Applications of Cone Beam CT in Oral and Maxillofacial Surgery

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Volume Acquisition

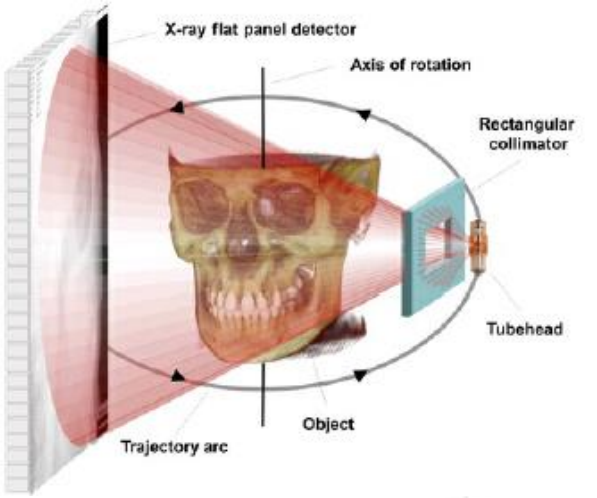
•Cone beam computed tomography is a recent technology initially developed for ***angiography*** in 1982 and subsequently applied to maxillofacial imaging.

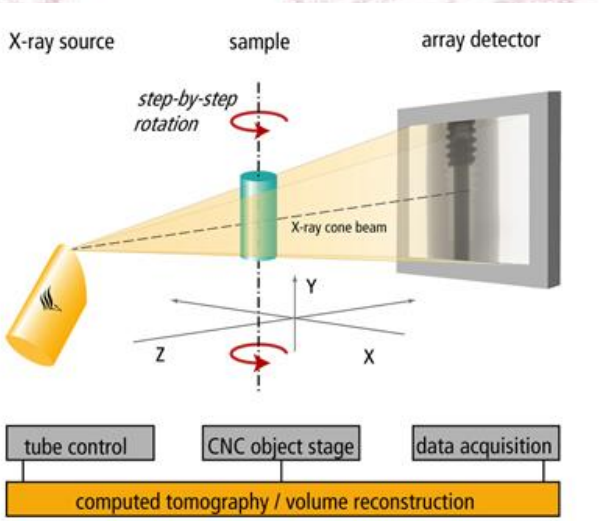
• it uses a ***divergent*** or ***cone-shaped source*** ionizing radiation and a ***two dimensional area detector*** fixed on a rotating gantry to acquire multiple sequentional projection images in one complete scan around the area of interest

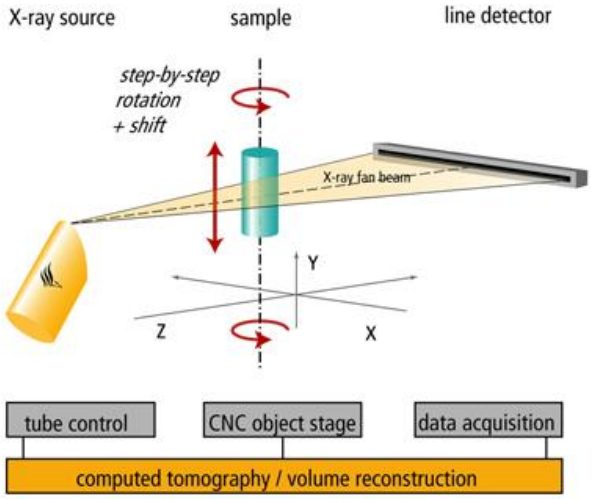
There are three main processes in CBCT imaging:

- image production
- visualization
- interpretation

Principles of Cone Beam Computed Tomographic Imaging







Components of Image Production

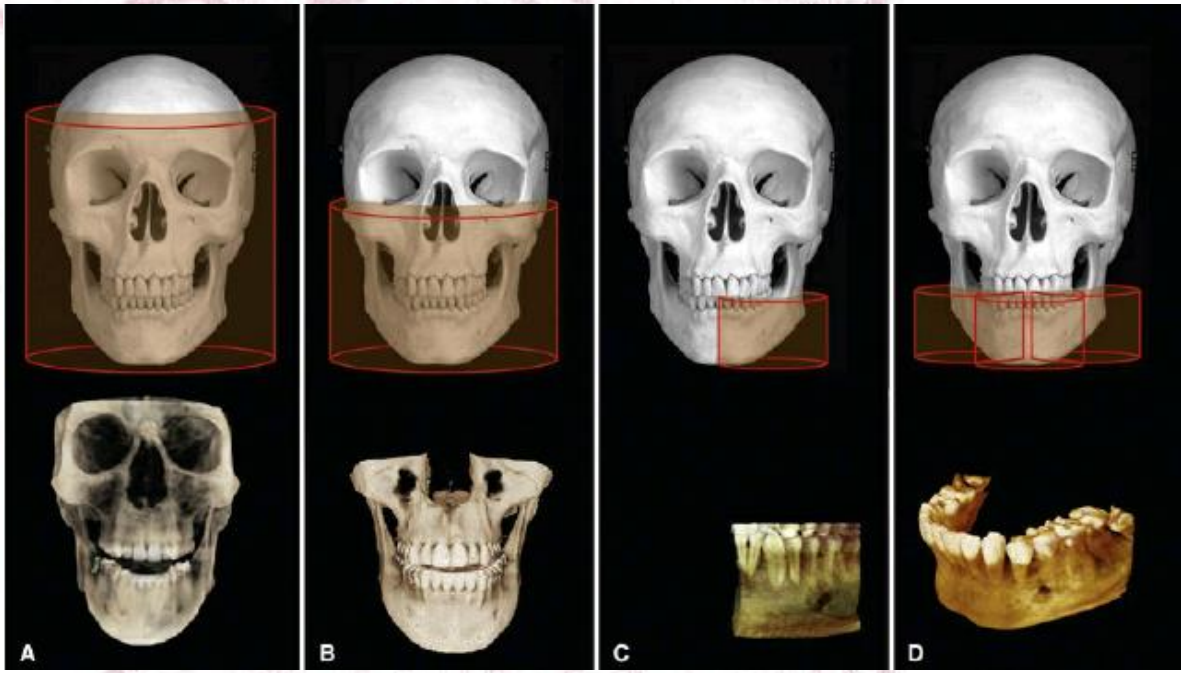
- X-ray generation
- X-ray detection
- Image reconstruction

X-ray generation

- Patient Stabilization
- X-Ray Generator

  It is ***preferable to pulse the x-ray beam*** to coincide with the detector sampling which results *in reducing scanning time and also patient dose*

- Scan Volume
- Scan Factors

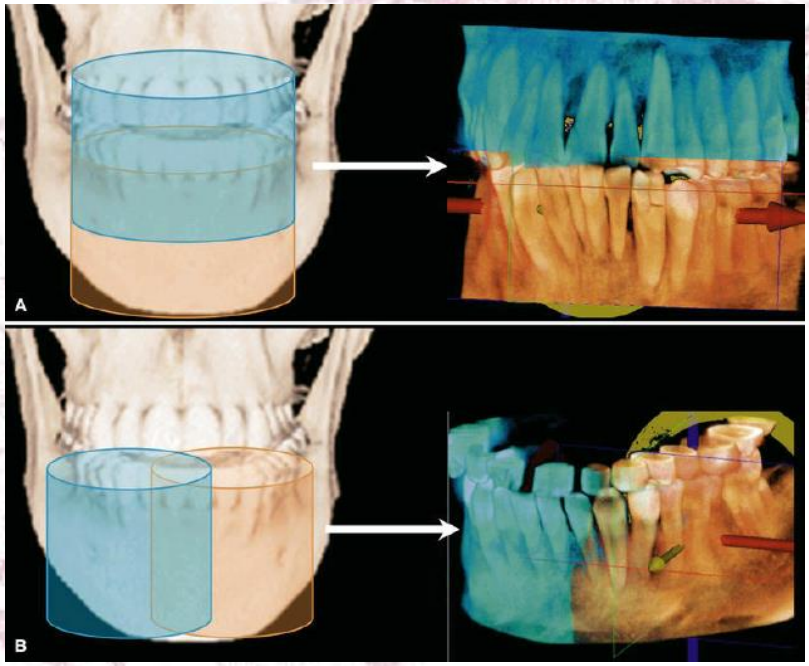


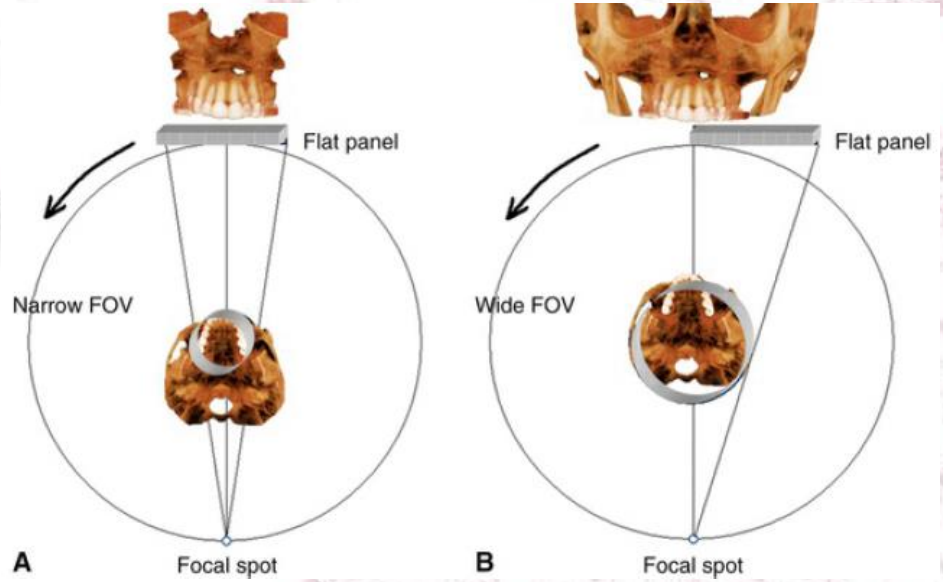
The primary determinants of patient exposure are:

- **Variation in exposure parameters**
- **Presence of pulsed x-ray beam**
- **Size of the image field(FOV)**

Scan Volume(FOV)

- ***the detector size*** and ***shape***
- ***beam projection geometry***
- ***the ability to collimate the beam***





Scan factors

- The speed with which individual images are acquired is called the ***frame rate*** and is measured in frames ,projected images ,per second.

- The **maximum frame rate of the detector** and **rotational speed** determines the number of projections that may be acquired.

- With a **high frame rate** more information is available to reconstruct the image therefore the **reconstruction time is increased**

Higher frame rate → *increase signal to noise ratio*

→ *less noise*

In maxillofacial region :

Higher frame rate → *reduces metallic artifact*

Higher frame rate → (usually) *longer scan time*

→ *higher patient dose*

- it is desirable to **reduce CBCT scan time** to **as short as possible** to *reduce motion artifacts* resulting from subject movement this can be substantial and may be *limiting factor in voxel resolution*

Decreased **scanning time** may be achieved :

- **increasing** the detector frame rate(is optimal)
- **Reducing** the number of projections → ***higher noise***
- **Reducing** the scan arc → **higher noise**

Image Detectors

a - image intensifier tube charge-coupled device combination

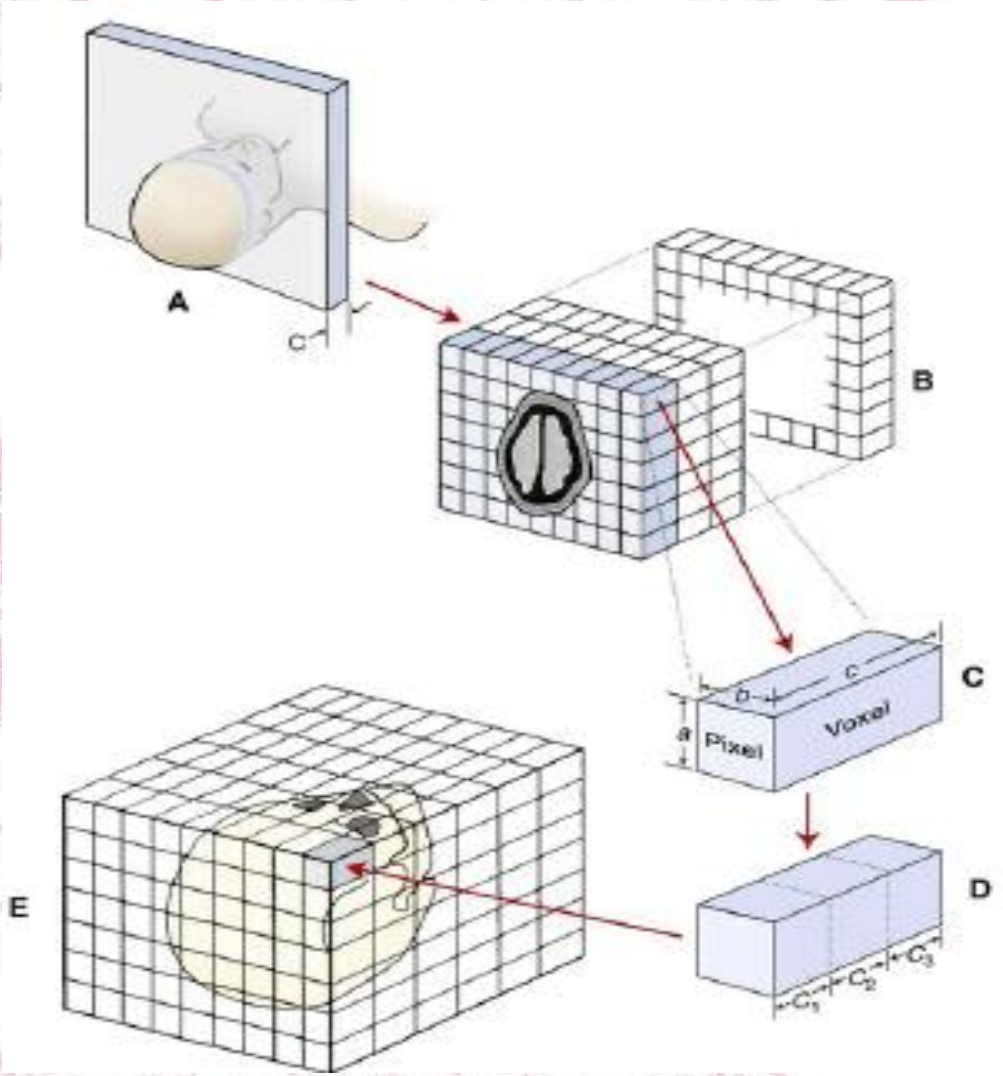
b- flat-pannel imager (commonly use)

