OphthalmicVolumetricPropertiesFlag	CS	1
(0022,1624)	Ophthalmic Anatomic Reference Point X-Coordinate	OphthalmicAnatomicReferencePointXCoordinate	FL	1
(0022,1626)	Ophthalmic Anatomic Reference Point Y-Coordinate	OphthalmicAnatomicReferencePointYCoordinate	FL	1
(0022,1628)	Ophthalmic En Face Image Quality Rating Sequence	OphthalmicEnFaceImageQualityRatingSequence	SQ	1
(0022,1630)	Quality Threshold	QualityThreshold	DS	1
(0022,1640)	OCT B-scan Analysis Acquisition Parameters Sequence	OCTBscanAnalysisAcquisitionParametersSequence	SQ	1
(0022,1642)	Number of B-scans Per Frame	NumberofBscansPerFrame	UL	1
(0022,1643)	B-scan Slab Thickness	BscanSlabThickness	FL	1
(0022,1644)	Distance Between B-scan Slabs	DistanceBetweenBscanSlabs	FL	1
(0022,1645)	B-scan Cycle Time	BscanCycleTime	FL	1
(0022,1646)	B-scan Cycle Time Vector	BscanCycleTimeVector	FL	1-n
(0022,1649)	A-scan Rate	AscanRate	FL	1

(0022,1650)	B-scan Rate	BscanRate	FL	1
(0022,1658)	Surface Mesh Z-Pixel Offset	SurfaceMeshZPixelOffset	UL	1

Modify Table A3 to PS3.6 for new CIDs

Table A-3. Context Group UID Values

Context UID	Context Identifier	Context Group Name
1.2.840.10008.6.1.1150	**CID 4270**	**OCT-A Processing Algorithm Families**
1.2.840.10008.6.1.1151	**CID 4271**	**En Face Image Types**
1.2.840.10008.6.1.1152	**CID 4272**	**OPT Scan Pattern Types**
1.2.840.10008.6.1.1153	**CID 4273**	**Retinal Segmentation Surfaces**

Changes to NEMA Standards Publication PS 3.16

Digital Imaging and Communications in Medicine (DICOM)
Part 16: Content Mapping Resource

Add the following codes to Part 16 Annex B DCMR CID 7202, 7203, and 7151 (Normative)

CID 7202 Source Image Purposes of Reference

Type: **Extensible**
Version: **2017mmdd**

Table CID 7202. Source Image Purposes of Reference

Coding Scheme Designator	Code Value	Code Meaning
……	……	……
DCM	113130	Predecessor containing group of imaging subjects
DCM	**128250**	**Structural image for image processing**
DCM	**128251**	**Flow image for image processing**

CID 7203 Image Derivation

Type: **Extensible**
Version: **2017mmdd**

Table 7203. Image Derivation

Coding Scheme Designator	Code Value	Code Meaning
……	……	……
DCM	**128303**	**OCT B-scan analysis**

CID 7151 Segmentation Property Types

Type: **Extensible**
Version: **20130617**

Table CID 7151. Segmentation Property Types

Coding Scheme Designator	Code Value	Code Meaning
Include CID 8 "Angiographic Interventional Devices"		
Include CID 3010 "Cardiovascular Anatomic Locations"		

Coding Scheme Designator	Code Value	Code Meaning
……		
Include CID 4273 "Retinal Segmentation Surfaces"		

Add the following definitions to Part 16 Annex B DCMR Context Groups (Normative)

CID 4270 OCT-A Processing Algorithm Families

Type: **Extensible**
Version: **2017mmdd**

Table 4270 OCT-A Processing Algorithm Families

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	128252	OCT-A amplitude decorrelation
DCM	128253	OCT-A complex variance
DCM	128254	OCT-A speckle variance
DCM	128255	OCT-A correlation mapping
DCM	128256	Doppler OCT-A

