

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 sequential projection images in one complete scan around the area of interest

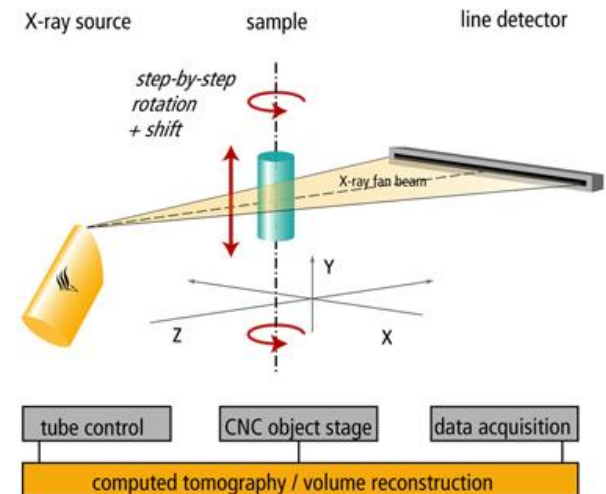
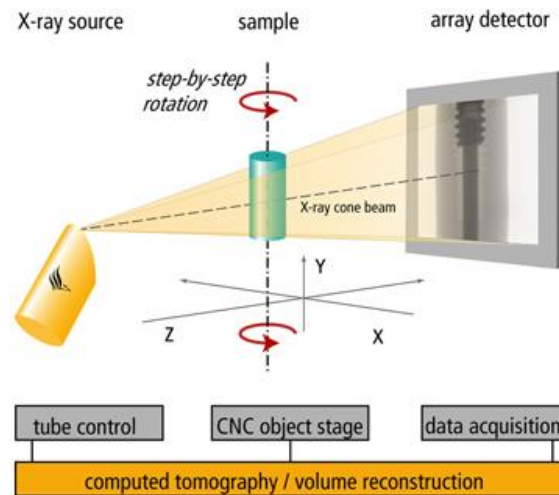
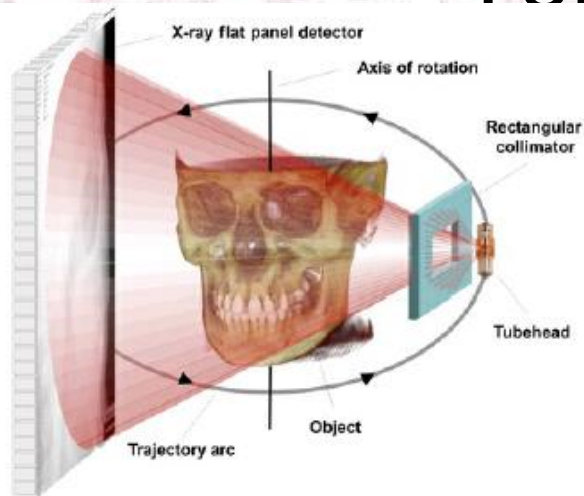


There are three main processes in CBCT imaging:

- image production
- visualization
- interpretation



Principles of Cone Beam Computed Tomographic Imaging



Components of Image Production

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

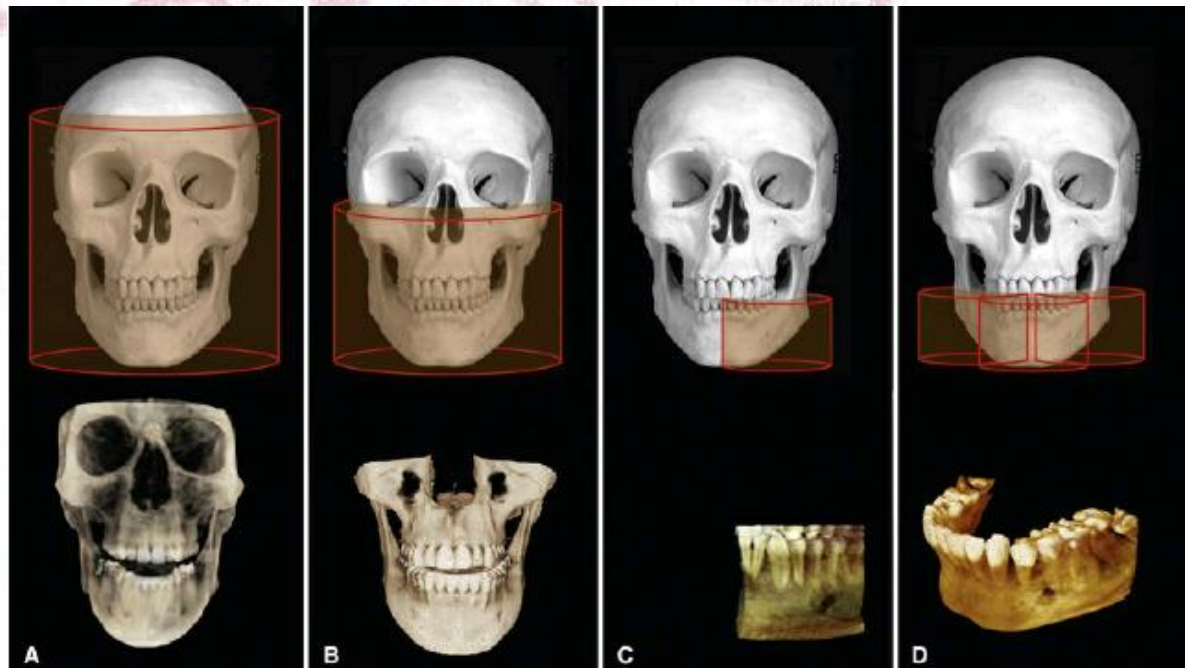


X-ray generation

- 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



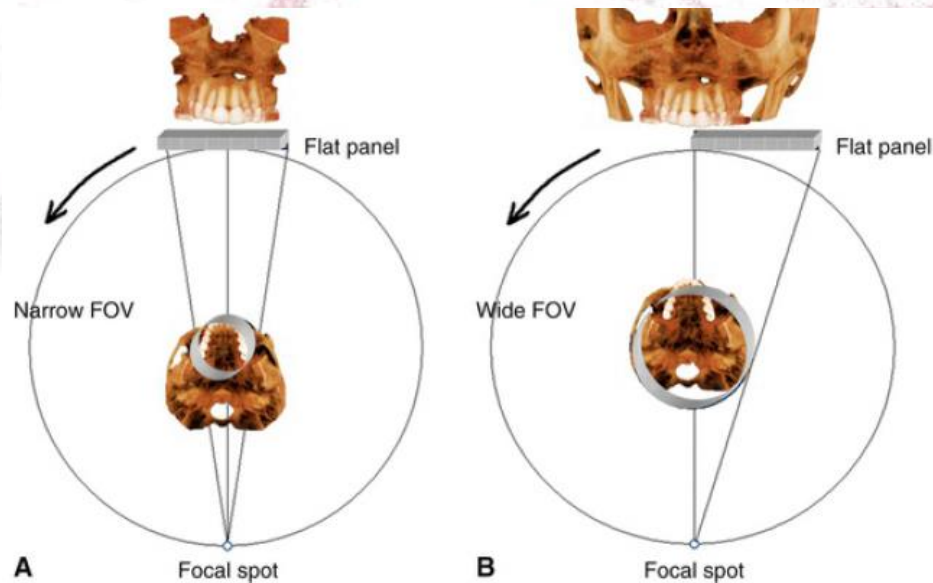
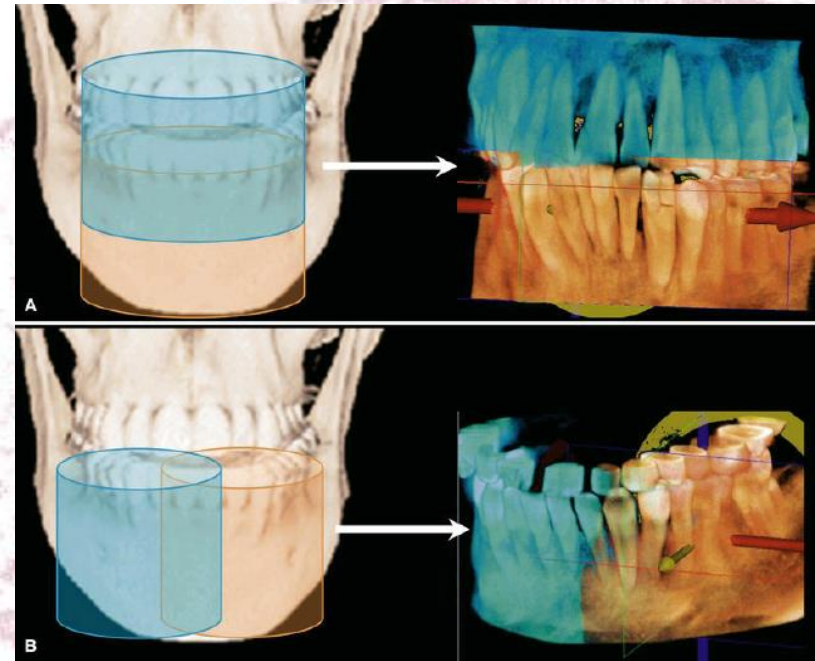
The primary determinants of patient exposure are:

- **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

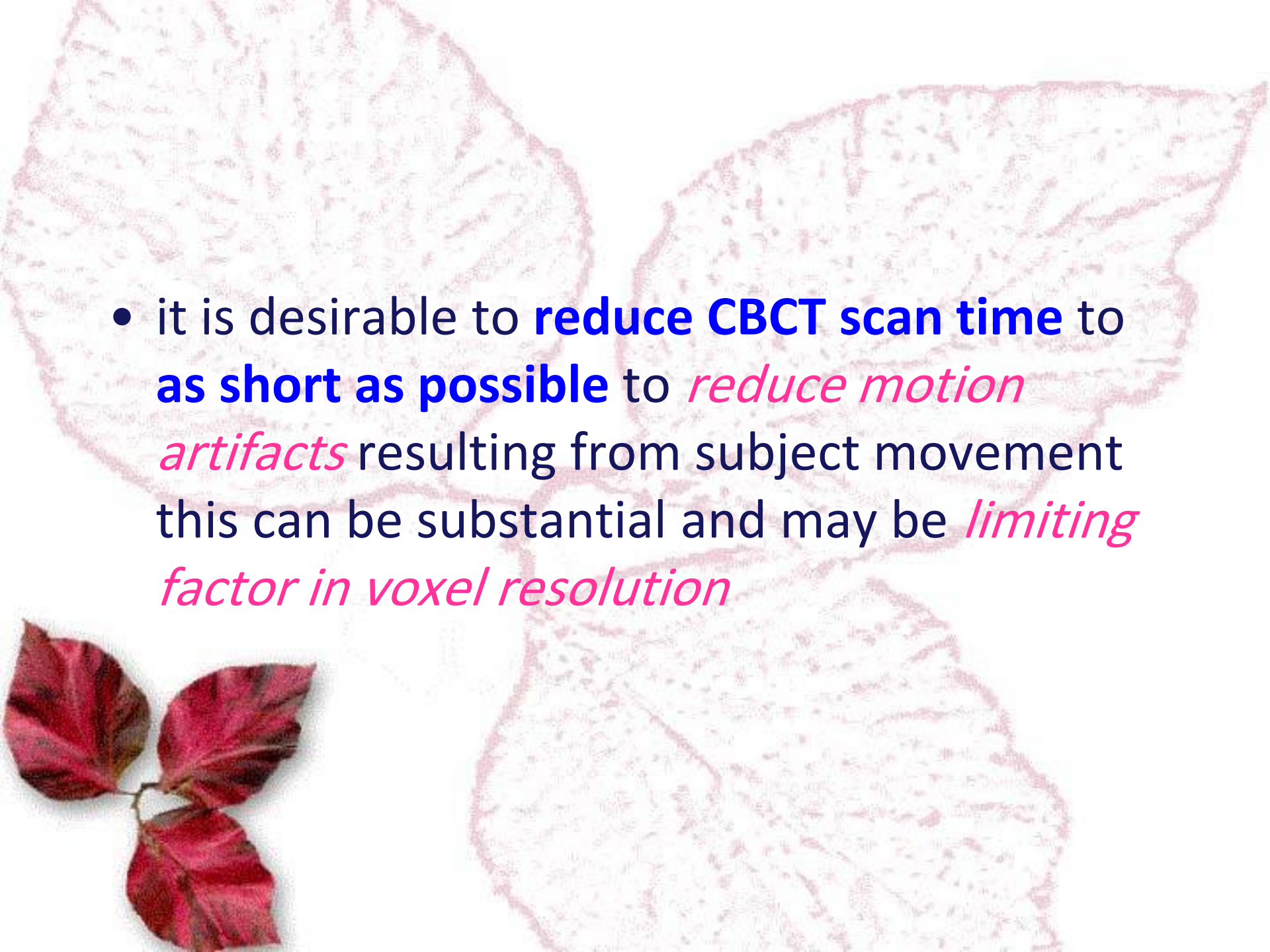
- The speed with which individual images are acquired is called the **frame rate** and is measured in frames ,projected images ,per second.
- The **maximum frame rate of the detector** and **rotational speed** determines the number of projections that may be acquired.
- With a **high frame rate** more 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

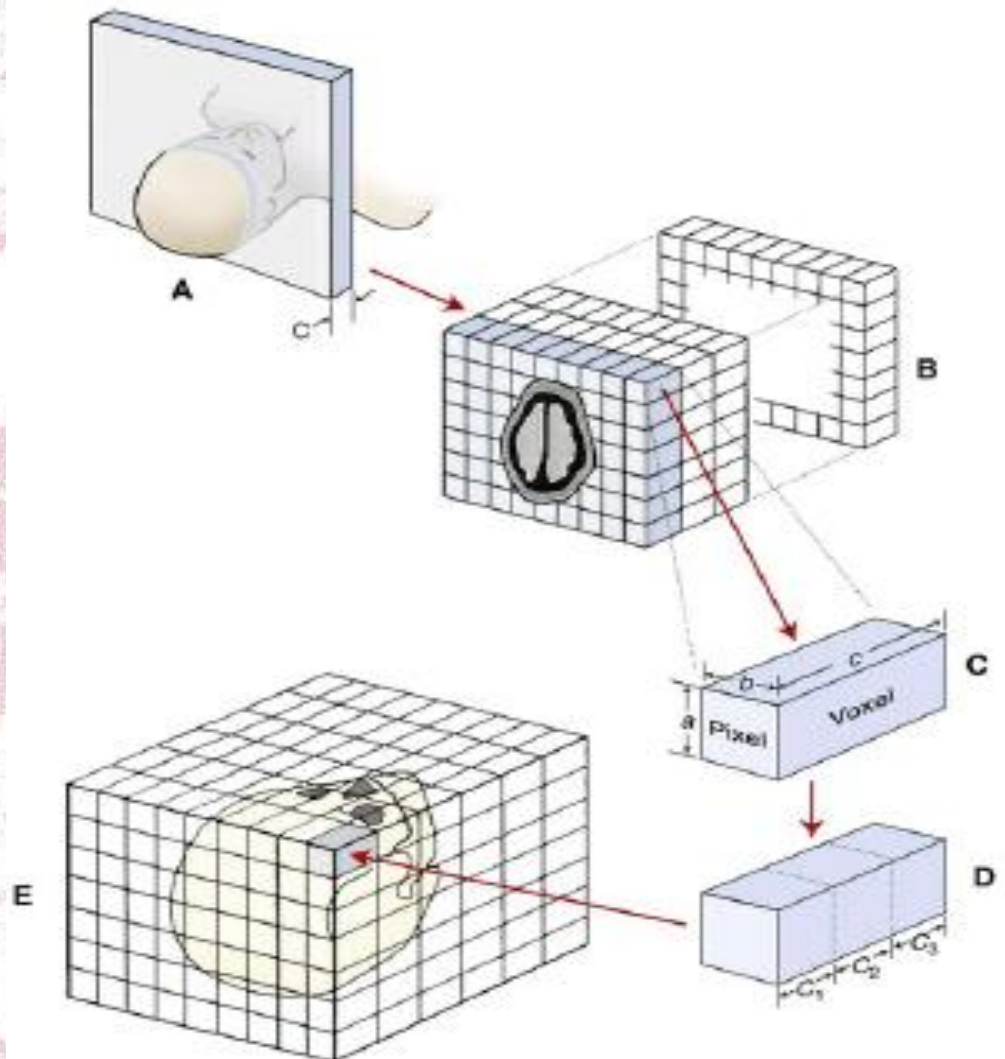
a - image intensifier tube charge-coupled device combination