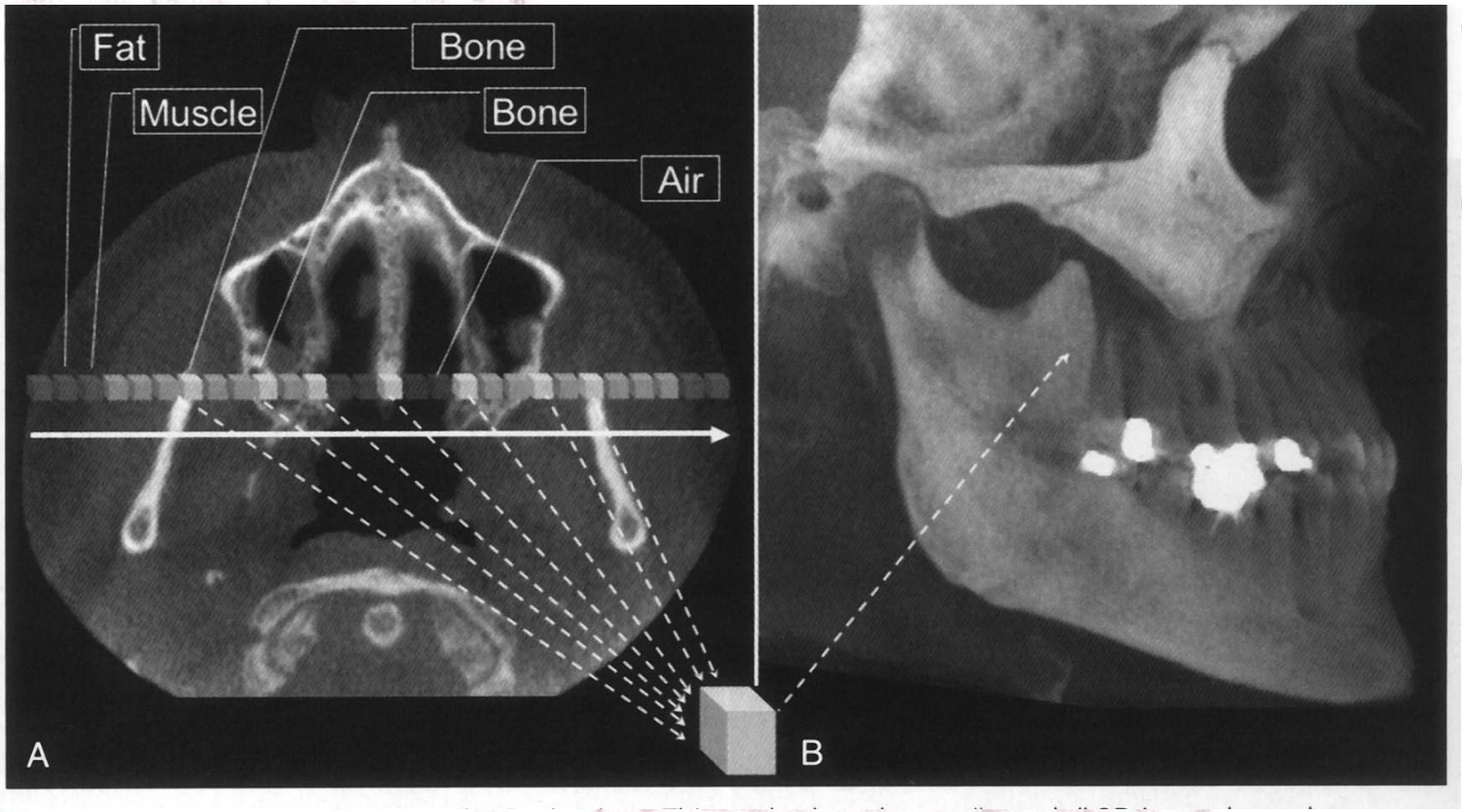
- Voxel Size

  isotropic

- Grayscale

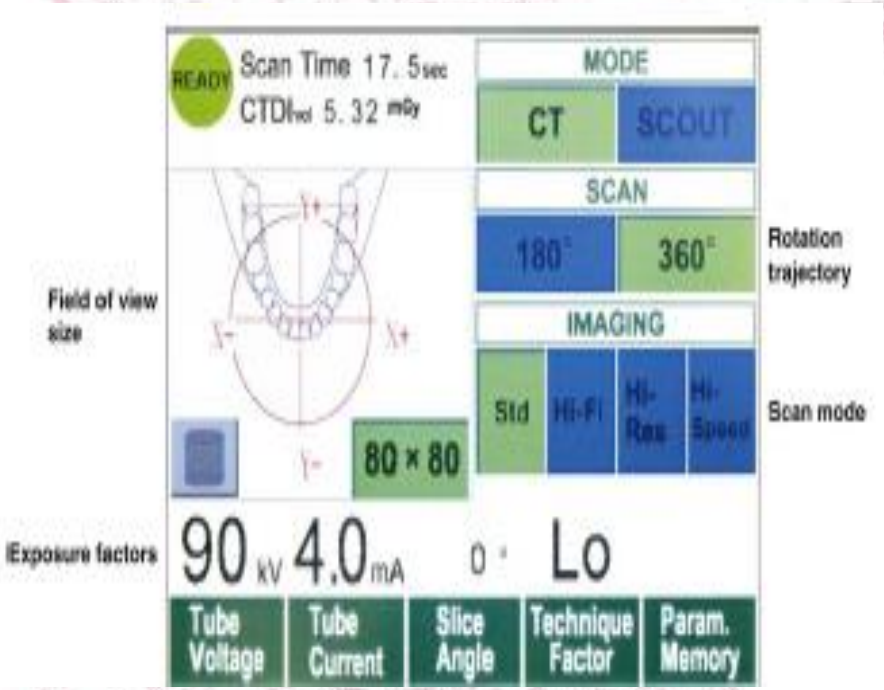
  bit depth




Fat
Bone
Muscle
Bone
Air
A
B

Clinical Considerations

- Patient Selection Criteria
- Patient Preparation
- Imaging Protocol
- Exposure Settings

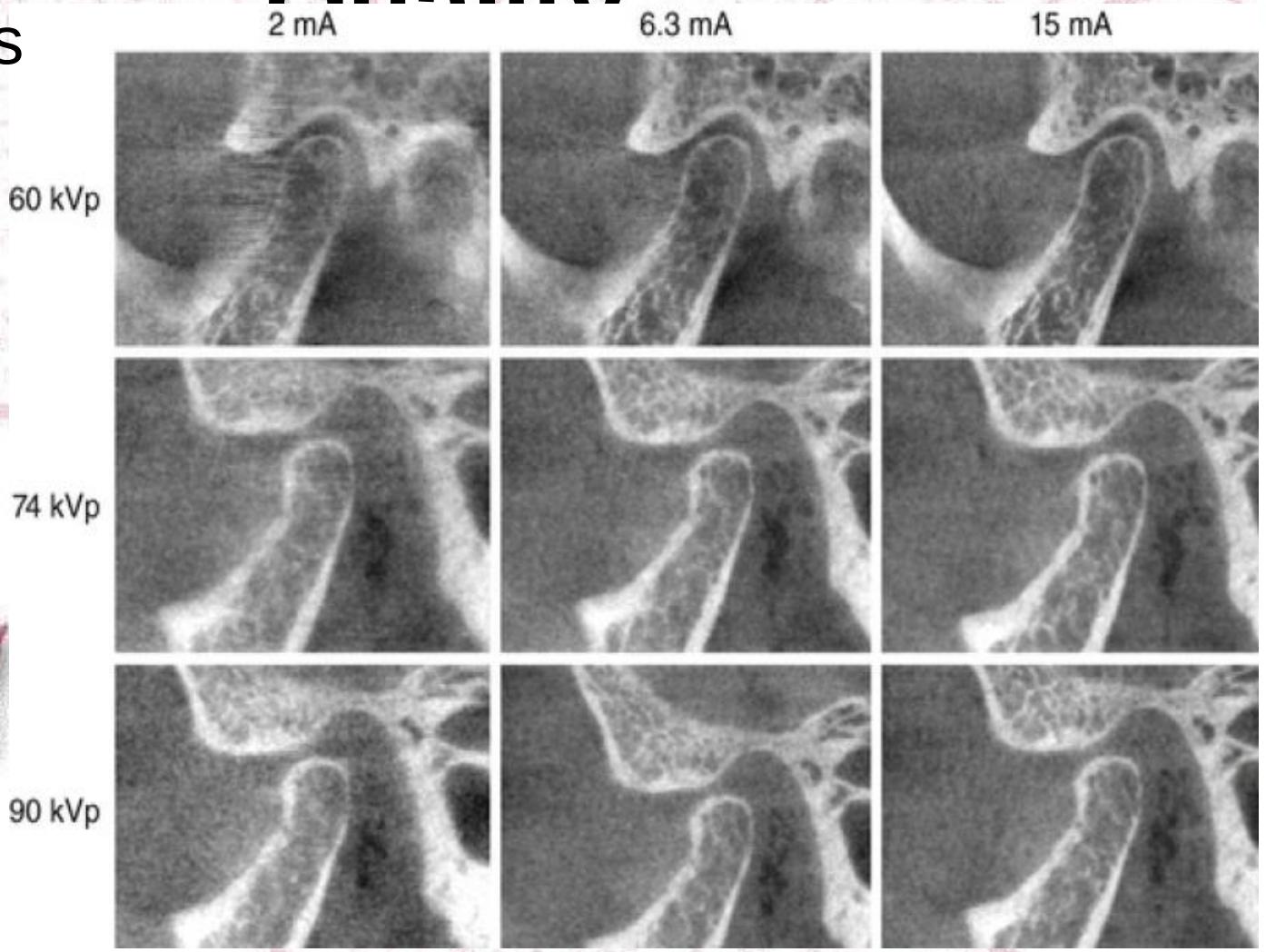


Exposure Parameters

- AEC
- mA changes are preferable to kVp changes
→ increase in noise for a given dose reduction is smaller for the former
- Decrease beam hardening → increase kvp

Effect of Exposure Parameters on Image Quality

- graininess



Spatial Resolution (fine detail)

- pixel size
- beam projection geometry
- patient scatter
- detector motion blur
- fill factor
- focal spot size
- number of basis images
- reconstruction
- algorithm

Increase the pixel size reveals to:

- Decrease spatial resolution
- Decrease image quality
- Decrease patient dose
- Increase partial volume averaging artifact