CID 4271 En Face Image Types

Type: **Extensible**
Version: **2017mmdd**

Table 4271 En Face Image Types

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	128257	Retina depth encoded vasculature flow
DCM	128258	Retina depth encoded structural reflectance map
DCM	128259	Retina vasculature flow
DCM	128260	Retina structural reflectance map
DCM	128261	Vitreous vasculature flow
DCM	128262	Vitreous structural reflectance map
DCM	128263	Radial peripapillary vasculature flow
DCM	128264	Radial peripapillary structural reflectance map
DCM	128265	Superficial retina vasculature flow
DCM	128266	Superficial retina structural reflectance map

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	128267	Middle inner retina vasculature flow
DCM	128268	Middle inner structural reflectance map
DCM	128269	Deep retina vasculature flow
DCM	128270	Deep retina structural reflectance map
DCM	128271	Outer retina vasculature flow
DCM	128272	Outer retina structural reflectance map
DCM	128273	Choriocapillaris vasculature flow
DCM	128274	Choriocapillaris structural reflectance map
DCM	128275	Choroid vasculature flow
DCM	128276	Choroid structural reflectance map
DCM	128277	Whole eye vasculature flow
DCM	128278	Whole eye structural reflectance map

CID 4272 OPT Scan Pattern Types

Type: **Extensible**
Version: **2017mmdd**

Table 4272 OPT Scan Pattern Types

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	128279	Cube B-scan pattern
DCM	128280	Raster B-scan pattern
DCM	128281	Line B-scan pattern
DCM	128282	Radial B-scan pattern
DCM	128283	Cross B-scan pattern
DCM	128284	Circle B-scan pattern
DCM	128285	Concentric circle B-scan pattern
DCM	128286	Circle-raster B-scan pattern
DCM	128287	Circle-radial B-scan pattern
DCM	128288	Grid B-scan pattern

CID 4273 Retinal Segmentation Surfaces

Type: **Extensible**
Version: **2017mmdd**

Table 4273 Retinal Segmentation Surfaces

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)	SNOMED-CT Concept ID
SRT	T-AA62D	ILM - Internal limiting membrane	280677004
DCM	128289	Outer surface of RNFL	
DCM	128290	Outer surface of GCL	
DCM	128291	Outer surface of IPL	
DCM	128292	Outer surface of INL	
DCM	128293	Outer surface of OPL	
DCM	128294	Outer surface of HFL	
SRT	T-AA650	ELM - External limiting membrane	76710003
DCM	128295	Surface between Inner and Outer Segments of the photoreceptors	
DCM	128296	Surface of the interdigitating zone between retina and RPE	
DCM	128297	Anterior surface of the RPE	
DCM	128298	Surface of the center of the RPE	
DCM	128299	Posterior surface of the RPE	
DCM	128300	Outer surface of the BM	
DCM	128301	Surface of the choroid-sclera interface	
DCM	128302	Outer surface of the CC	

(Add the following definitions to Part 16 Annex D DICOM Controlled Terminology Definitions (Normative)

Annex D DICOM Controlled Terminology Definitions (Normative)

Code Value	Code Meaning	Definition	Notes
128250	Structural image for image processing	A structural image used for image processing.	
128251	Flow image for image processing	A flow image used for image processing.	
128252	OCT-A amplitude decorrelation	OCT angiography method that de-correlates the amplitudes between two consecutive B-scans from the narrowed spectral bands was computed, and all the decorrelation values within certain repeated B-scans were averaged to visualize blood vessels.	Methods and algorithms for optical coherence tomography-based angiography: a review and comparison Anqi Zhang ; Qinqin Zhang ; Chieh-Li Chen ; Ruikang K. Wang (2015) See http://biomedicaloptics.spiedigitallibrary.org/article.aspx?articleid=2464650#QuantitativeComparisons