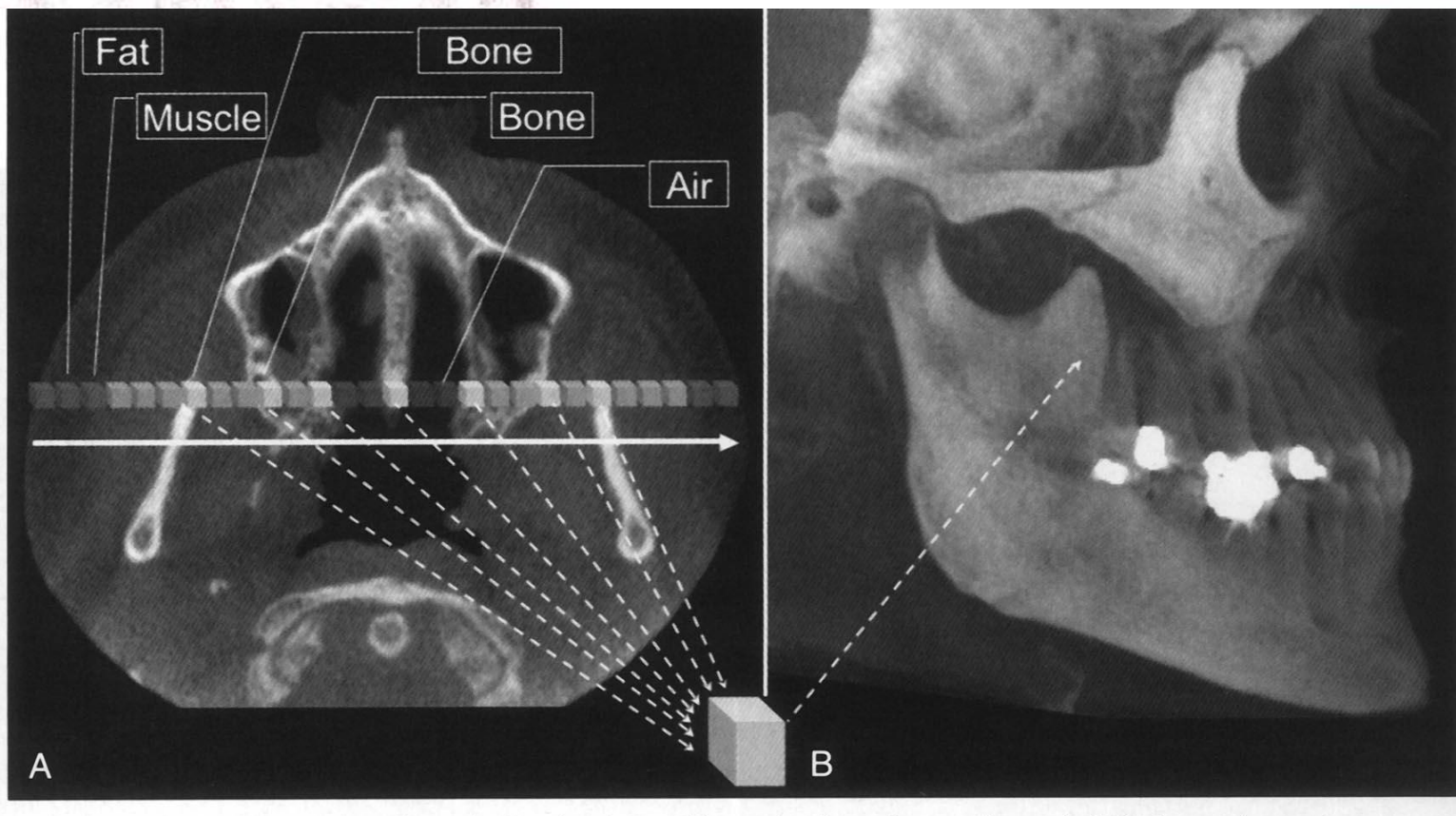
b- flat-panel imager (**commonly use**)



