DICOM Correction Proposal

<table>
<thead>
<tr>
<th>STATUS</th>
<th>Assigned</th>
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<tbody>
<tr>
<td>Date of Last Update</td>
<td>2024/03/19</td>
</tr>
<tr>
<td>Person Assigned</td>
<td>Kevin O'Donnell</td>
</tr>
<tr>
<td>Submitter Name</td>
<td>Kevin O'Donnell</td>
</tr>
<tr>
<td>Submission Date</td>
<td>2023/10/26</td>
</tr>
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<table>
<thead>
<tr>
<th>Correction Number</th>
<th>CP-2370</th>
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<tbody>
<tr>
<td>Log Summary:</td>
<td>Orientation guidance for vertical CT gantries</td>
</tr>
<tr>
<td>Name of Standard</td>
<td>PS 3.3, PS 3.17</td>
</tr>
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**Rationale for Correction:**

Most CT gantries have a bore with a horizontal axis and a patient table that moves horizontally in and out of the bore from one side. The usage of attributes relating to patient orientation and couch movement are well understood in this configuration.

Gantry designs exist where the bore is vertical, the patient stands or is seated in the middle of the bore, and the gantry moves up and down to scan the patient. This CP provides guidance on the usage of related attributes in this configuration.

A vertical gantry may scan top to bottom or bottom to top. It would be very unusual for the patient to be inverted.

It is desirable that images from vertical gantries not be mislabeled when presented by naïve viewers that have not been specifically coded to consider such gantries.

In a vertical gantry, the patient could readily face any direction while standing. The gantry may or may not be able to sense the patient orientation. If not, it would depend on standardized acquisition procedures and/or technologist input to correctly encode orientation details, just as is done for patients on conventional horizontal scanners who are prone or decubitus.

**Correction Wording:**

Add the Patient Orientation Module to the CT Image IOD

**A.3.3 CT Image IOD Module Table**

<table>
<thead>
<tr>
<th>IE</th>
<th>Module</th>
<th>Reference</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>Equipment</td>
<td>General Equipment</td>
<td>C.7.5.1</td>
<td>M</td>
</tr>
<tr>
<td>Image</td>
<td>General Image</td>
<td>C.7.6.1</td>
<td>M</td>
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<tr>
<td></td>
<td>General Reference</td>
<td>C.12.4</td>
<td>U</td>
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<tr>
<td></td>
<td>Patient Orientation</td>
<td>C.7.6.20</td>
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<tr>
<td></td>
<td>Image Plane</td>
<td>C.7.6.2</td>
<td>M</td>
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</tbody>
</table>

Commented [OK1]: New CP? Add Radlex/LOINC Playbook Procedure Codes to order/prescribe such imaging types?
WG6Q To change the third attribute from Patient Gantry Relationship Code Sequence (0054,0414) to Patient Equipment Relationship Code Sequence ((03010,0030) and make it Type 1, we can clone the Patient Orientation Module (C.7.6.20) into an Enhanced Patient Orientation Module (C.7.6.30ish) that references the Patient Orientation And Equipment Relationship Macro instead of the Patient Orientation Macro.

WG6Q Also fix attribute description which says “with respect to the head of the table” when both the attribute name and the referenced section talk about the gantry.


Add the Patient Orientation Module to the Enhanced CT Image IOD

A.38.1.3 Enhanced CT Image IOD Module Table

Table A.38-1. CT Image IOD Modules

<table>
<thead>
<tr>
<th>IE</th>
<th>Module</th>
<th>Reference</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>…</td>
<td>Equipment</td>
<td>C.7.5.1</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>General Equipment</td>
<td>C.7.5.2</td>
<td>M</td>
</tr>
<tr>
<td>Image</td>
<td>Image Pixel</td>
<td>C.7.6.3</td>
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</tr>
<tr>
<td></td>
<td>Patient Orientation</td>
<td>C.7.6.20</td>
<td>U</td>
</tr>
<tr>
<td></td>
<td>Enhanced Contrast/Bolus</td>
<td>C.7.6.4b</td>
<td>C – Required if contrast media was applied</td>
</tr>
</tbody>
</table>

Modify A.1.4 tables (not shown) to reflect the above IOD Module changes

Add the following section to WG6Q. Where should this go?