128253	OCT-A complex variance	OCT angiography method based on variations in the complex (amplitude and phase) OCT signal from repeated B-scans at the same location.	There are a number of factors that may cause a change in the OCT signal frequency relative to the signal due to static tissue background. These factors include, for example, the Doppler effect that induces optical frequency shift and the change in backscattering due to the particles that are moving in and out of the OCT-probe volume during imaging. The changes in signal frequency cause the changes in both the amplitude and the phase of the OCT signal. Comparison of the complex (amplitude and phase) signal from repeated B-scans at the same location provides an image that has higher contrast in areas of erythrocyte motion. This method is referred to as OCT-based micro-angiography – complex (OMAG^{C}).
128254	OCT-A speckle variance	OCT angiography method that analyzes the temporal or spatial statistics of the intensity of speckle from OCT images and identifies blood vessels.	
128255	OCT-A correlation mapping	OCT angiography method that differentiates flow regions. Static regions usually have high correlation values while flow regions have lower correlation values.	
128256	Doppler OCT-A	OCT angiography method that utilizes the Doppler phase resolved information to provide the velocity of flow. Sometimes referred to as the phase variance method.	
128257	Retina depth encoded vasculature flow	Image using pseudo colors to illustrate multiple OPTENF images obtained at various depth levels within the retina from the OPT flow volume.	
128258	Retina depth encoded structural reflectance map	Image using pseudo colors to illustrate multiple OPTENF images obtained at various depth levels within the retina from the OPT structural volume.	
128259	Retina vasculature flow	Image that illustrates the vasculature flow within the entire retina. Generated from the OPT flow volume with pixels approximately from inner limiting membrane (ILM) to photoreceptor inner segment/ellipsoid region (ISe).	
128260	Retina structural reflectance map	Image that illustrates the OCT structural reflectance within the entire retina. Generated from the OPT structural volume with pixels approximately from inner limiting membrane (ILM) to photoreceptor inner segment/ellipsoid region (ISe).	
128261	Vitreous vasculature flow	Image that illustrates the vasculature flow within the vitreous. Generated from the OPT flow volume with pixels approximately from a selected location anterior to ILM, to ILM. This space/potential space is referred clinically as the Vitreo-retinal Interface (VRI).	
128262	Vitreous structural reflectance map	Image that illustrates the OCT structural reflectance within the vitreous. Generated from the OPT	

		structural volume with pixels approximately from a selected location that is anterior to ILM, to ILM. This space/potential space is referred clinically as the Vitreo-retinal Interface (VRI).	
128263	Radial peripapillary vasculature flow	Image that illustrates the OCT vasculature flow within the RNFL around the optic disk. Generated from the OPT flow volume with pixels approximately from ILM to the outer boundary of the RNFL.	
128264	Radial peripapillary structural reflectance map	Image that illustrates the OCT structural reflectance within the RNFL around the optic disk. Generated from the OPT structural volume with pixels approximately from ILM to the outer boundary of the RNFL.	
128265	Superficial retina vasculature flow	Image that illustrates the vasculature flow within the anterior layers of retina. Generated from the OPT flow volume with pixels approximately from ILM to ganglion cell layer/inner plexiform layer (GCL/IPL).	
128266	Superficial retina structural reflectance map	Image that illustrates the OCT structural reflectance within the anterior layers of retina. Generated from the OPT structural volume with pixels approximately from ILM to ganglion cell layer/inner plexiform layer (GCL/IPL).	
128267	Middle inner retina vasculature flow	Image that illustrates the vasculature flow in the capillaries that connect the superficial and deeper capillary beds. Generated from the OPT flow volume with pixels approximately at the level of the IPL. Sometimes referred to as the intermediate retina flow.	
128268	Middle inner structural reflectance map	Image that illustrates the OCT structural reflectance in the capillaries that connect the superficial and deeper capillary beds. Generated from the OPT structural volume with pixels approximately at the level of the IPL. Sometimes referred to as the intermediate retina flow.	
128269	Deep retina vasculature flow	Image that illustrates the vasculature flow at the level of the plexiform layers within the retina. Generated from the OPT flow volume with pixels approximately from inner plexiform layer (IPL) to outer plexiform layer (OPL).	
128270	Deep retina structural reflectance map	Image that illustrates the structural reflectance at the level of the plexiform layers within the retina. Generated from the OPT structural volume with pixels approximately from inner plexiform layer (IPL) to outer plexiform layer (OPL).	
128271	Outer retina vasculature flow	Image that illustrates the vasculature flow at the level of the posterior layers of the retina (outer retina). Generated from the OPT flow volume with pixels approximately in the translucent layers, from OPL to ISe. Sometimes referred to as flow in the deep avascular structure. Note For normal eyes, this image would not show detectable vascular flow.	
128272	Outer retina structural reflectance	Image that illustrates the structural reflectance at the level of the posterior layers of the retina (outer	