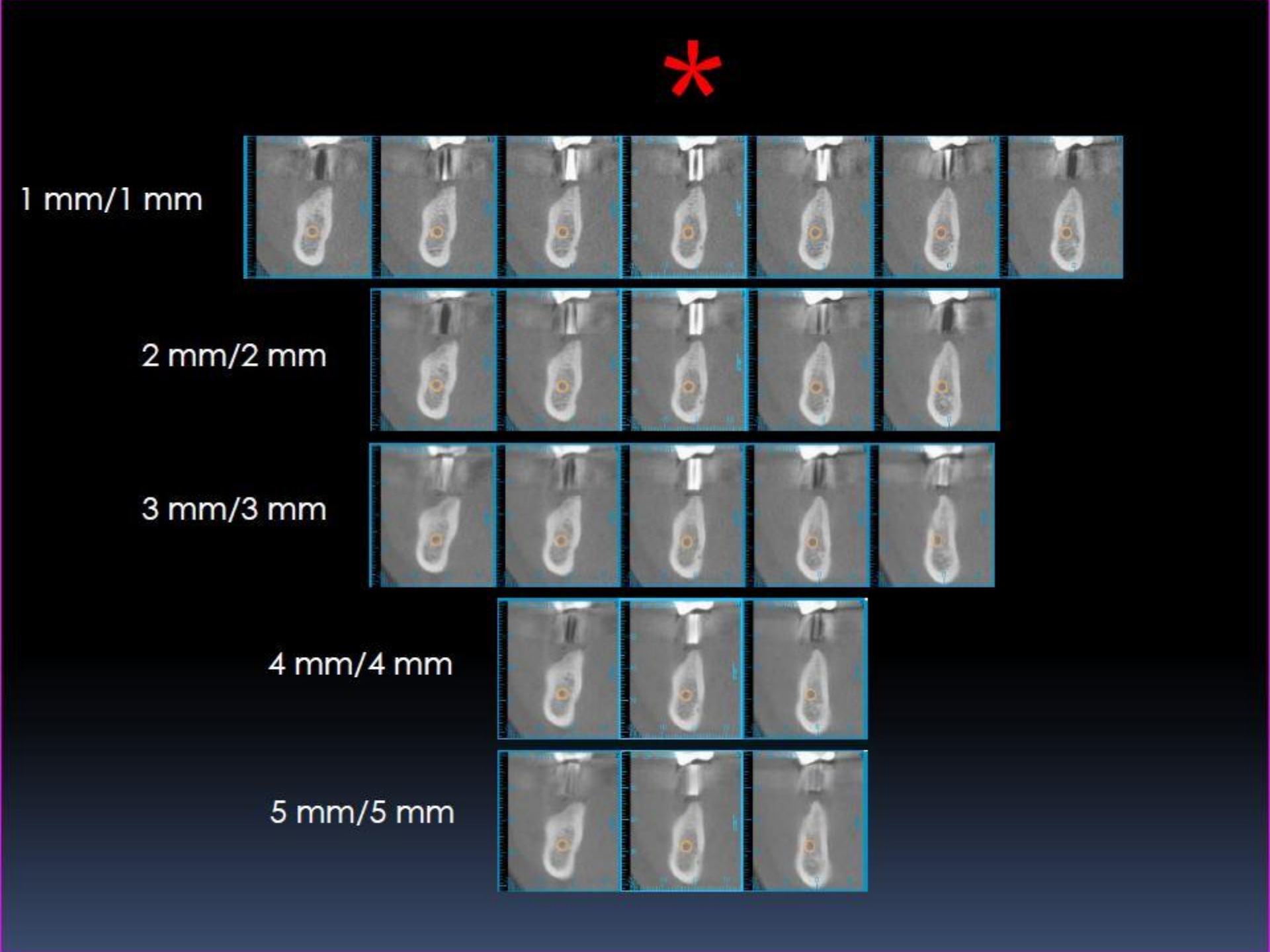

*
1 mm/1 mm
2 mm/2 mm
3 mm/3 mm
4 mm/4 mm
5 mm/5 mm

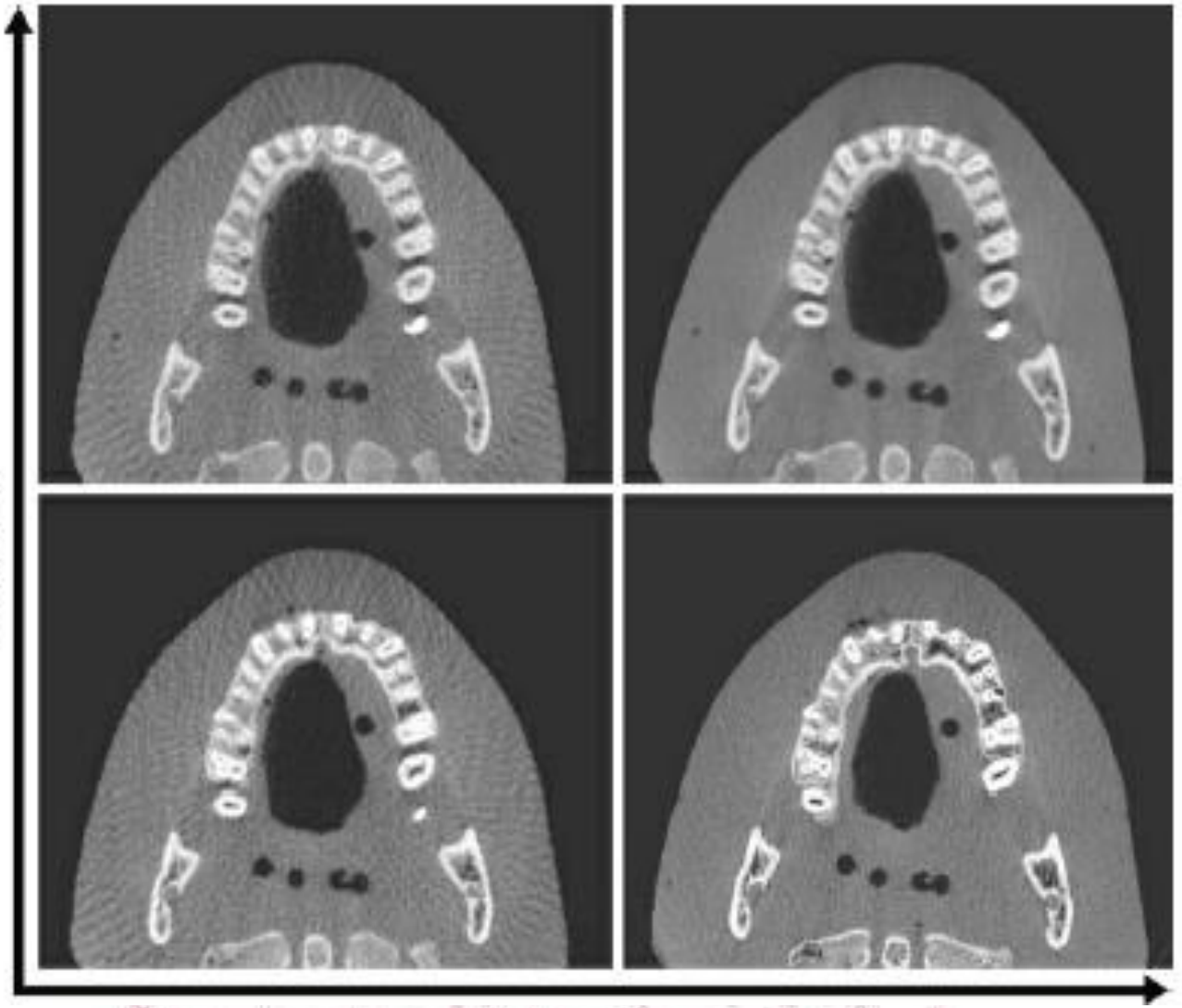
Image Artifacts

- Inherent Artifacts
- Procedure-Related Artifacts
- Introduced Artifacts
- Patient Motion Artifacts

Inherent Artifacts

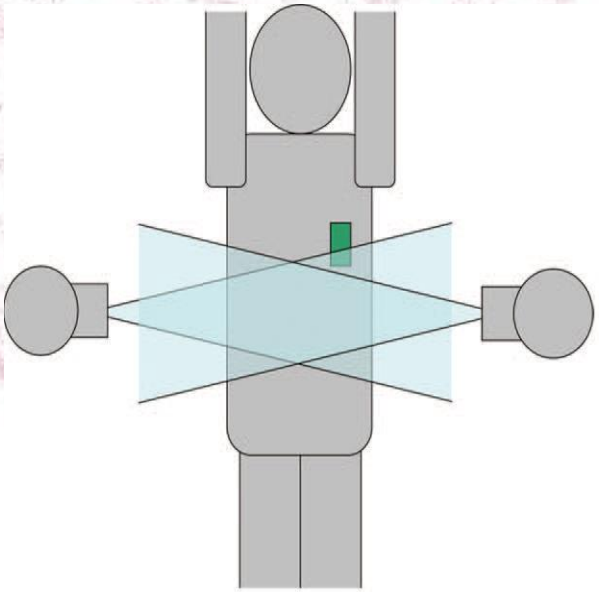
- Scatter → quantom noise + streak
- Partial volume averaging → "step" appearance or homogeneity
- Cone beam effect

streak

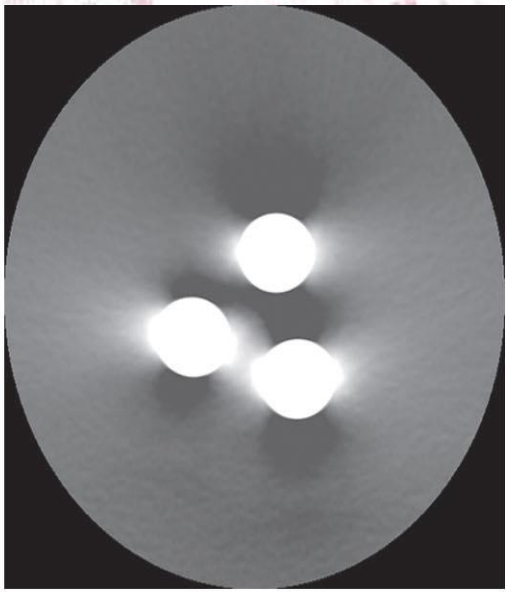


quantom noise

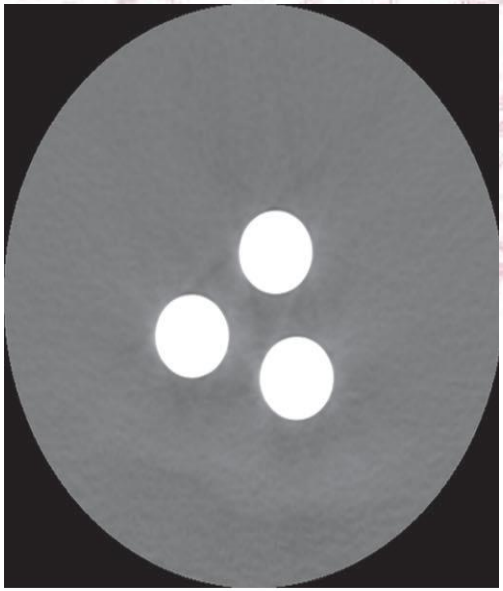
PVA



7.

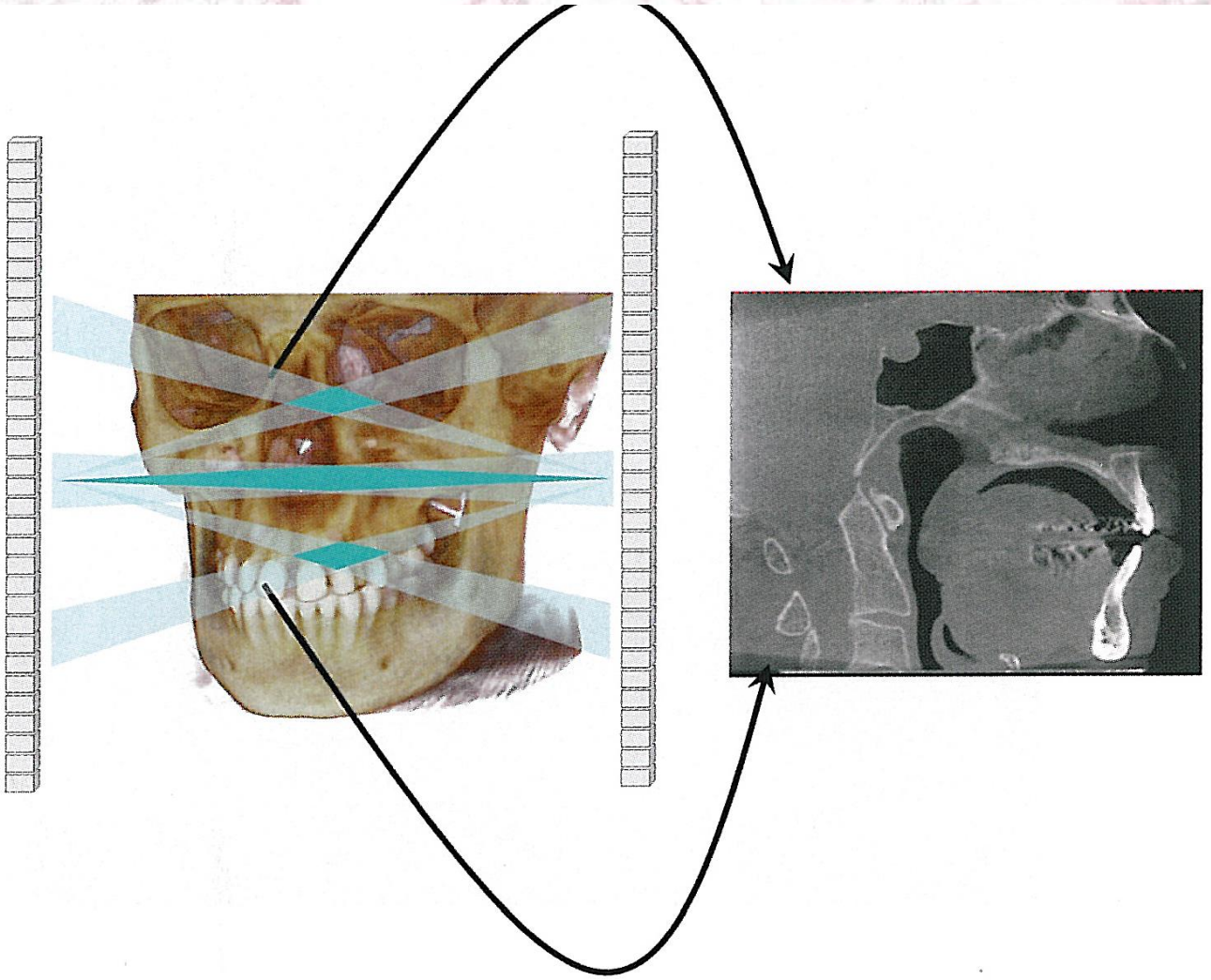


8a.