X.Y Guidance for Vertical Gantries

This section provides guidance on the population of position and orientation attributes in images that were acquired on a vertical gantry. A vertical gantry is defined as one where the axis of the bore is aligned in the direction of gravity (See Figure X), while a horizontal gantry (which is the most typical arrangement) has the axis of the bore aligned horizontally (i.e., orthogonal to gravity). This text assumes that if motion is required to cover the scan range, the gantry moves up and/or down during scanning, however the guidance would also apply if the patient support were to move up and/or down.

Position and orientation can be considered in terms of the image pixels with respect to the patient, the patient with respect to the gantry, and the patient with respect to gravity.

Image pixels with respect to the patient

The position and orientation of the pixels with respect to the patient is independent of the gantry and is thus the same for both vertical and horizontal gantries. A mathematical description is provided in the Image Plane Module by Type 1 attributes for Image Position (Patient) (0020,0032) and Image Orientation (Patient) (0020,0037). As stated in PS3.3 C.7.6.2.1.1 these are defined in the patient-based coordinate system which is a right-handed system where:

- x-axis is increasing to the left-hand side of the patient
- y-axis is increasing to the posterior side of the patient

Commented [OK2]: New CP: The last two sentences of the first paragraph do not read quite right. https://dicom.nema.org/medical/dicom/current/output/html/part03/sect_C.7.6.2.html#sect_C.7.6.2.1.1
• z-axis is increasing toward the head of the patient.

Image Position (Patient) (0020,0037) contains the x, y, and z coordinates of the Top Left-Hand Corner (TLHC) of the image.

Image Orientation (Patient) (0020,0032) contains direction cosines of image first row and first column.

The Image Module includes the Type 2C attribute Patient Orientation (0020,0020) which provides a rough orientation. As stated in PS3.3 C.7.6.1.1.1, two letters indicate the direction from the first to last pixel in a row, and the direction from the first to last pixel in a column, respectively using letters for Anterior, Posterior, Left, Right, Head, and Feet.

**Patient with respect to the gantry and gravity**

The position and orientation of the patient with respect to the gantry is generally expressed in terms of the "front" of the gantry. To maintain consistency with the existing definitions, for the purposes of these attributes for a vertical gantry the "front" of the imaging equipment is considered to be the side containing the bore that is closest to the ground.

**Patient Position (0018,5100)**

The Series Module includes the Type 2C attribute Patient Position (0018,5100) which is intended to support annotation (as opposed to mathematical calculations). The Patient Position code string values provide a rough description of the scan axis (meaning the axis along which the scan plane is incremented from one frame to the next), and a description of how the patient is “rotated” around that axis.

The first two characters of the code string describes the scan axis. When facing the front of the imaging equipment,

- HF Head First is defined as the patient's head being positioned toward the front of the imaging equipment (i.e., head entering the front of the equipment).
- FF Feet First is defined as the patient's feet being positioned toward the front of the imaging equipment (i.e., feet entering the front of the equipment).
- LF Left First is defined as the patient's left side being positioned towards the front of the imaging equipment (i.e., patient's left side entering the front of the equipment).
- RF Right First is defined as the patient's right being positioned towards the front of the imaging equipment (i.e., patient's right side entering the front of the equipment).

Note that these codes describe the scan axis in terms of the patient when they are fully outside the imaging equipment on the front side of the imaging equipment, and does not presume a scanning direction. So, for a horizontal gantry, a value of Head First is still valid when the patient table is advanced fully into the gantry and the patient is scanned as the table comes back out, resulting in the head being temporally the last part scanned. Correspondingly, for a vertical gantry, the value will almost always be Head First when scanning either upwards or downwards, given that the front of the gantry is defined as the face closest to the ground and the patient will almost always be seated or standing.