	map	retina). Generated from the OPT structural volume with pixels approximately in the translucent layers, from OPL to ISe.	
128273	Choriocapillaris vasculature flow	Image that illustrates the vasculature flow at the level of the chroriocapillaris. Generated from the OPT flow volume with pixels approximately below the retinal pigment epithelium (RPE) encompassing the thickness of choriocapillaris.	
128274	Choriocapillaris structural reflectance map	Image that illustrates the structural reflectance at the level of the chroriocapillaris. Generated from the OPT structural volume with pixels approximately below the retinal pigment epithelium (RPE) encompassing the thickness of choriocapillaris.	
128275	Choroid vasculature flow	Image that illustrates the vasculature flow at the level of the choroid. Generated from the OPT flow volume with pixels approximately below RPE, encompassing the thickness of choroid.	
128276	Choroid structural reflectance map	Image that illustrates the structural reflectance at the level of the choroid. Generated from the OPT structural volume with pixels approximately below RPE, encompassing the thickness of choroid.	
128277	Whole eye vasculature flow	Image that illustrates the vasculature flow at the entire posterior segment, including retina and choroid. Generated from the OPT flow volume with pixels encompassing the entire OCT scan.	
128278	Whole eye structural reflectance map	Image that illustrates the structural reflectance from the entire posterior segment, including retina and choroid. Generated from the OPT structural volume with pixels encompassing the entire OCT scan.	
128279	Cube B-scan pattern	A series of densely spaced, parallel B-scans of the same length covering an area.	
128280	Raster B-scan pattern	A series of sparsely spaced, parallel B-scans of the same length covering an area.	
128281	Line B-scan pattern	A single line B-scan.	
128282	Radial B-scan pattern	A series of B-scans arranged in a radial pattern of the same length covering an area.	
128283	Cross B-scan pattern	A pair of horizontal and vertical B-scans in a cross pattern.	
128284	Circle B-scan pattern	A single circular pattern B-scan.	
128285	Concentric circle B-scan pattern	A series of concentric circular pattern B-scans with various diameters.	
128286	Circle-raster B-scan pattern	A series of concentric circular pattern B-scans with various diameters combined with a series of raster B-scan patterns.	
128287	Circle-radial B-scan pattern	A series of concentric circular pattern B-scans with various diameters combined with a series of radial B-scan patterns.	
128288	Grid B-scan pattern	A series of vertical and horizontal B-scans.	
128289	Outer surface of RNFL	Retinal surface located approximately at the outer boundary of the retinal nerve fiber layer (RNFL).	
128290	Outer surface of GCL	Retinal surface approximately at the outer boundary of the Ganglion Cell Layer (GCL).	

128291	Outer surface of IPL	Retinal surface located approximately at the outer boundary of the Inner Plexiform Layer (IPL).	
128292	Outer surface of INL	Retinal surface located approximately at the outer boundary of the Inner Nuclear Layer (INL).	
128293	Outer surface of OPL	Retinal surface located approximately at the outer boundary of the Outer Plexiform Layer (OPL).	
128294	Outer surface of HFL	Retinal surface located approximately at the outer boundary of the Henle Fiber Layer (HFL) when present.	
128295	Surface between Inner and Outer Segments of the photoreceptors	Retinal surface approximately located at the boundary between the Inner Segments and Outer Segments of the photoreceptors.	
128296	Surface of the interdigitating zone between retina and RPE	Retinal surface located approximately at the retina-RPE interdigitating zone when present.	
128297	Anterior surface of the RPE	Retinal surface located approximately at the anterior surface of the Retinal Pigment Epithelium (RPE).	
128298	Surface of the center of the RPE	Retinal surface located approximately at the center of the Retinal Pigment Epithelium (RPE).	
128299	Posterior surface of the RPE	Retinal surface located approximately at the posterior surface of the Retinal Pigment Epithelium (RPE).	
128300	Outer surface of the BM	Retinal surface located approximately at the outer boundary of the Bruch's Membrane (BM).	
128301	Surface of the choroid-sclera interface	Retinal surface located approximately at the choroid-sclera interface (SC).	
128302	Outer surface of the CC	Retinal surface located approximately at the outer boundary of the choriocapillaris (CC).	
128303	OCT B-scan analysis	Values are derived from performing analysis on OCT B-scans	