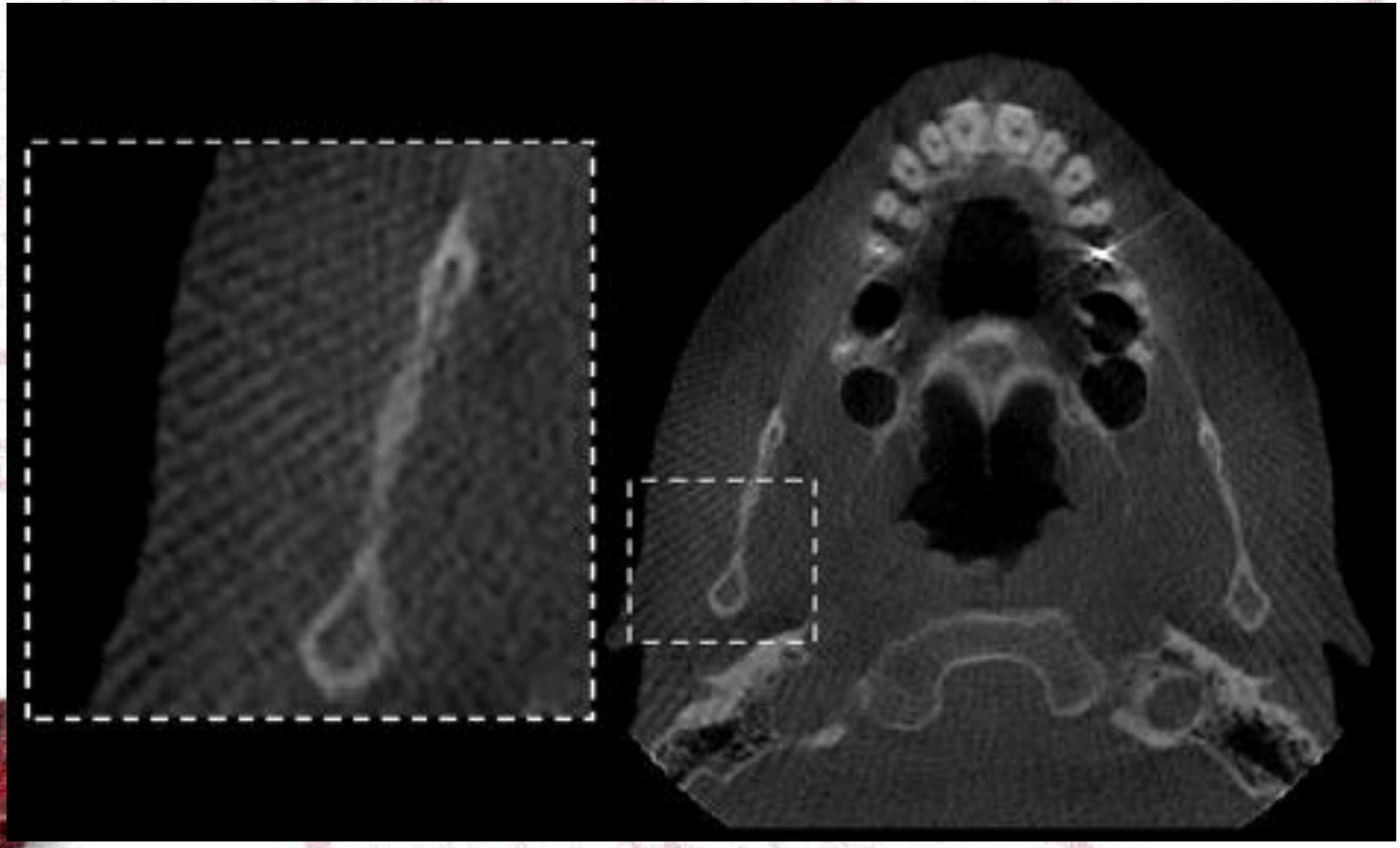
8b.

Cone beam effect



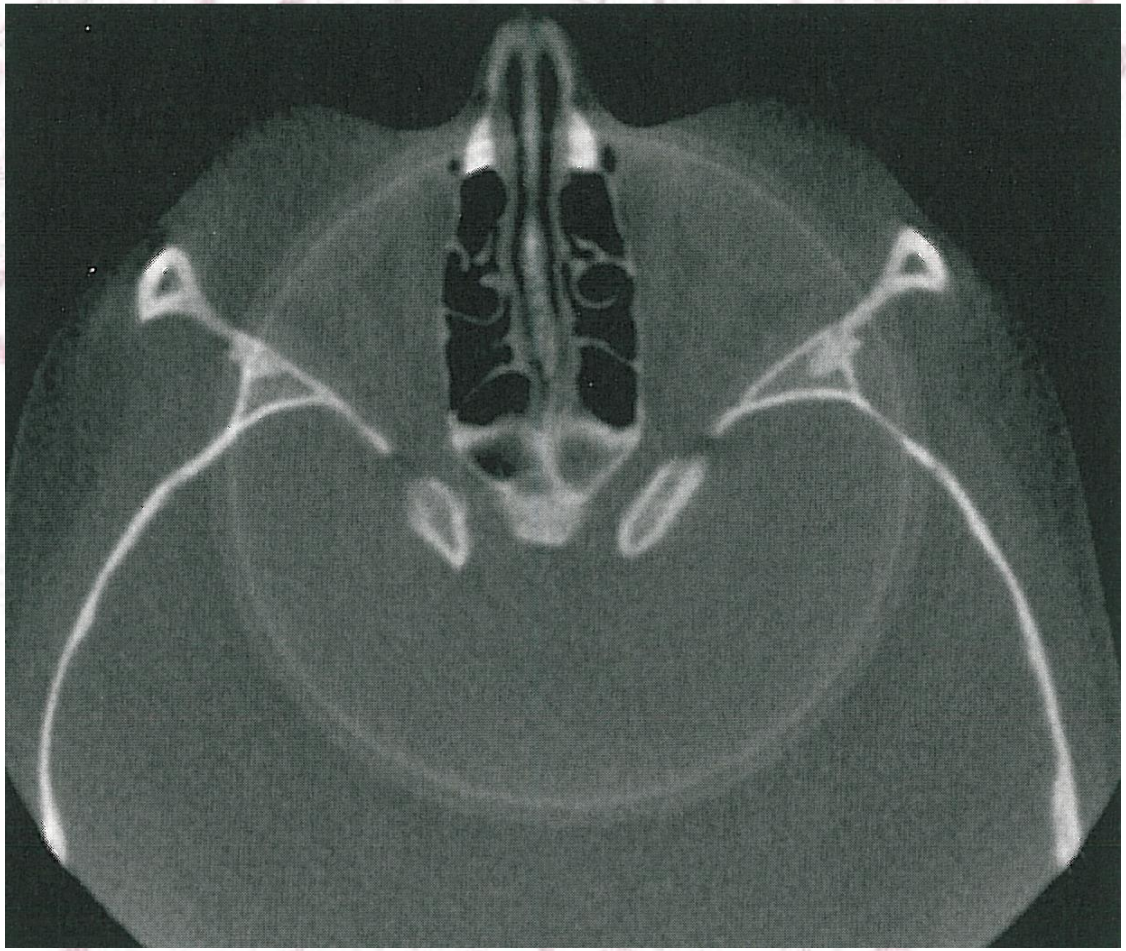
Procedure-Related Artifacts

Aliasing artifact → **Moiré Artifact**



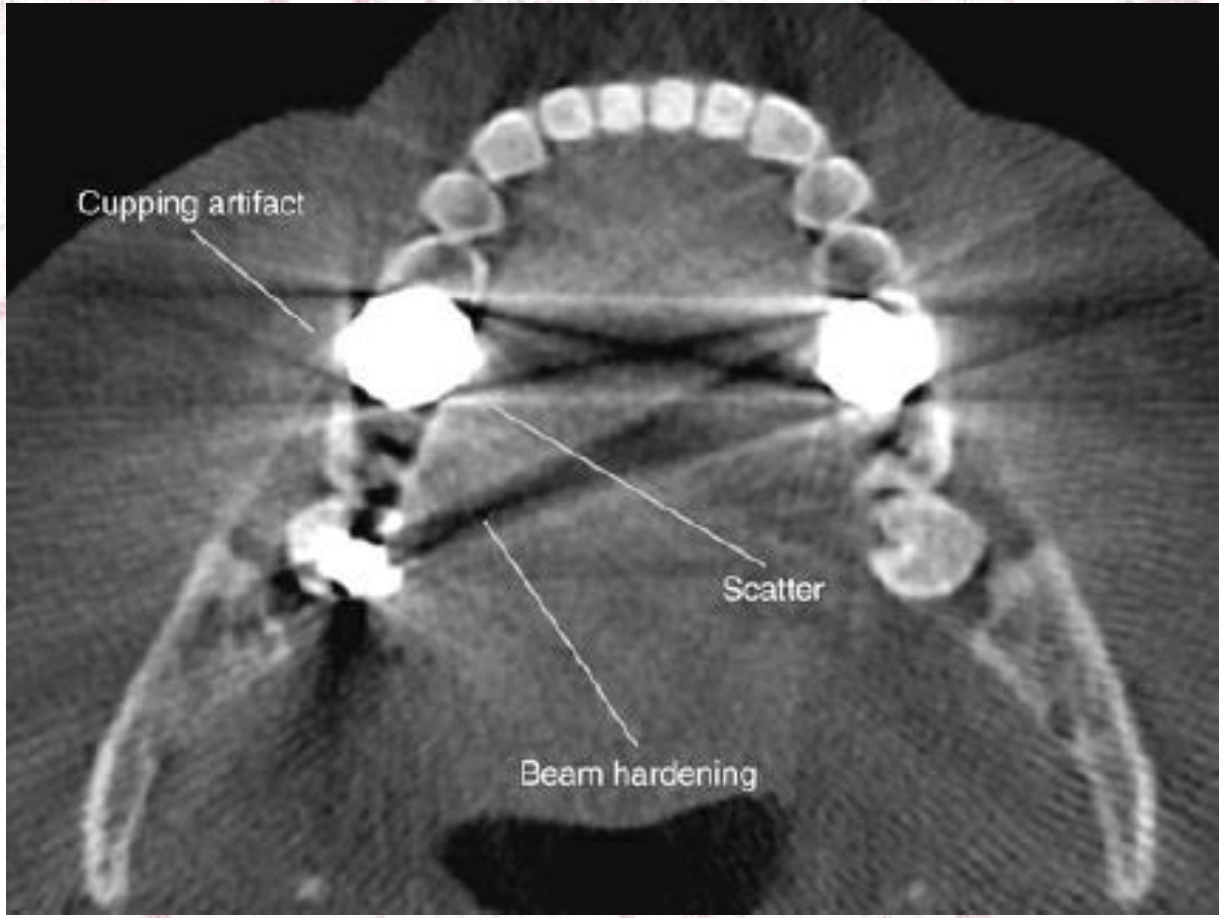
Procedure-Related Artifacts

- Circular or ring artifact → imperfections in scanner detection or poor calibration

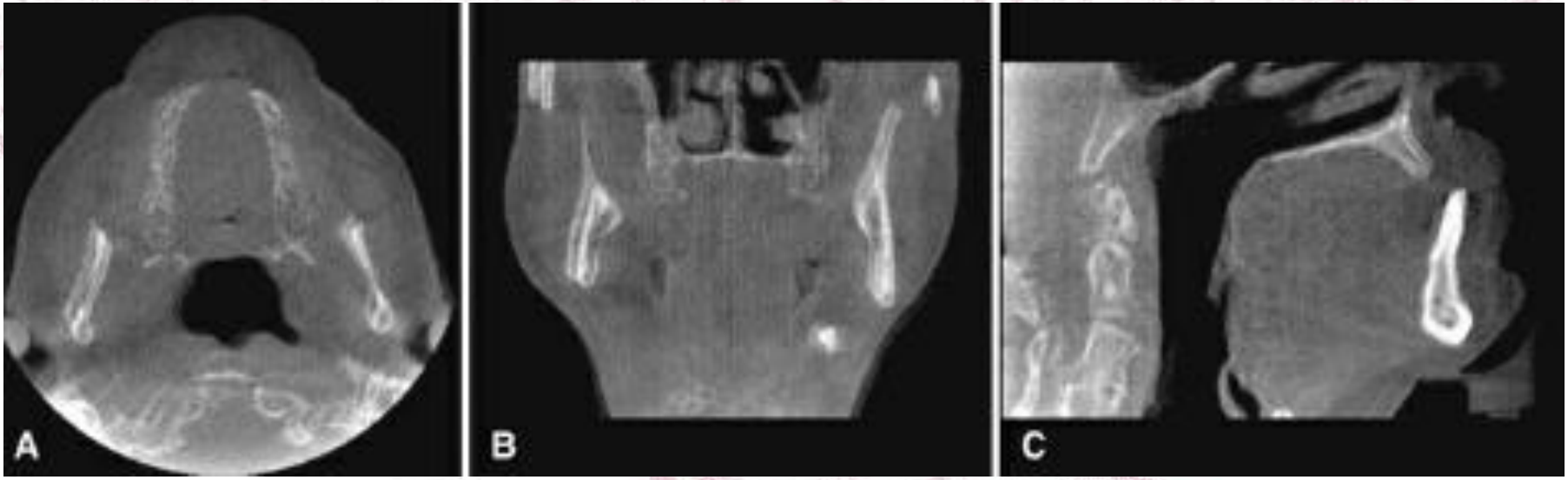


Introduced Artifacts

- **cupping artifact**
- **extinction or missing value**

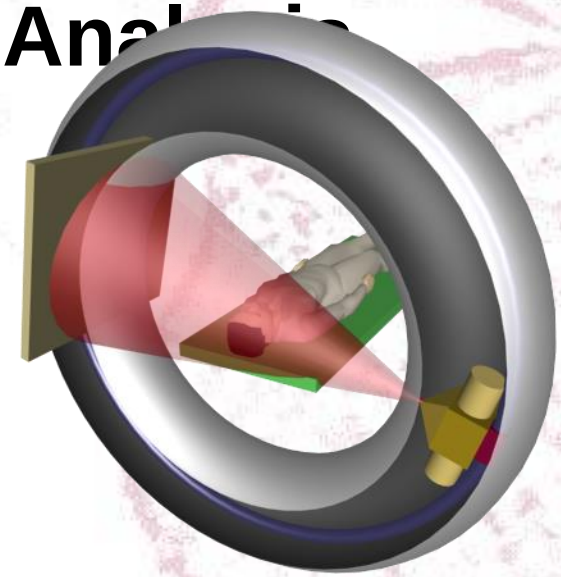


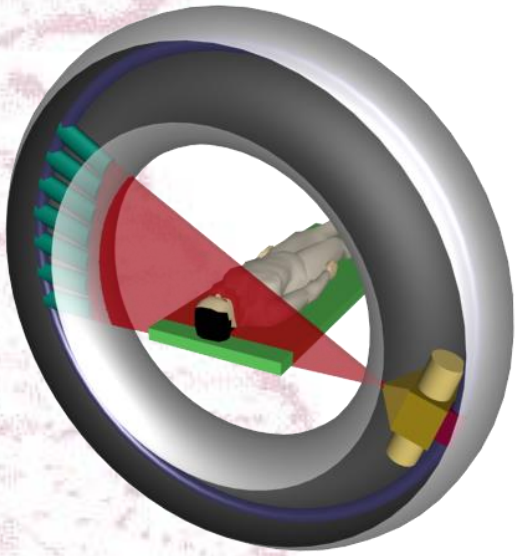
Patient Motion Artifacts



Strengths of cbct

- Size and Cost
- Fast Acquisition
- Submillimeter Resolution(CT >CBCT)
- Relatively Low Patient Radiation Dose(CT<CBCT)
- Interactive Ana