- Voxel Size
isotropic

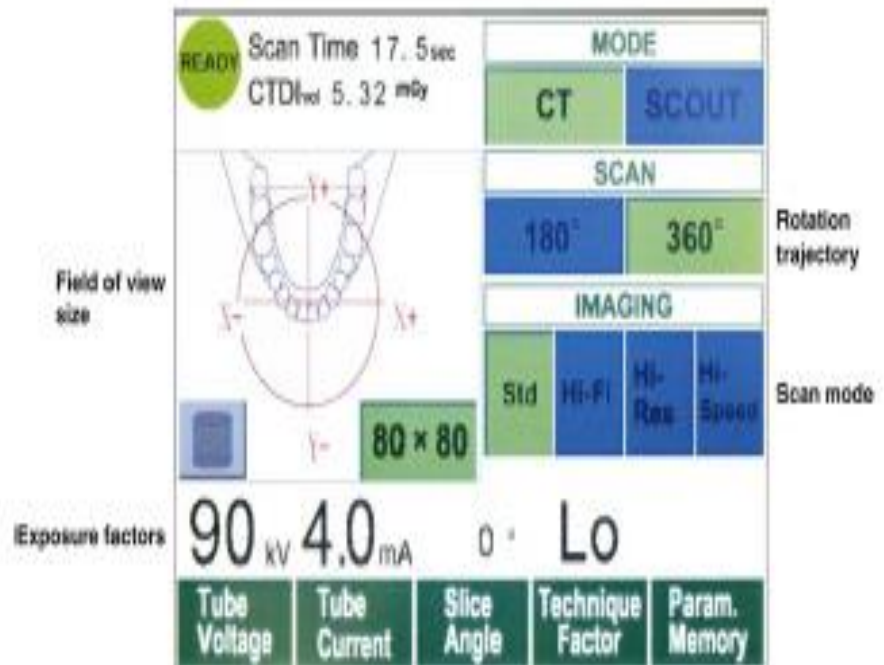
- Grayscale
bit depth





Clinical Considerations

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



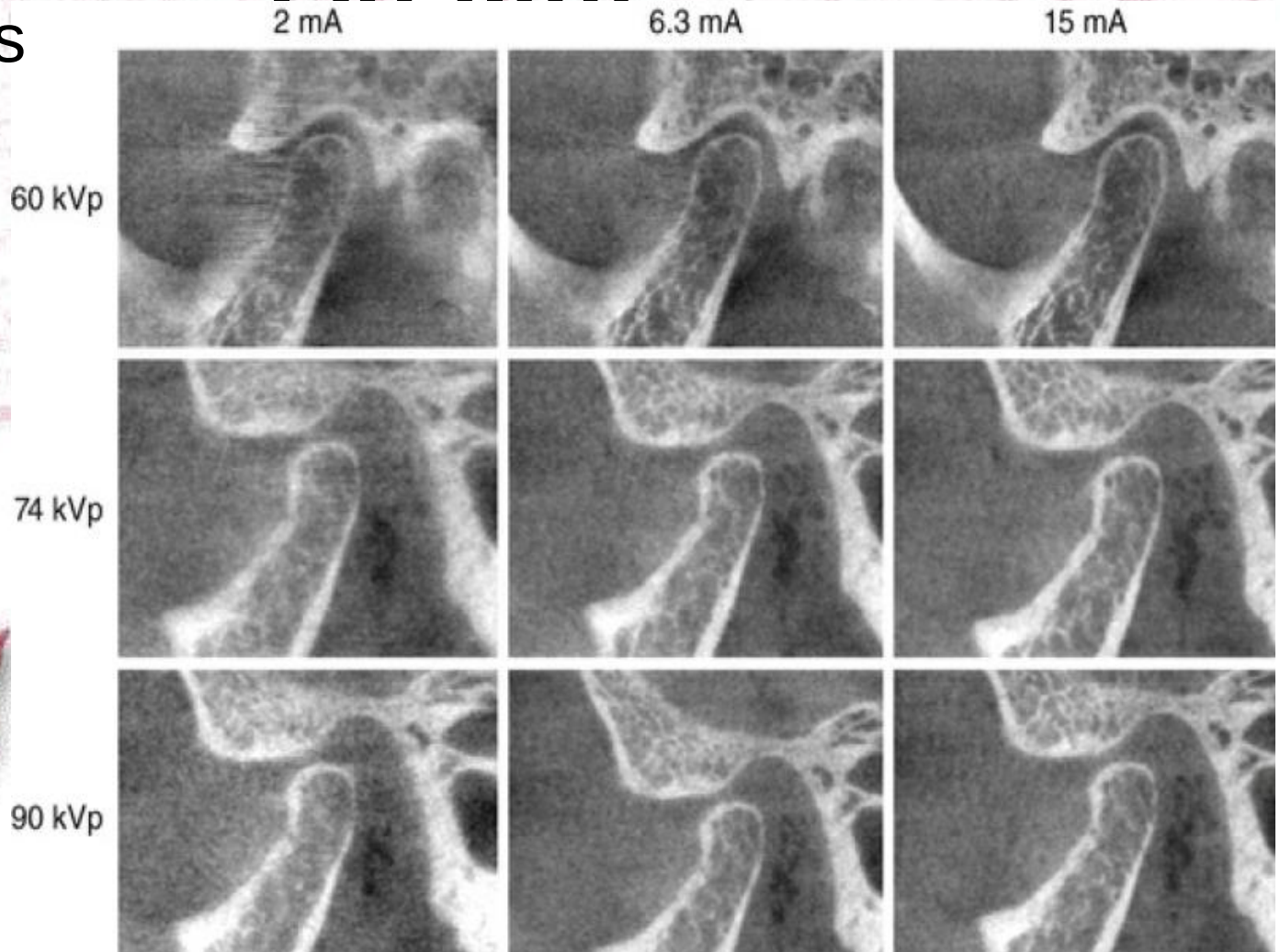
Exposure Parameters

- 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

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



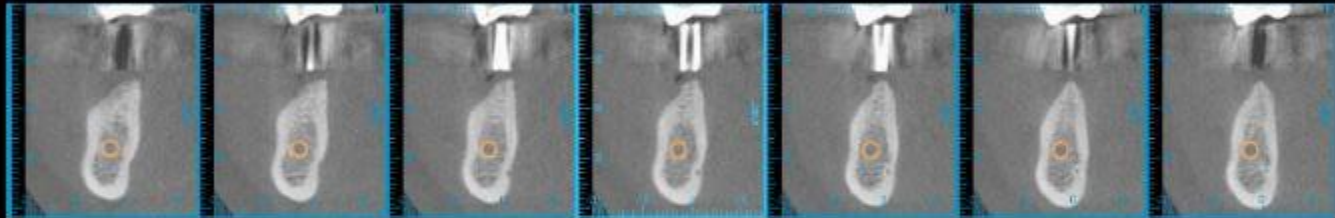
Increase the pixel size reveals to:

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

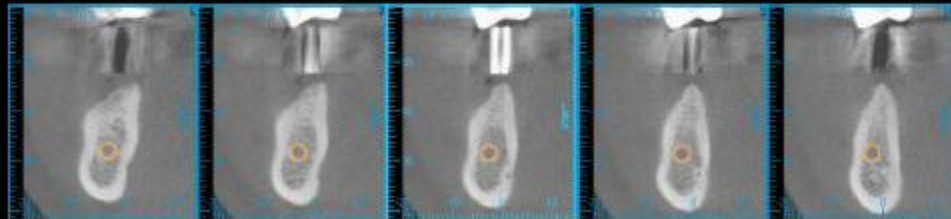




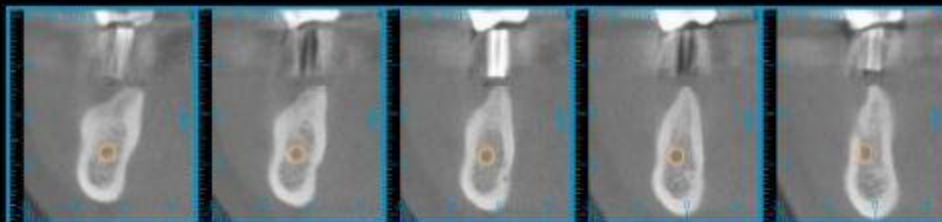
1 mm/1 mm



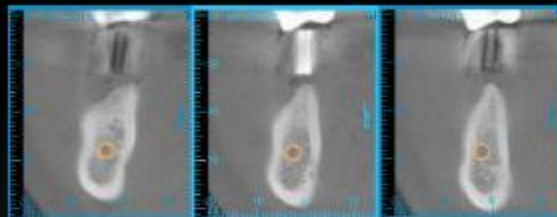
2 mm/2 mm



3 mm/3 mm



4 mm/4 mm



5 mm/5 mm

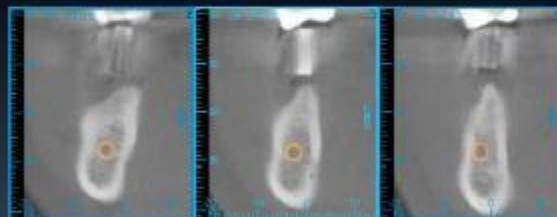


Image Artifacts

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



Inherent Artifacts

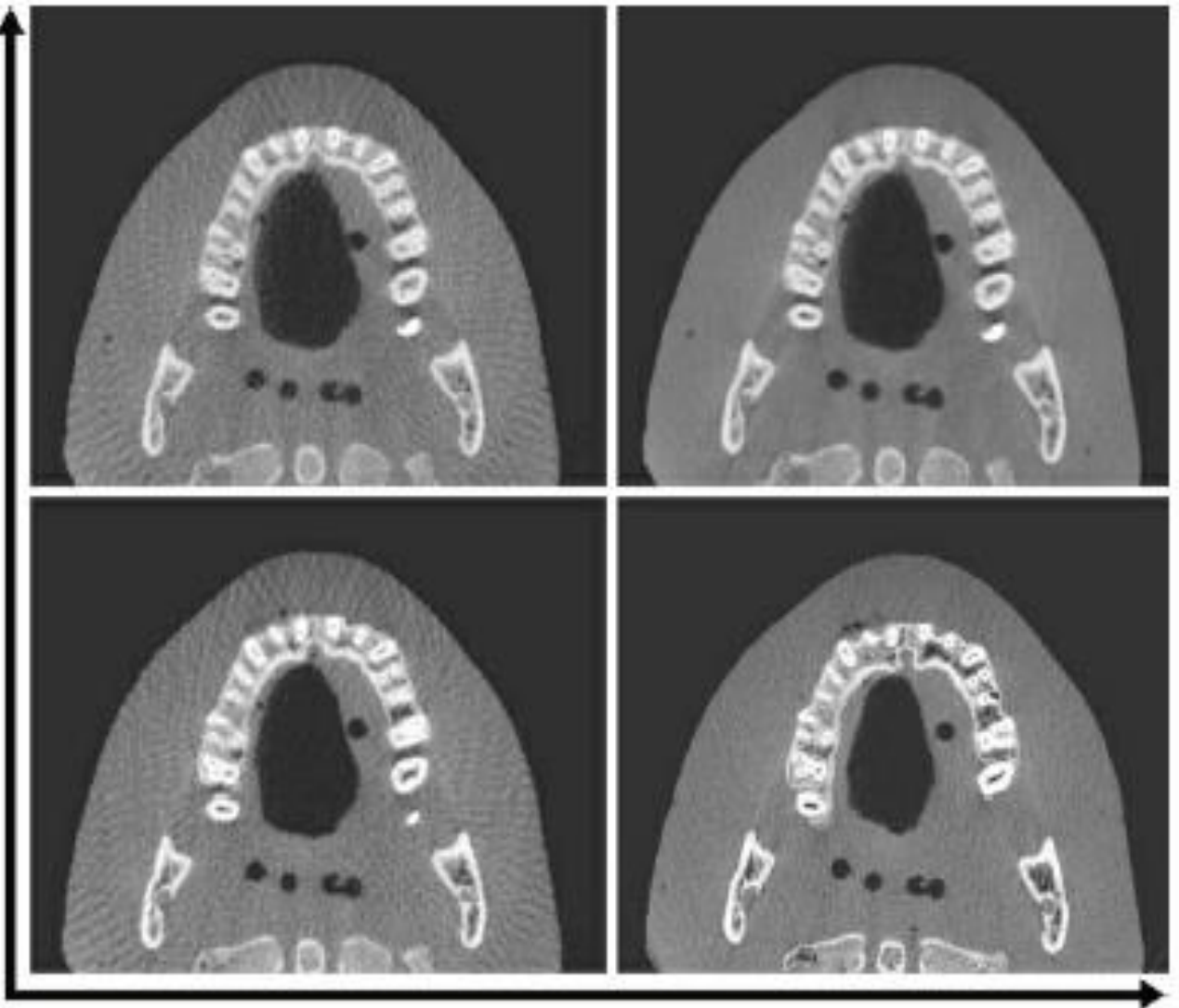
- Scatter → quantum noise + streak
- Partial volume averaging → “step” appearance or homogeneity
- Cone beam effect