Changes to NEMA Standards Publication PS 3.17
Digital Imaging and Communications in Medicine (DICOM)
Part 17: Explanatory Information

Add to PS3.17 Annex UUU

Annex UUU Ophthalmology Tomography En Face Angiography Examples (Informative)

UUU.1 Ophthalmic Tomography Angiography Examples

OCT en face images are derived from images obtained using OCT technology (i.e., structural OCT volume images plus angiographic flow volume information). With special image acquisition sequences and post hoc image processing algorithms, OCT-A detects the motion of the blood cells in the vessels to produce images of retinal and choroidal blood flow with capillary level resolution. En face images derived from these motion contrast volumes are similar to images obtained in retinal fluorescein angiography with contrast dye administered intravenously, though differences are observed when comparing these two modalities. This technology enables a high resolution visualization of the retinal and choroidal capillary network to detect the growth of abnormal blood vessels to provide additional insights in diagnosing and managing a variety of retinal diseases including diabetic retinopathy, neovascular age-related macular degeneration, retinal vein occlusion and others.

The following are examples of how the ophthalmic tomography angiography DICOM objects may be used.

UUU.1.1 Clinical Examples

UUU.1.1.1 Diabetic Macular Ischemia

A 54 year old female patient with an 18 year history of DM2 presents with unexplained painless decreased visual acuity in both eyes. The patient was on hemodialysis (HD) for diabetes related renal failure. She had a failed HD shunt in the right arm and a functioning shunt in the left. SD-OCT testing showed no thickening of the macula. Because of her renal failure and HD history IVFA was deferred and OCT angiography of the maculae was performed. This showed significant widening of the foveal avascular zone (FAZ) explaining her poor visual acuity and excluding treatment opportunities.

Figure UUU.1.1-1: Diabetic Macular Ischemia example

UUU.1.1.2 Age related Macular Degeneration

A 71 year old male patient presents with a 3 month history of decreased visual acuity and distorted vision in the right eye. He demonstrates a well-defined elevation of the deep retina adjacent to the fovea OD by biomicroscopy that correlates to a small pigment epithelial detachment (PED) shown by SD-OCT. OCT angiography demonstrated a subretinal neovascular network in the same area. This was treated with intravitreal anti-VEGF injection monthly for three months with resolution of

the PED and incremental regression of the subretinal neovascular membrane by point to point registration OCT angiography and finally non-perfusion of the previous SRN.