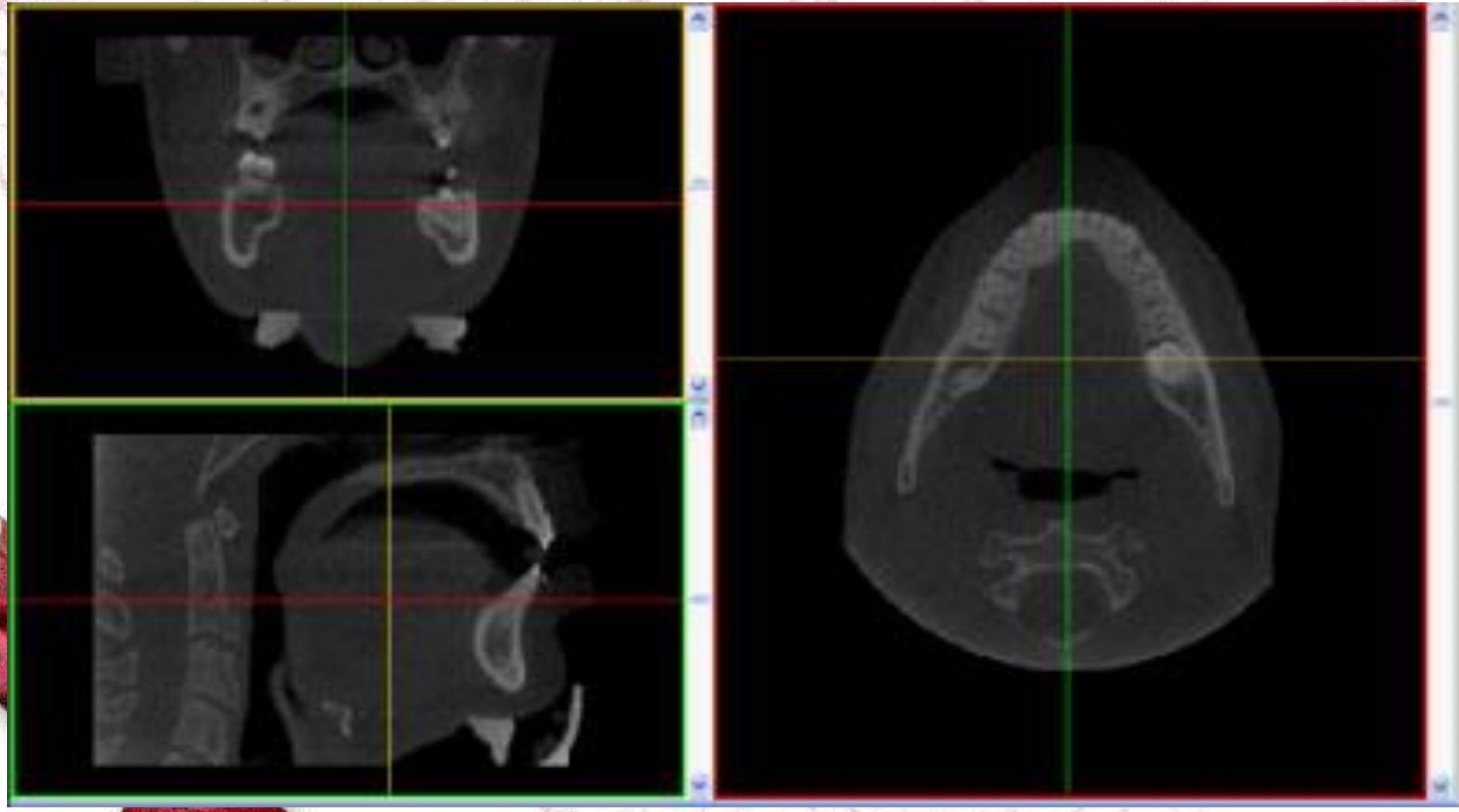
Limitations

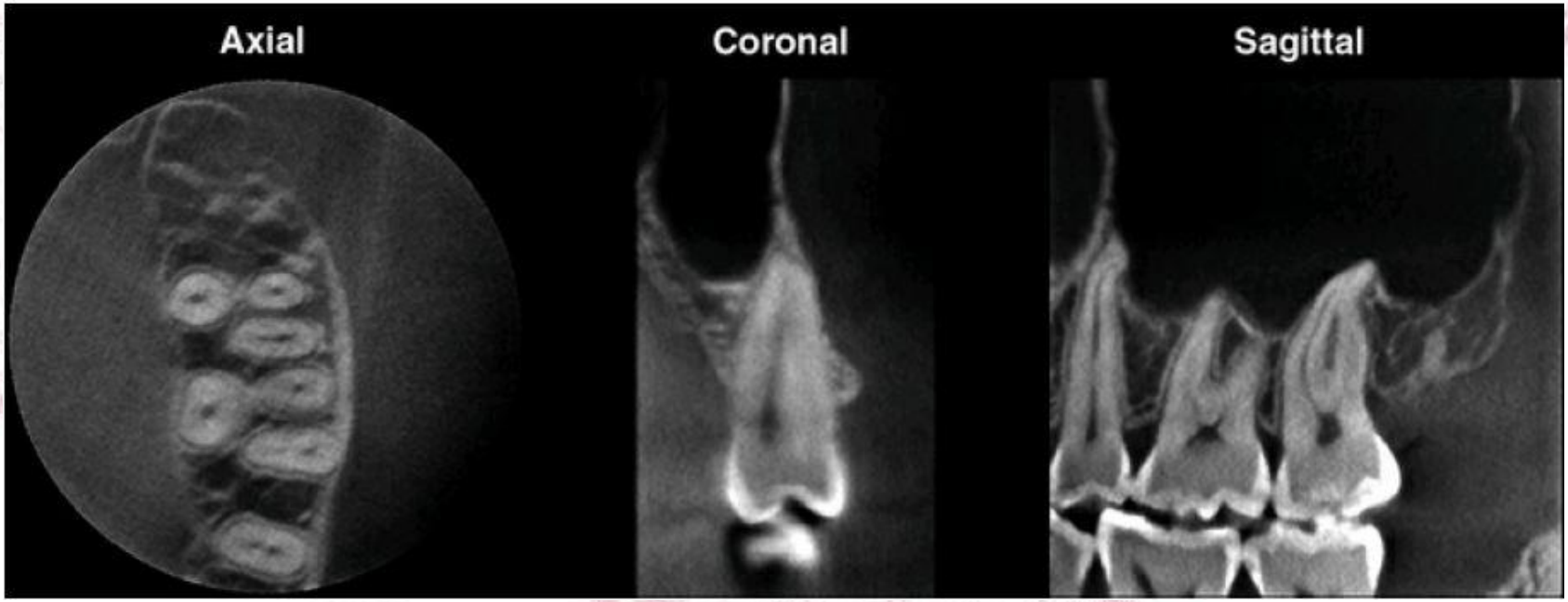
- **Image Noise**
- **Poor Soft Tissue Contrast**

Task-Specific Applications

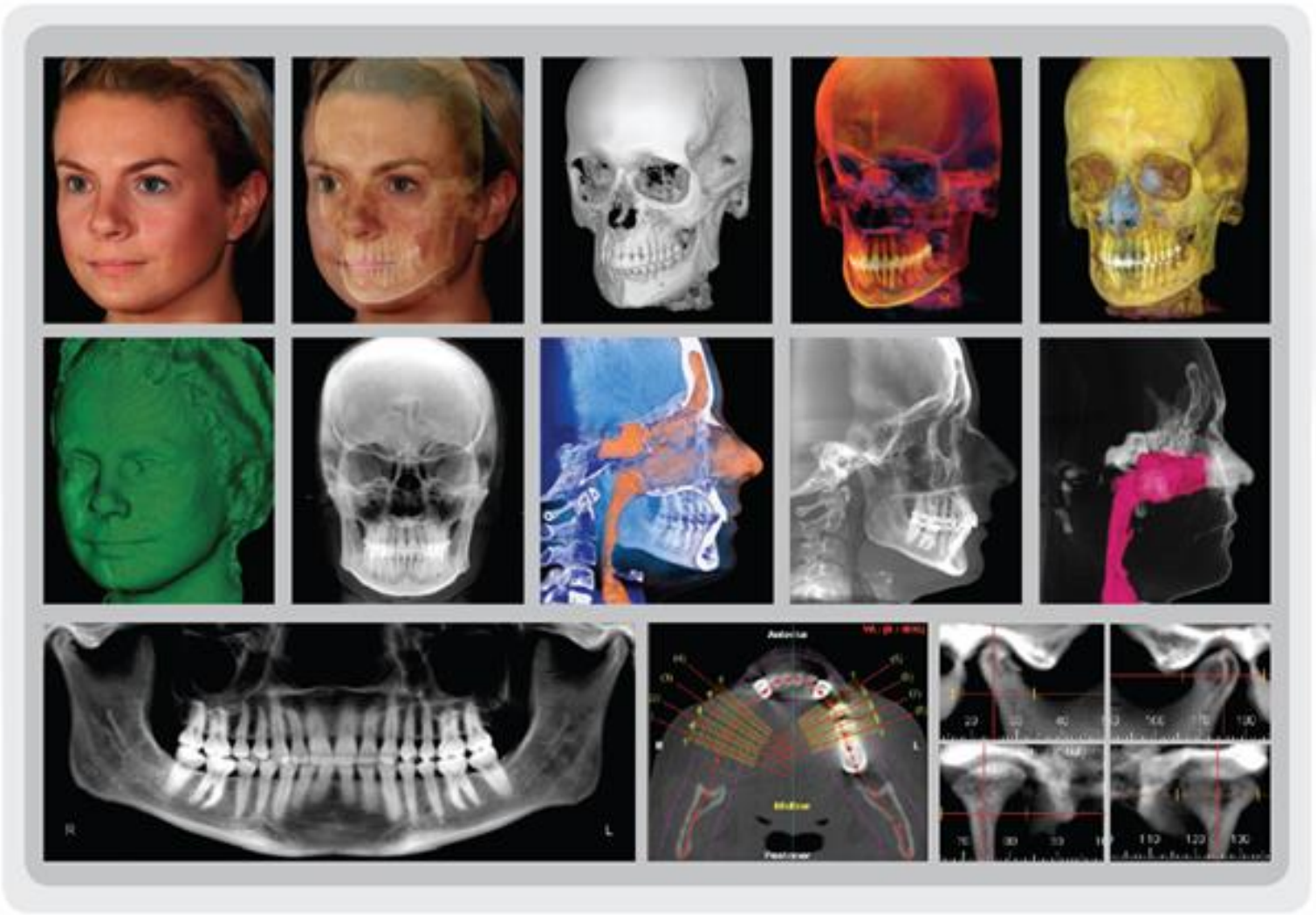
- Implant Site Assessment
- Endodontics
- Orthodontics and Three-Dimensional Cephalometry
- Mandibular Third Molar Position
- Temporomandibular Joint
- Maxillofacial Pathoses
- Treatment Planning and Virtual Simulations
- Image-Guided Surgery and Additive Manufacturing
- Periodontal disease
- Airway study