streak



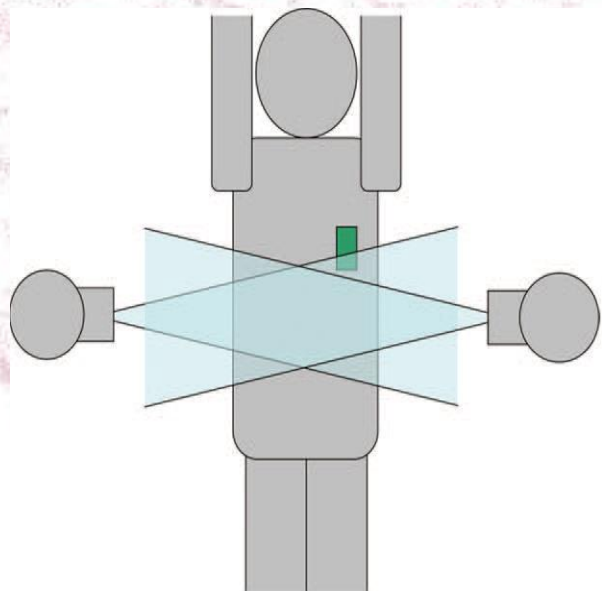
Field of view



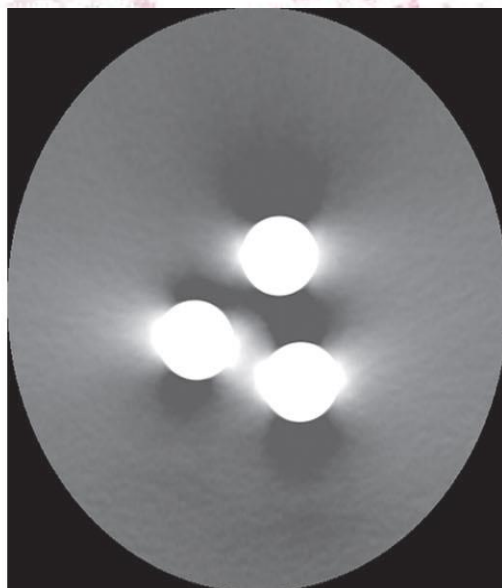
quantum noise



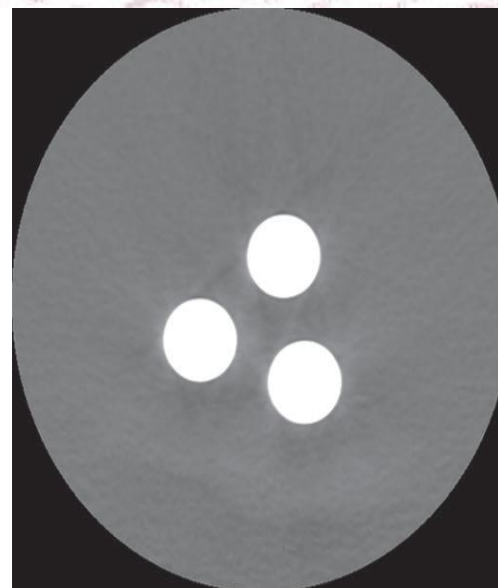
PVA



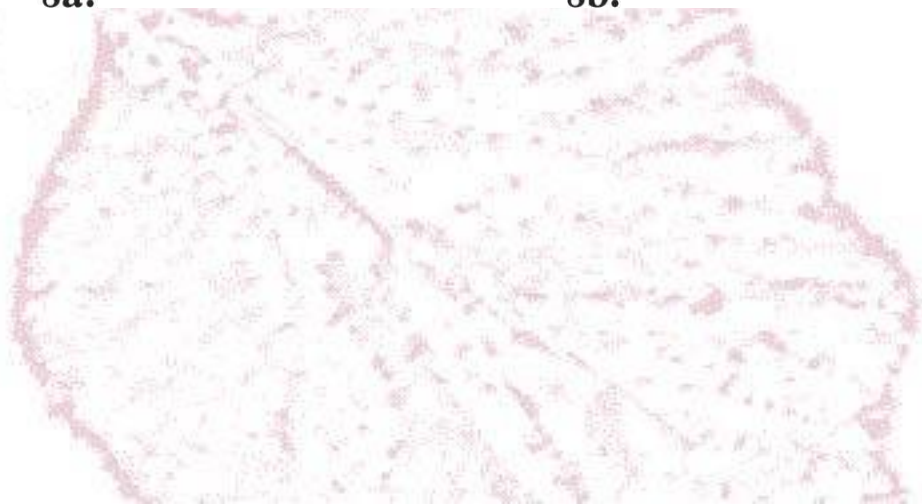
7.



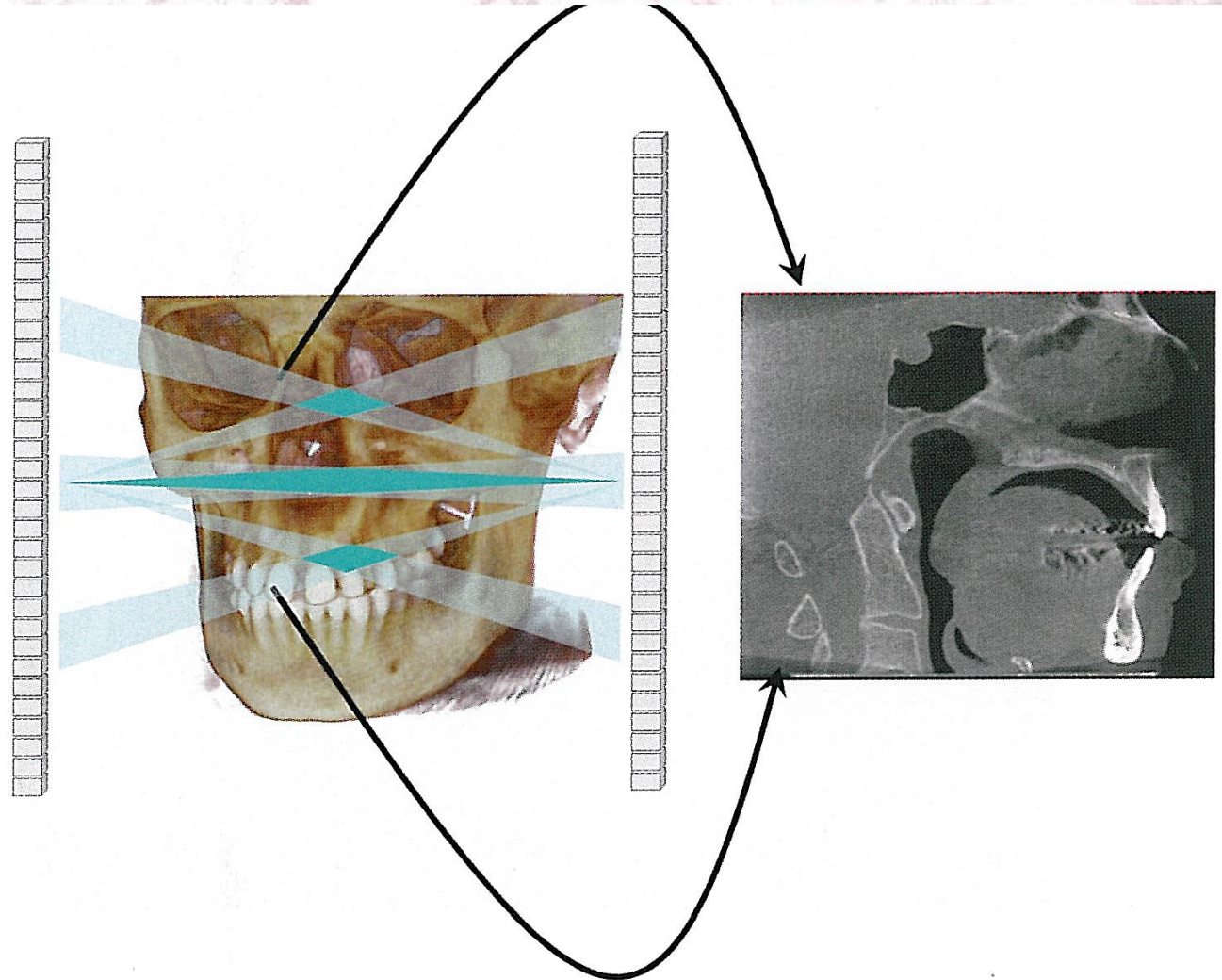
8a.