The subsequent characters of the code string value describe the direction of gravity and the rough patient "rotation" around the scan axis. These can be useful to a clinician viewing the images and wanting to understand how gravity might be affecting the positioning of the organs.

- P Prone is defined as the patient's face being positioned in a downward (gravity) direction.
- S Supine is defined as the patient's face being in an upward direction.
- DR Decubitus Right is defined as the patient's right side being in a downward direction.
- DL Decubitus Left is defined as the patient's left side being in a downward direction.
- V Vertical is defined as the patient's feet being positioned in a downward (gravity) direction.
For vertical gantries, the V code captures the position with respect to gravity, but the rough rotation about the scan axis is not clinically meaningful and is not captured. The anatomical orientation of the image axes is captured in Image Position (Patient) as described above.

**Patient Orientation Module**

The Enhanced Patient Orientation Module invokes the Patient Orientation And Equipment Relationship Macro to describe the patient orientation related to gravity and equipment.

Patient Orientation Code Sequence (0054,0410) describes the orientation of the imaged part of the Patient with respect to gravity. A scan of a seated patient's head, chest, and/or abdomen would be coded as (C86043, NCI, “erect”).

Note: (10259006, SCT, “semi-erect”) refers to the imaged anatomy being partway between erect and recumbent, for example, inclined 45 degrees.

Patient Orientation Modifier Code Sequence (0054,0412) provides more detailed description of the orientation and positioning of the patient. The referenced codes cover the latter part of the Patient Position (0018,5100) code string but include many additional and more specific concepts.

Patient Equipment Relationship Code Sequence (3010,0030) describes the orientation of the Patient with respect to the imaging equipment. The referenced codes cover the first part of the Patient Position (0018,5100) code string but include additional concepts.

### Other Relevant Attributes

Acquisition Context Sequence (0040,0555) permits inclusion of a content item with (130324, DCM, “Functional condition present during acquisition”) = (87731000, SCT, “Weight bearing”), which could be used to describe such conditions which would be more common in a vertical gantry.

Enhanced CT/Functional Groups/CT Position Seq - “Relative longitudinal position of acquisition location of this frame in mm from an implementation specific reference point. Shall be calculated by applying the table speed to the time of the scan. Shall be positive if the table moves toward the gantry. Shall be zero if the table is stationary during the scan. Shall be zero for a horizontal gantry. Shall be negative for a vertical gantry. Table speed is relative to the gantry frame of reference, thus if the gantry is moving, the distance value represents the net motion. This attribute also applies to patient support equipment other than tables.

Table Feed per Rotation (0018,9310) – “Motion of the table (in mm) during a complete revolution of the source around the gantry orbit. Table motion is relative to the gantry frame of reference, thus if the gantry is moving, the feed value represents the net motion. This attribute also applies to patient support equipment other than tables.

Spiral Pitch Factor (0018,9311) – “Ratio of the Table Feed per Rotation (0018,9310) to the Total Collimation Width (0018,9307).”

Rotation Direction (0018,1140) [3] – “Direction of rotation of the source when relevant, about nearest principal axis of equipment. Direction is determined when facing the front of the gantry from outside the gantry.”

Table Height (0018,1130) [3] – “The distance in mm of the top of the patient table to the center of rotation; below the center is positive. It is recommended to omit this value for vertical gantries.”

Gantry/Detector Tilt (0018,1120) [3] – “Nominal angle of tilt in degrees of the scanning gantry. Not intended for mathematical computations. When the tilt is zero (for either horizontal or vertical gantries) it is useful to encode the 0 value as a signal to receiving systems that they do not need to do advanced computation based on Image Position (Patient) (0020,0037) Image Orientation (Patient) (0020,0032) to handle “skewed” volume stacks.”

Table Position (0018,9327) – Enhanced CT/Functional Groups/CT Position Seq - "Relative longitudinal position of acquisition location of this frame in mm from an implementation specific reference point.
be relative to the same reference point for all frames in this SOP Instance, but may be different from the reference point in other SOP Instances. Positions as the table (or other patient support) moves into the gantry (or as the gantry moves toward the patient support) viewed from the front are more negative."