Image reconstruction in axial, sagittal and coronal plane

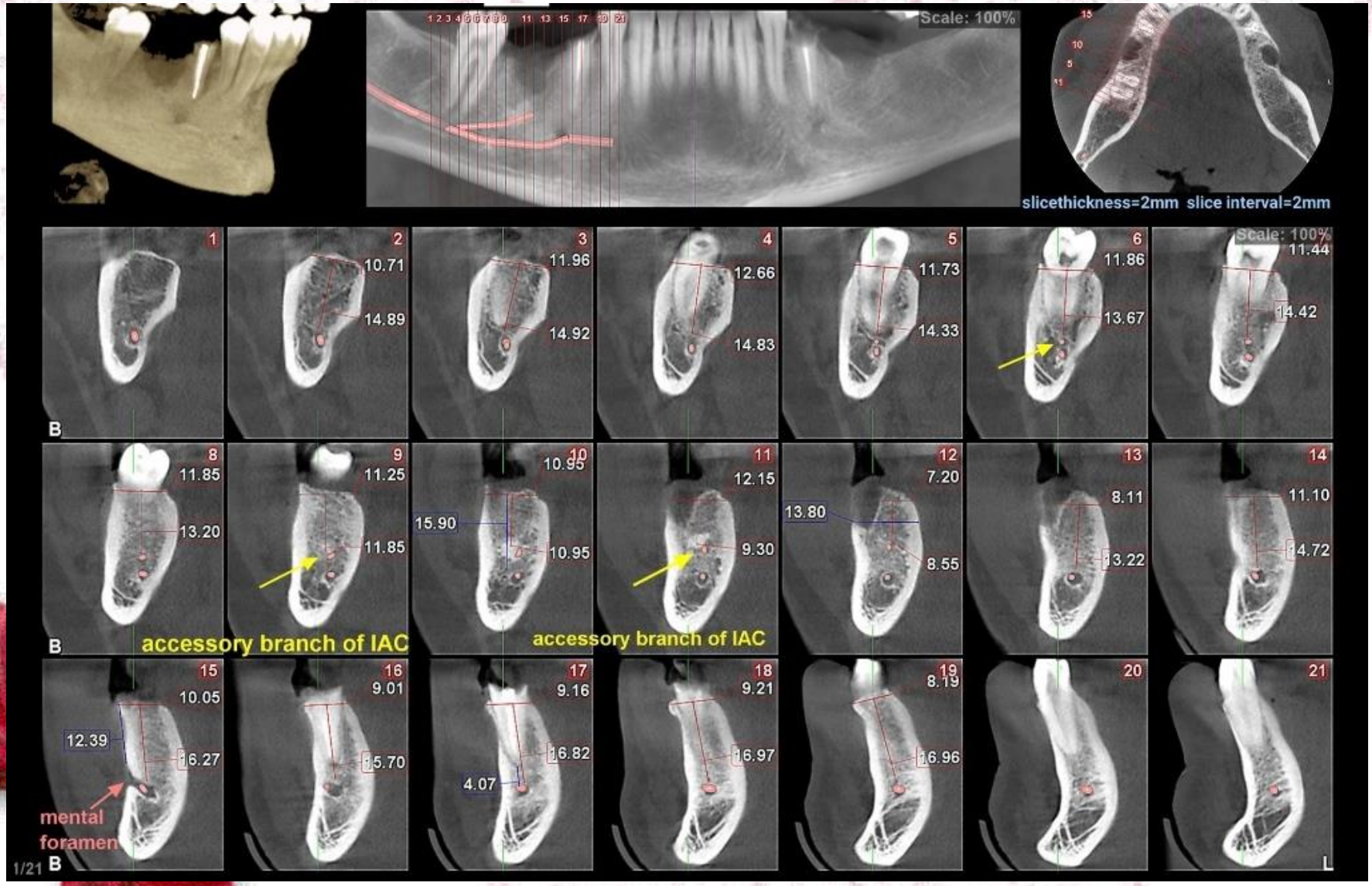


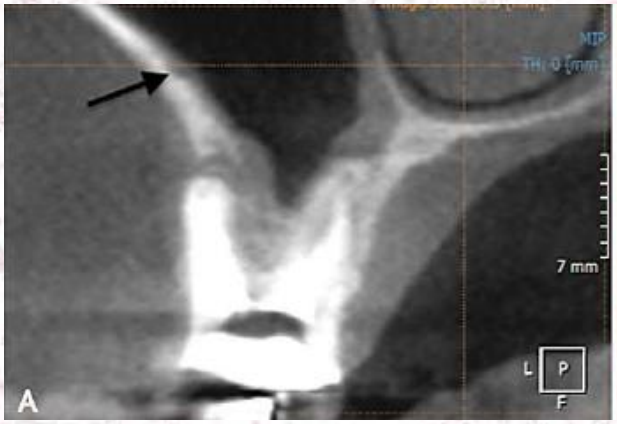

Axial
Coronal
Sagittal

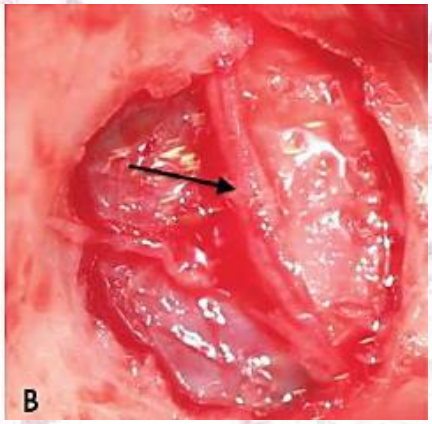
3D and airway analysis

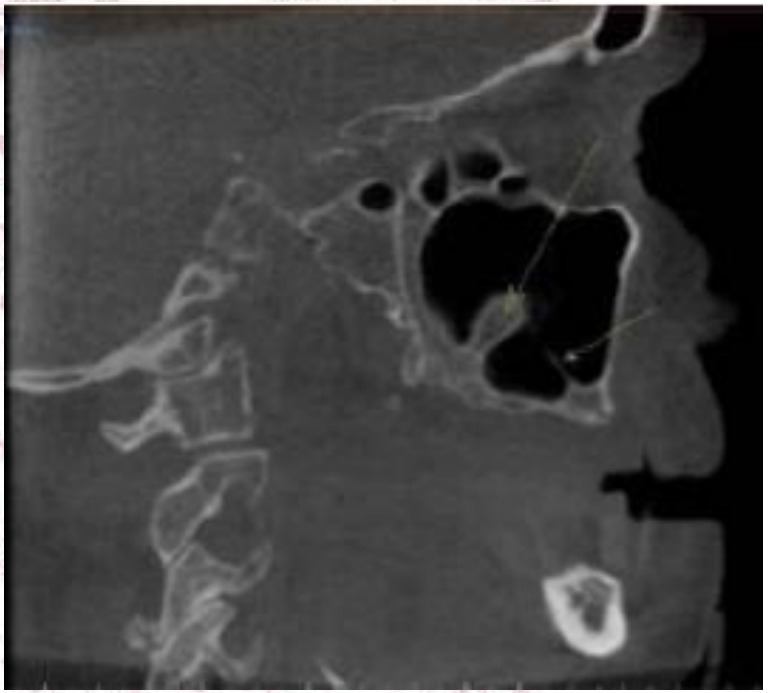


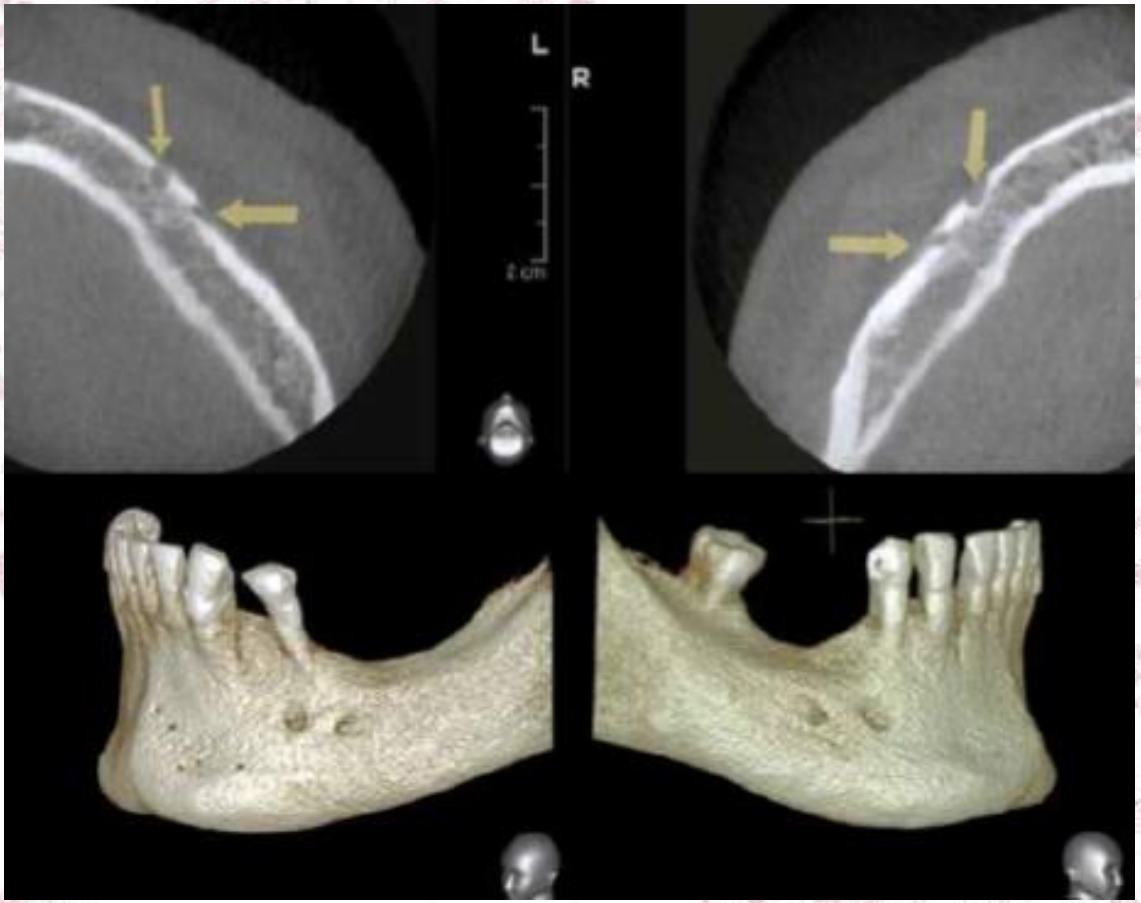
- **Implant Site Assessment**