8b.

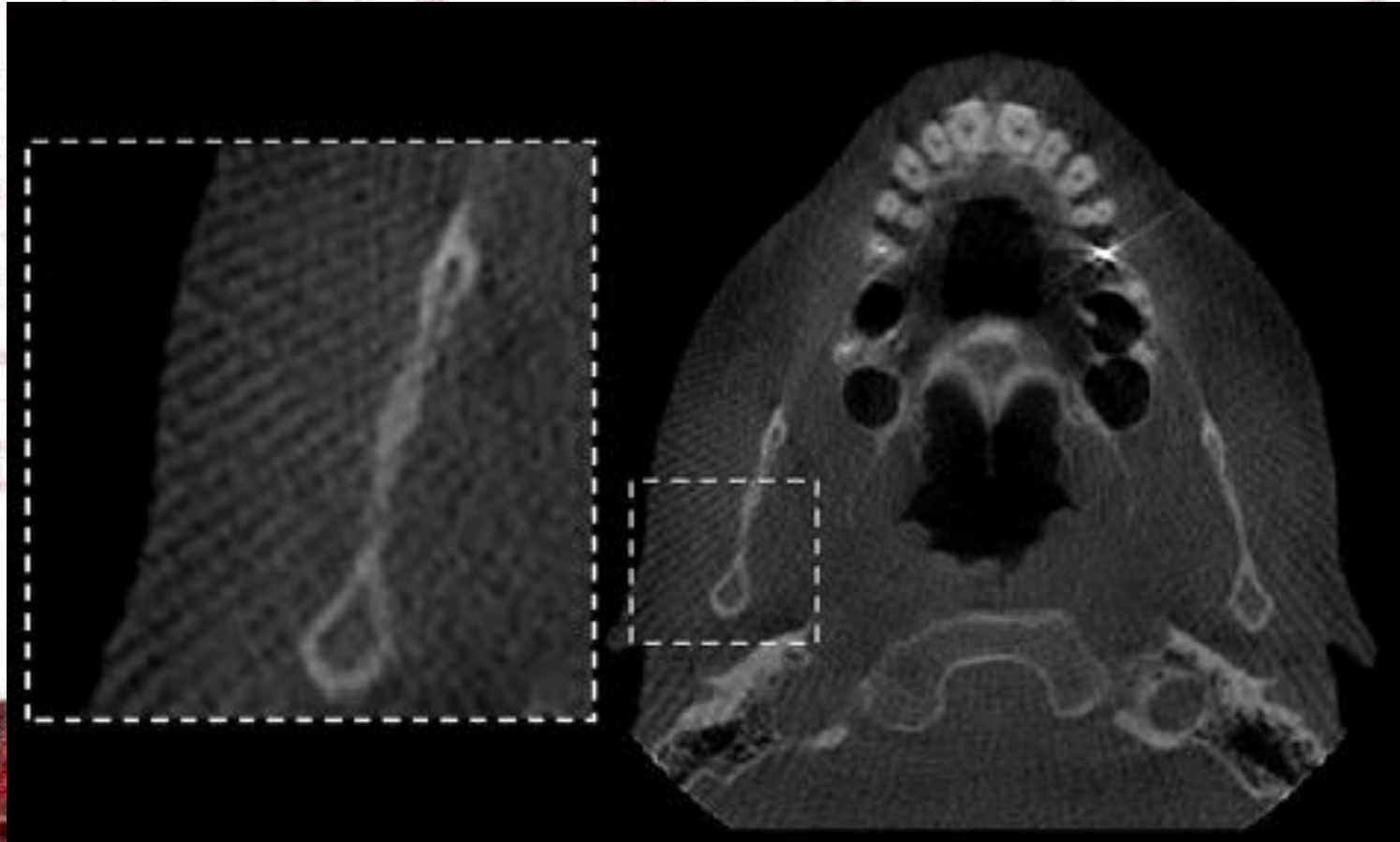


Cone beam effect



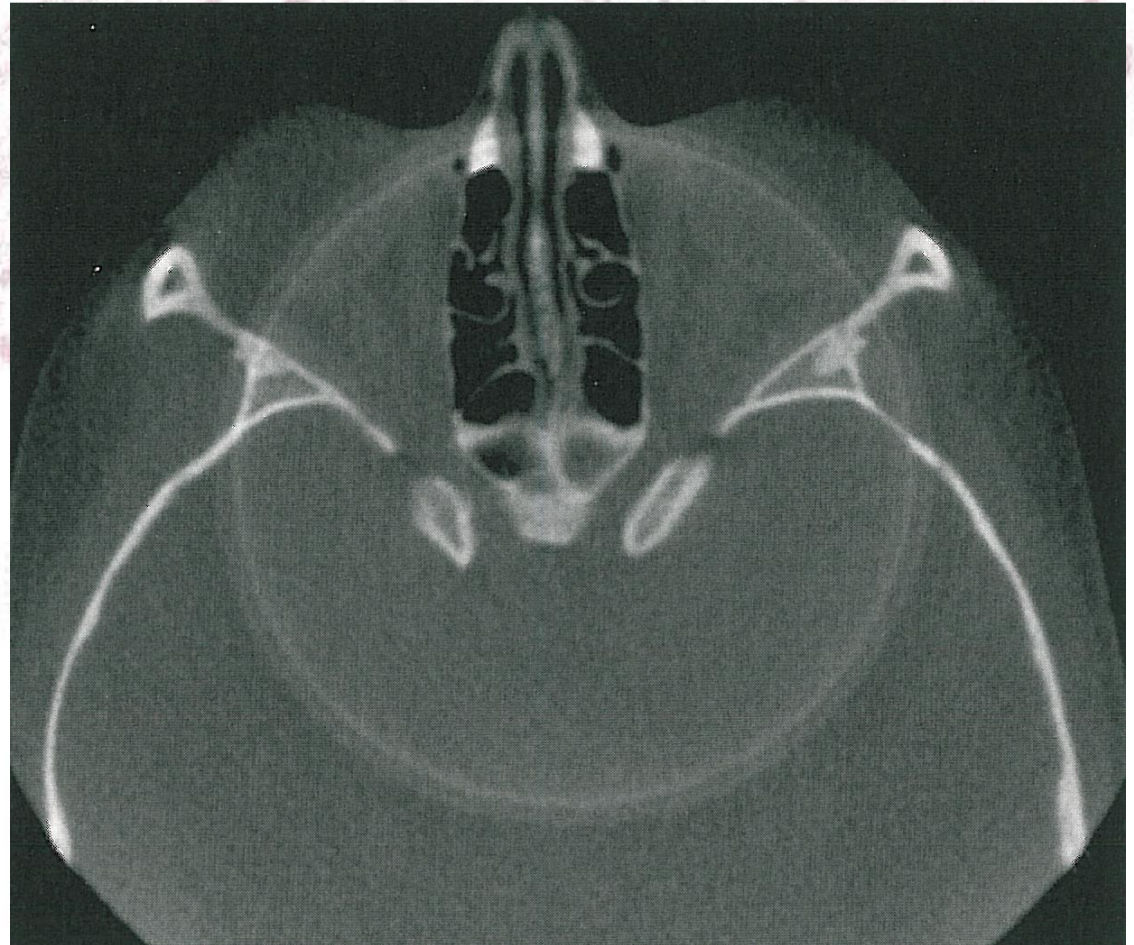
Procedure-Related Artifacts

Aliasing artifact → Moiré Artifact



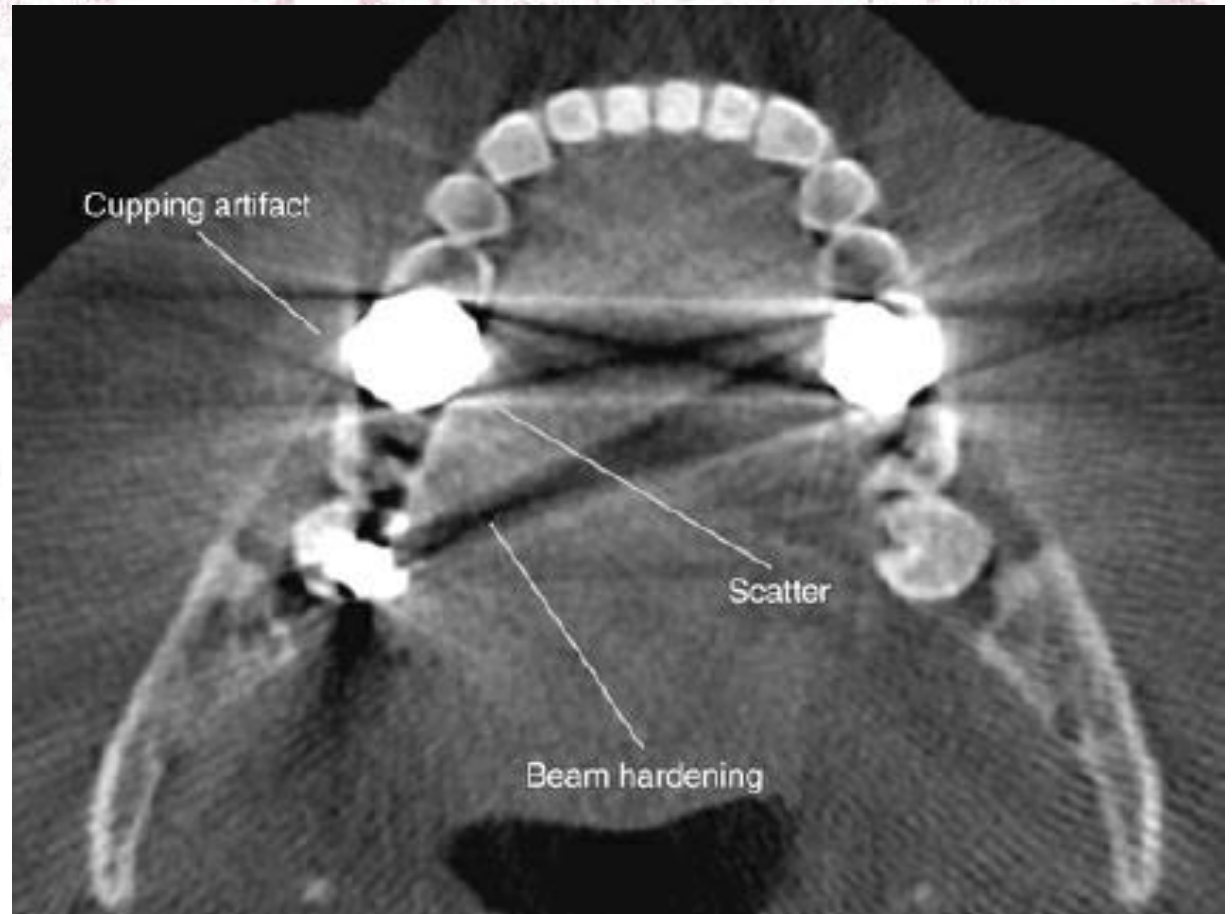
Procedure-Related Artifacts