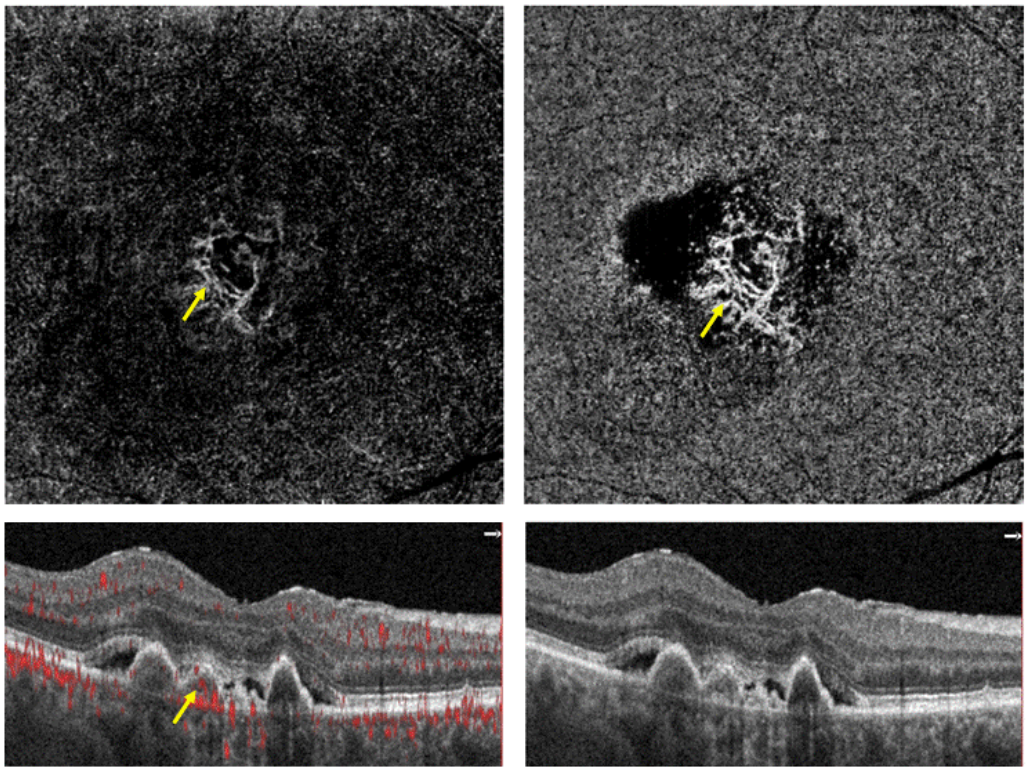


Figure UUU.1.1-2: Age related Macular Degeneration example

UUU.1.1.3 Branch Retinal Vein Occlusion

A 59 y/o male patient with hypertension and long smoking history presents with a six week history of painless decrease in vision in the right eye. Ophthalmoscopy showed dilated and tortuous veins inferior temporally in the right eye with a superior temporal distribution of deep retinal hemorrhages that extended to the mid-periphery, but did not include the macula. SD-OCT showed thickening of the macula and OCT angiography showed rarefaction of the retinal capillaries consistent with ischemic branch retinal vein occlusion and macular edema.

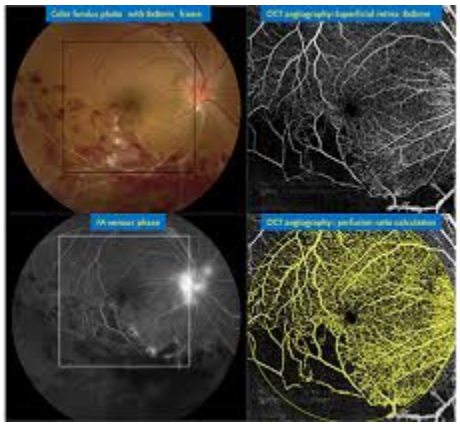


Figure UUU.1.1-3: Branch Retinal Vein Occlusion example

UUU.1.2 Research Examples

UUU.1.2.1 Proliferative Diabetic Retinopathy

A 38-year-old male patient with 26 year history of type 1 diabetes examined for evaluation of 10-day history of scant vitreous hemorrhage due to neovascularization of the optic disc.

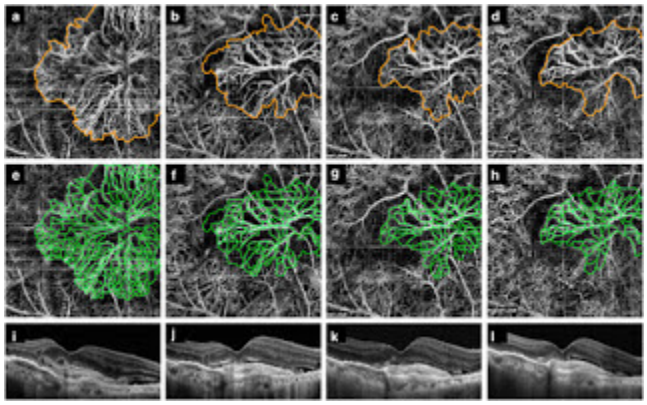


Figure UUU.1.2.1-1: Proliferative Diabetic Retinopathy example