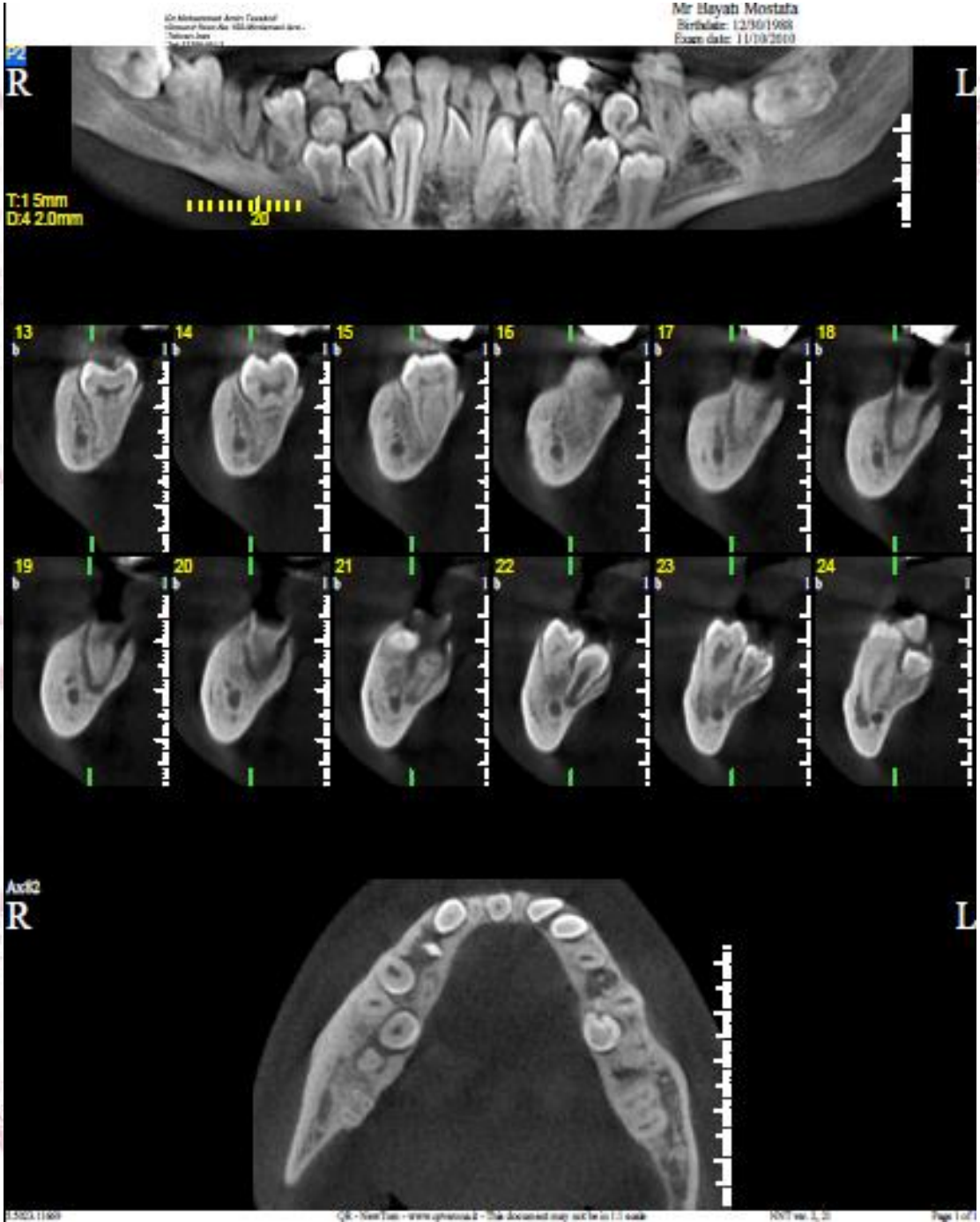

7 mm
L
P
F
A


B



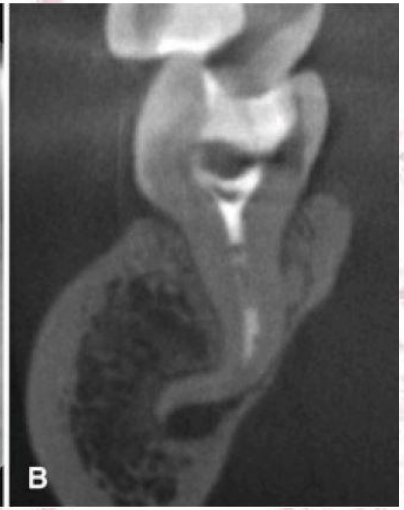

L
R

- Unerupted permanent teeth



Endodontics


A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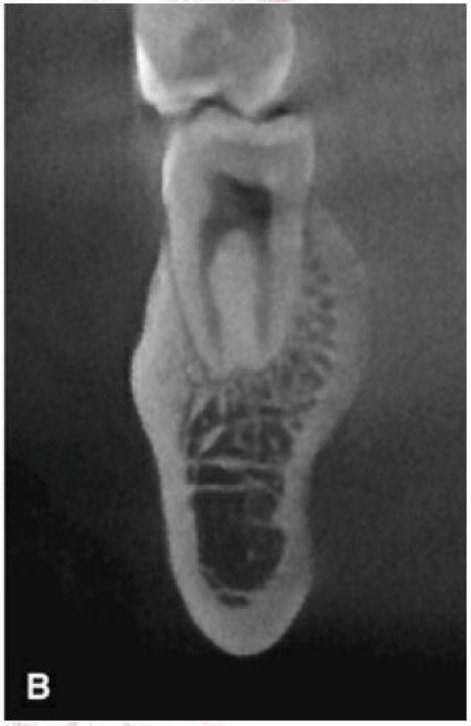
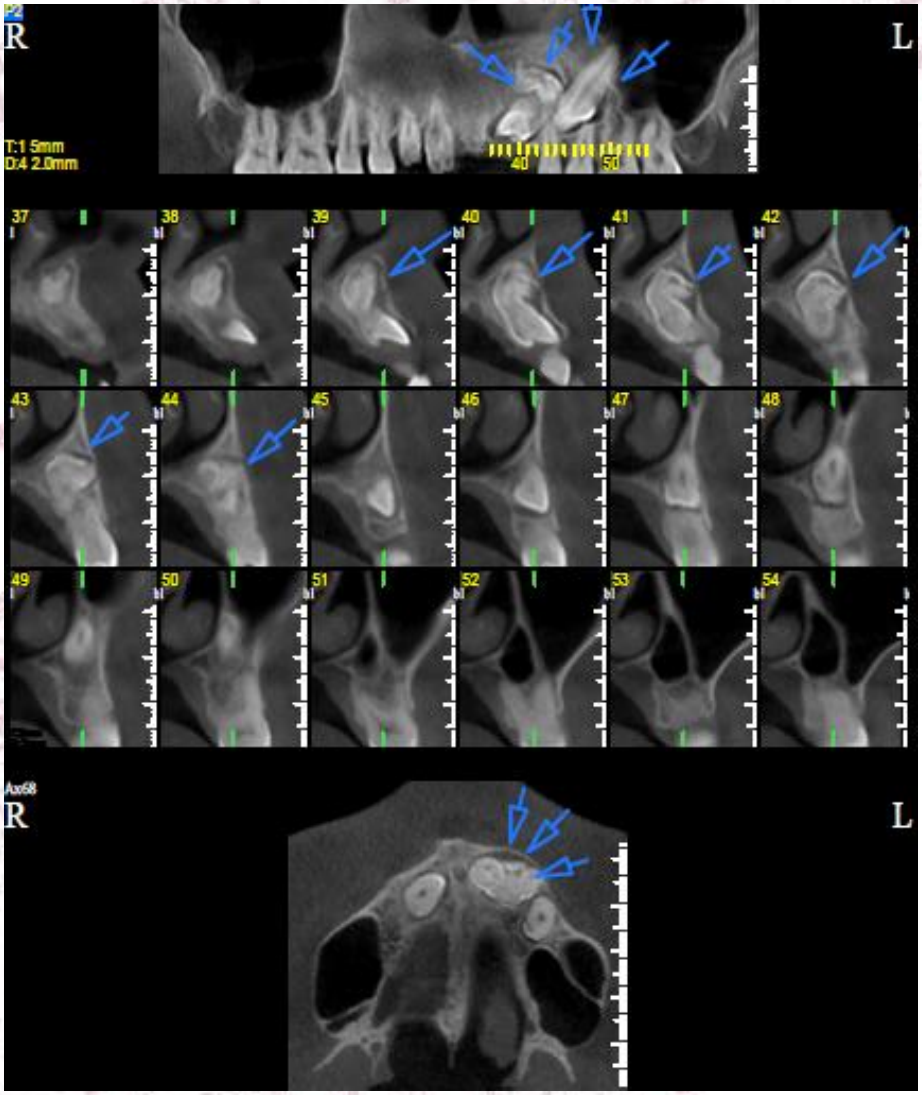
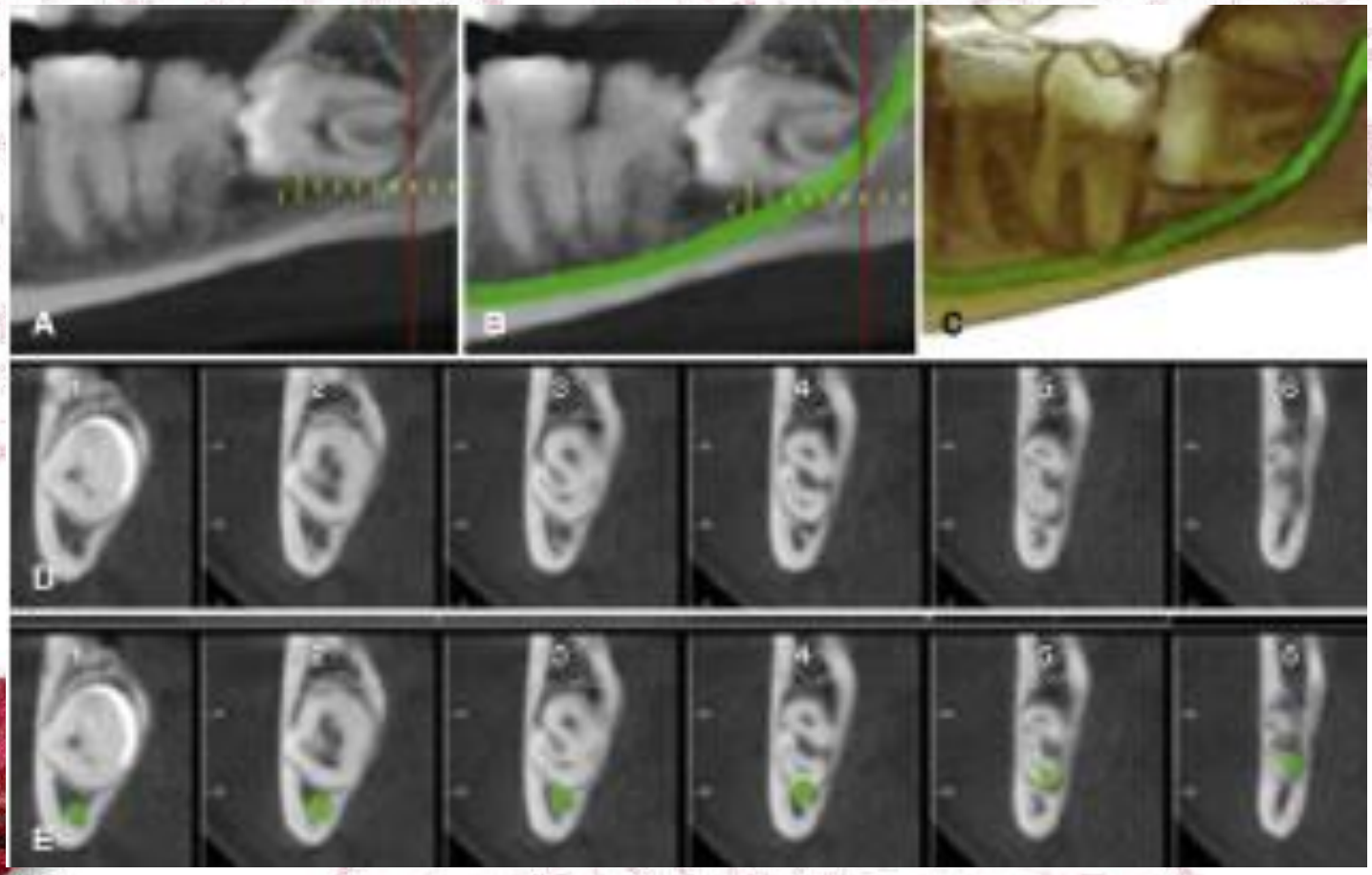
A