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

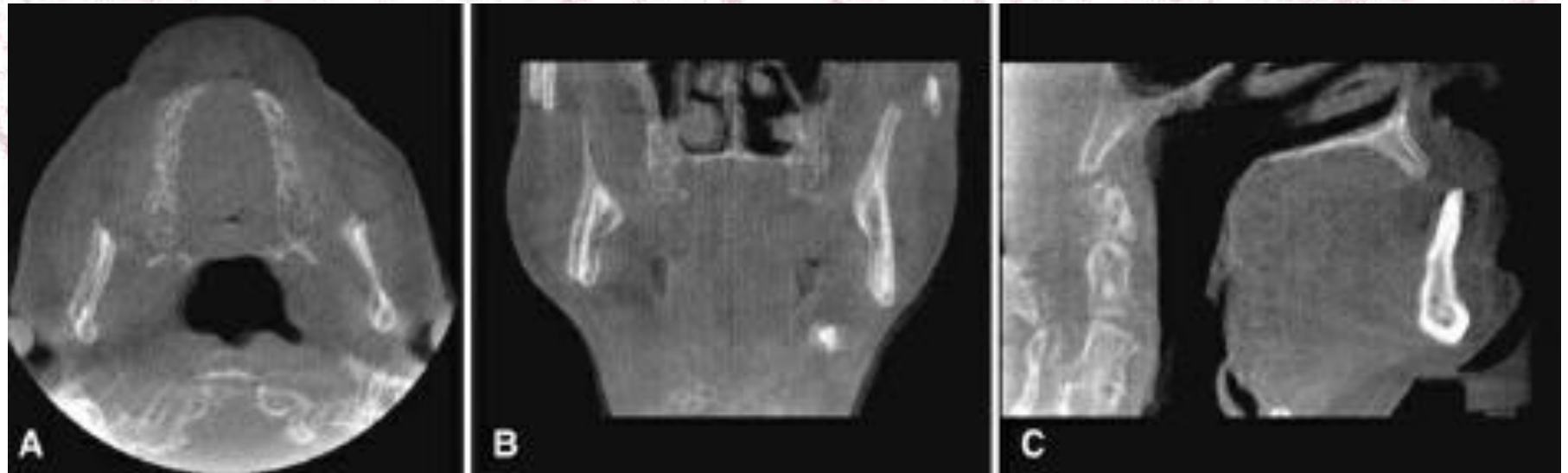


Introduced Artifacts

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

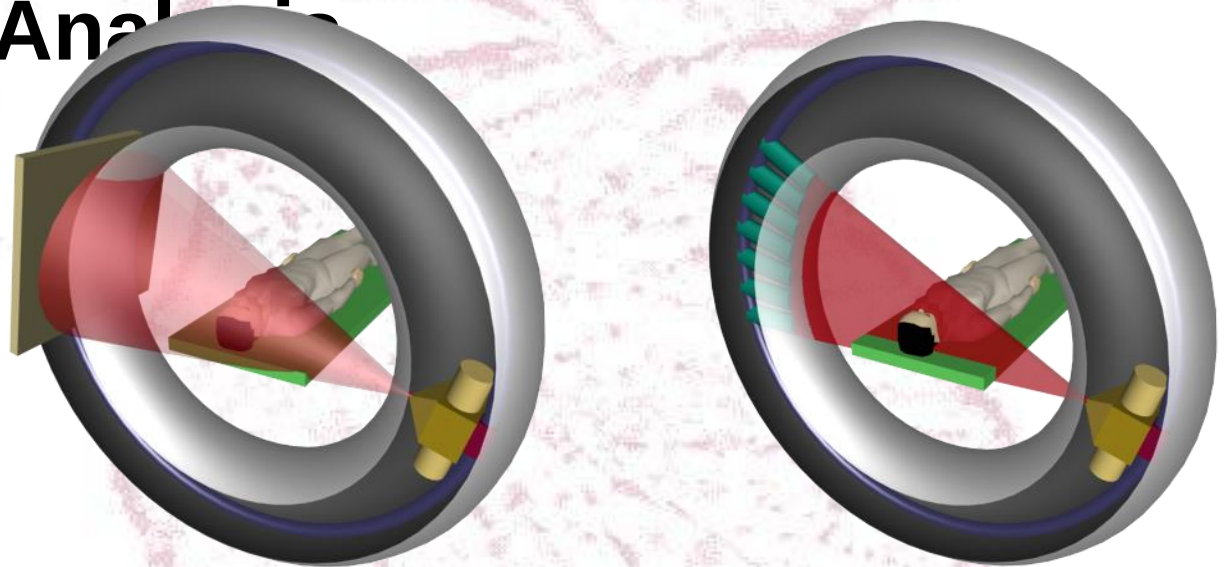


Patient Motion Artifacts