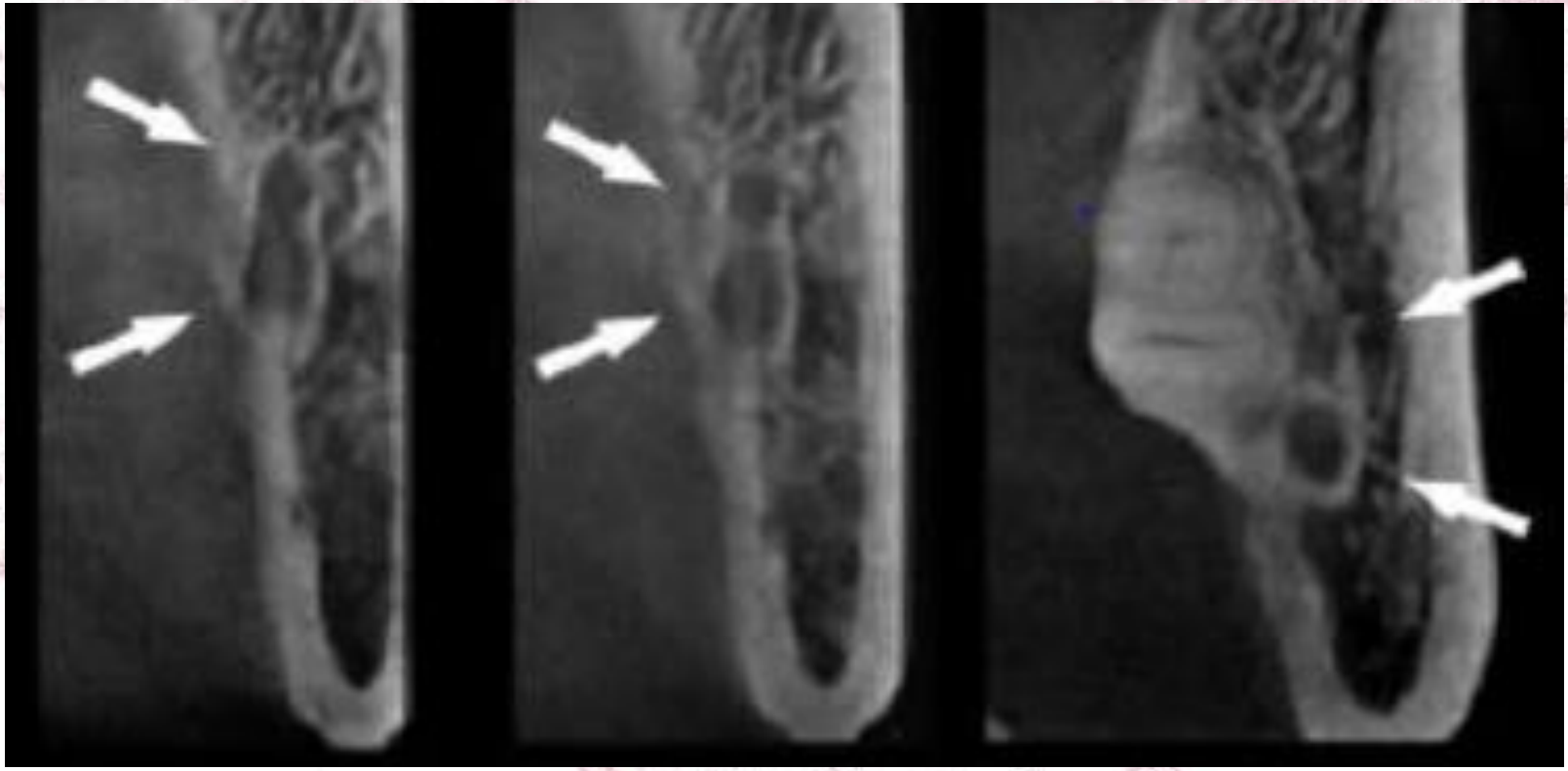

B

Orthodontics and Three-Dimensional Cephalometry

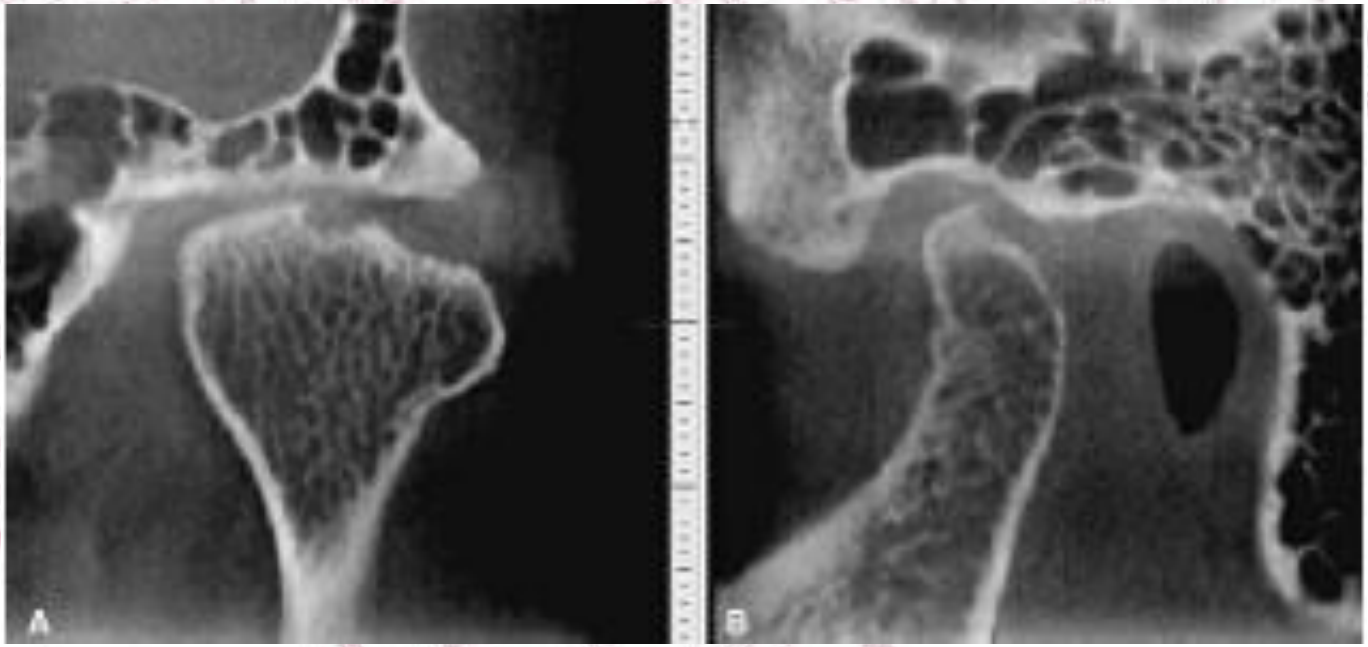


Mandibular Third Molar Position



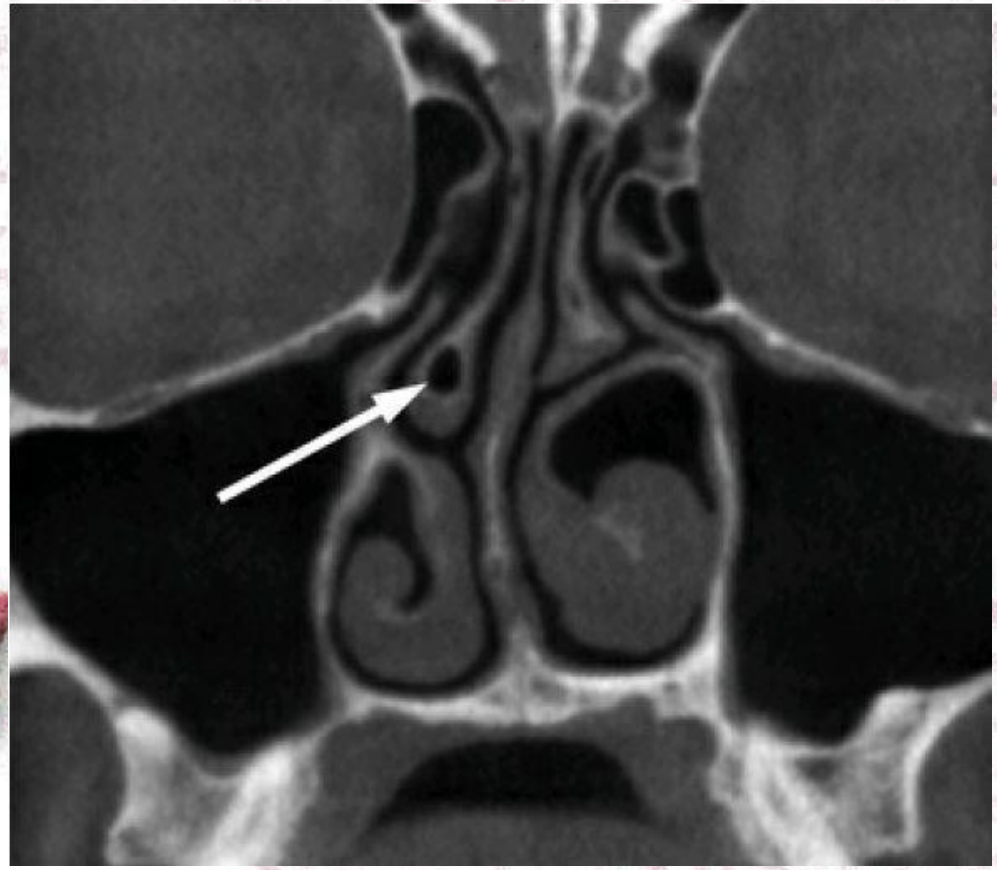


Temporomandibular Joint

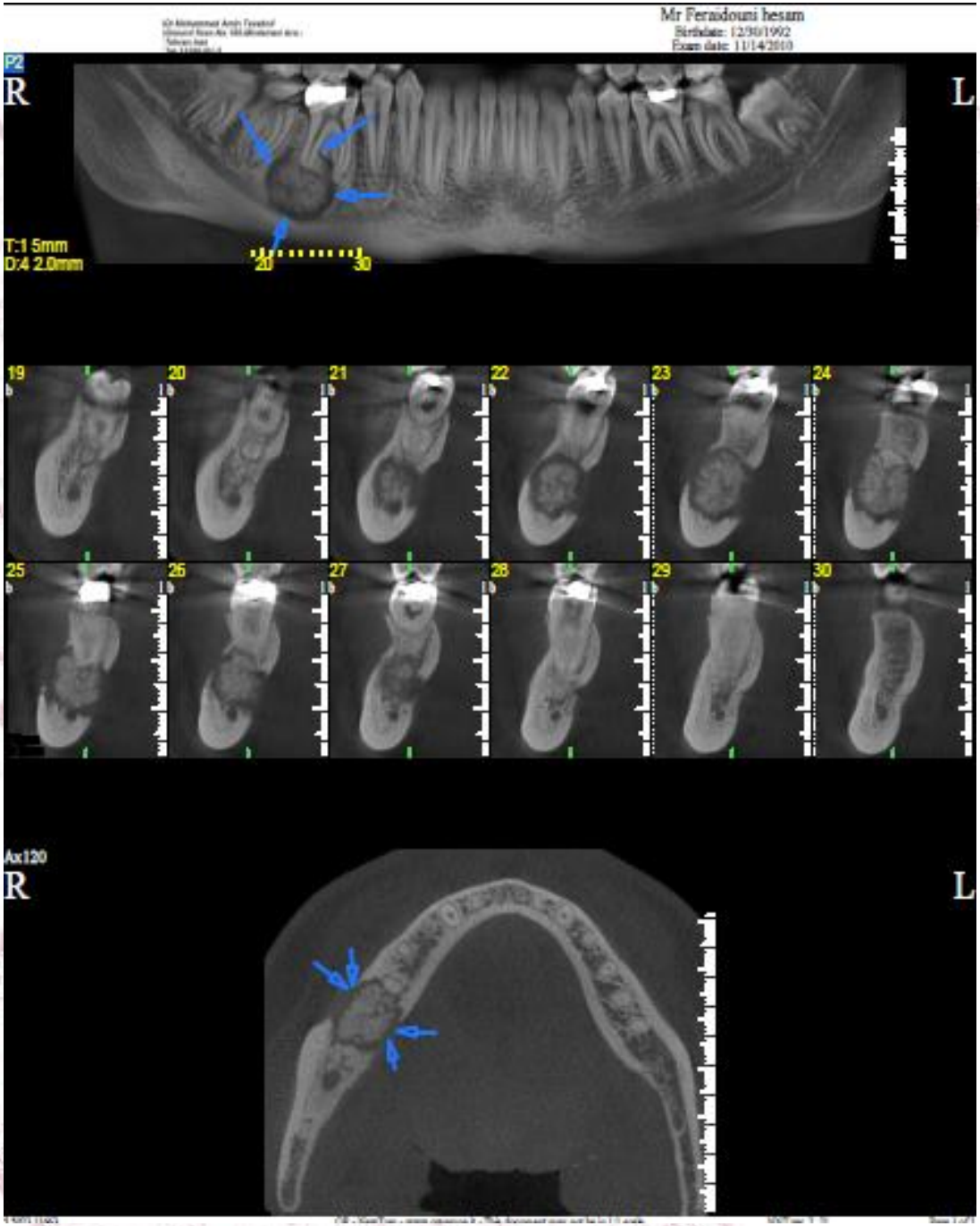


Maxillofacial Pathoses

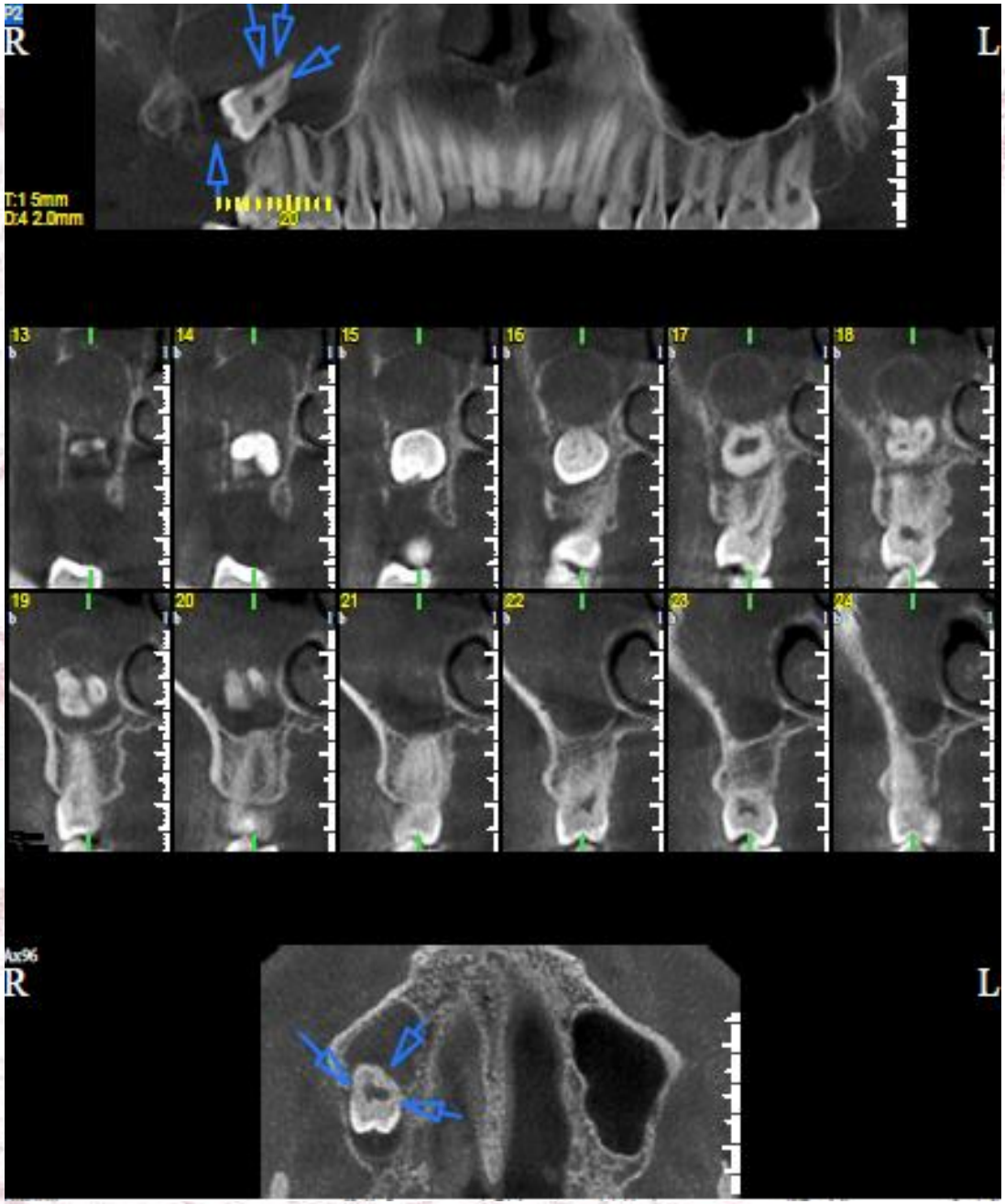
Concha bullosa: pneumatization of the middle concha



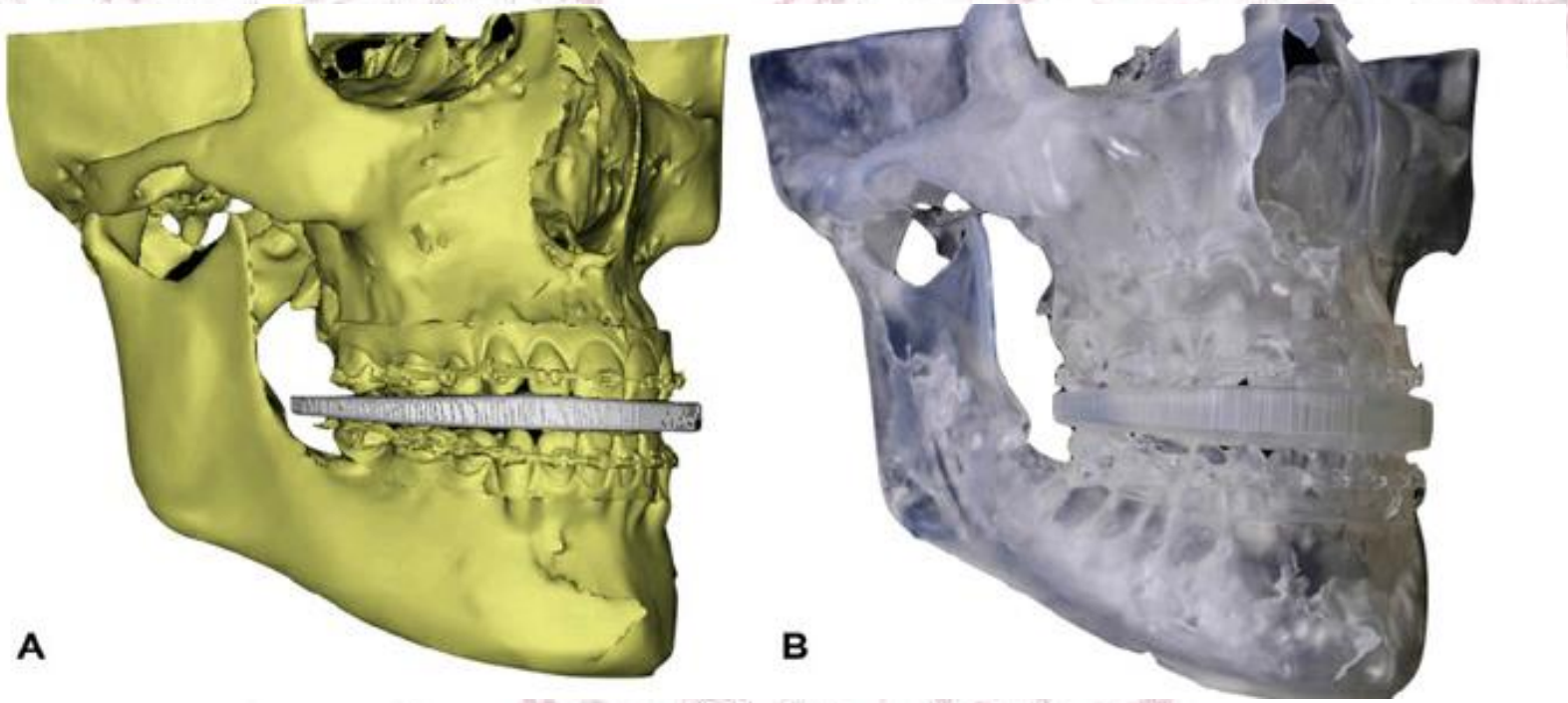
cementoblastoma



3rd molar in max. sinus + sinusitis



Additive Manufacturing for Orthognathic Surgery



Thanks …