Strengths of cbct

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



Limitations

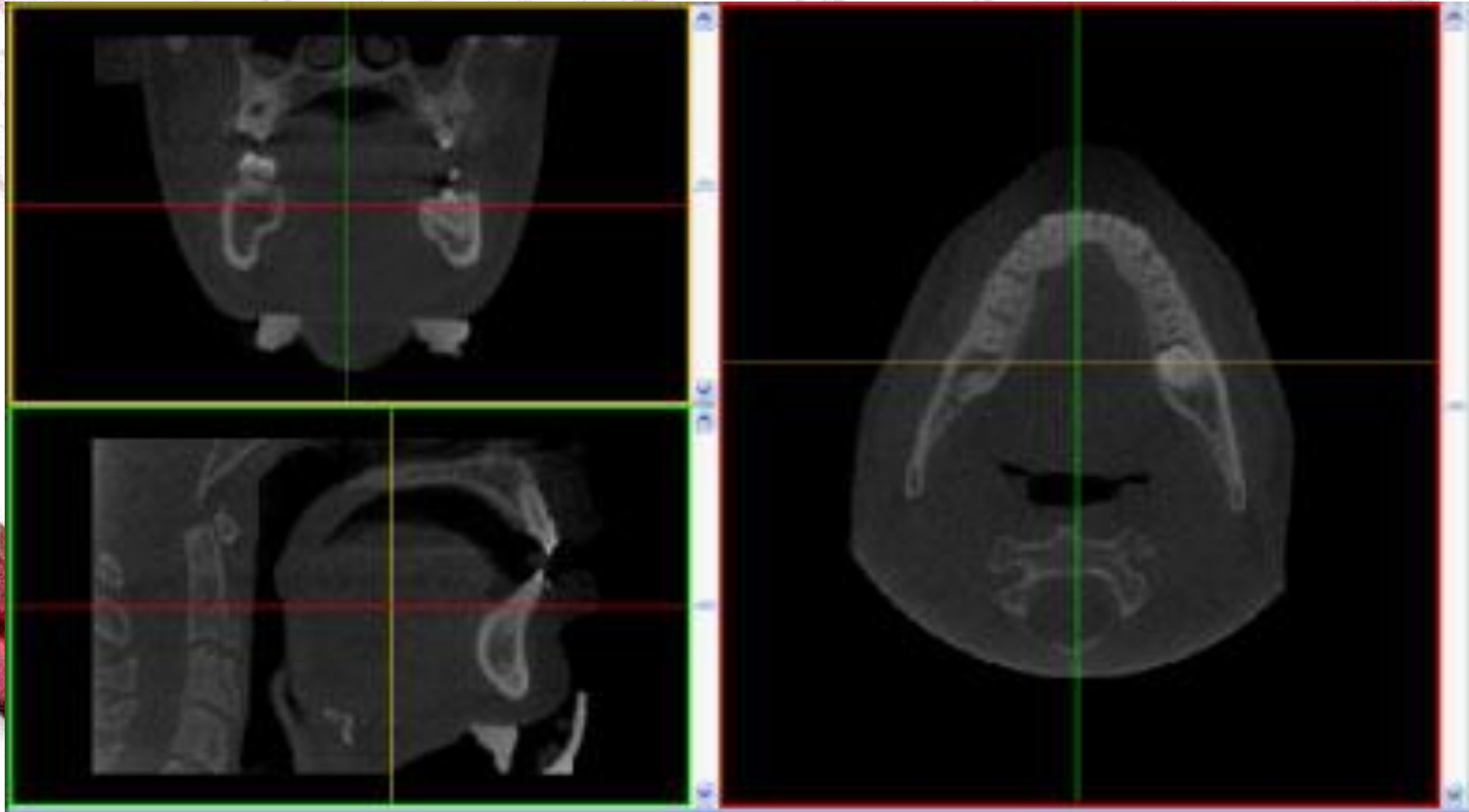
- **Image Noise**
- **Poor Soft Tissue Contrast**

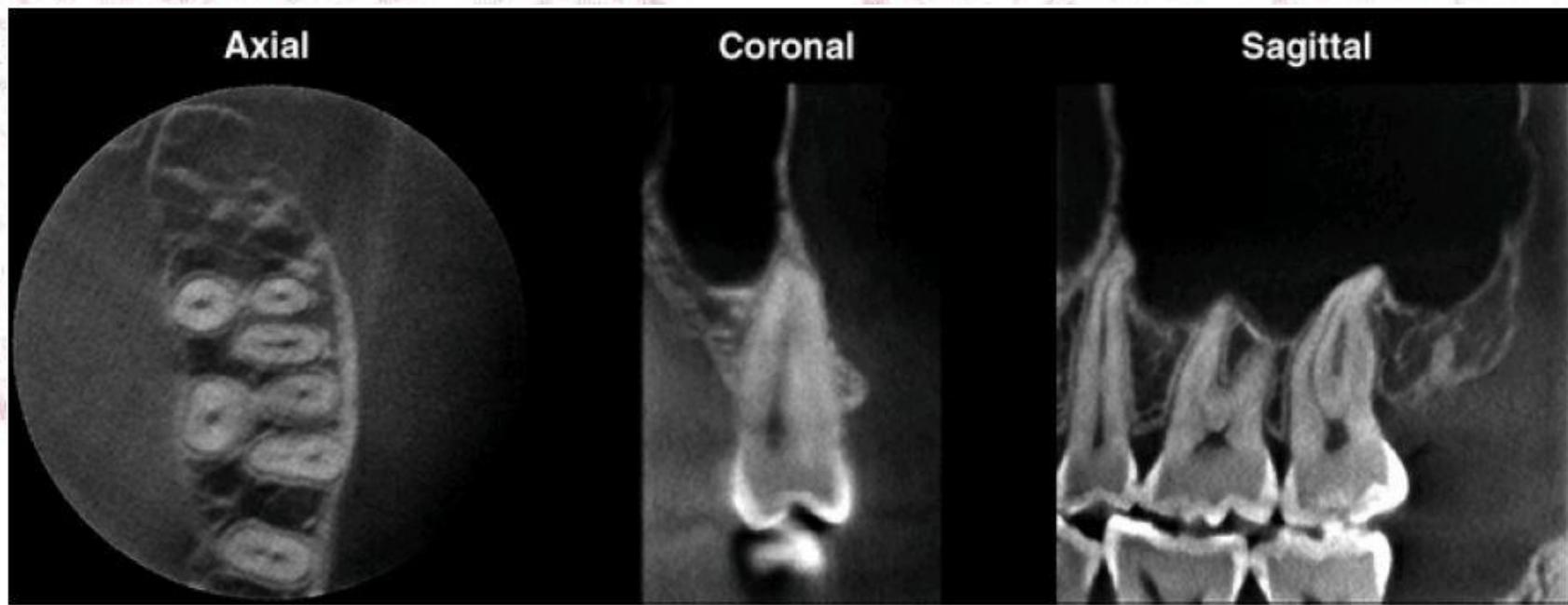


Task-Specific Applications

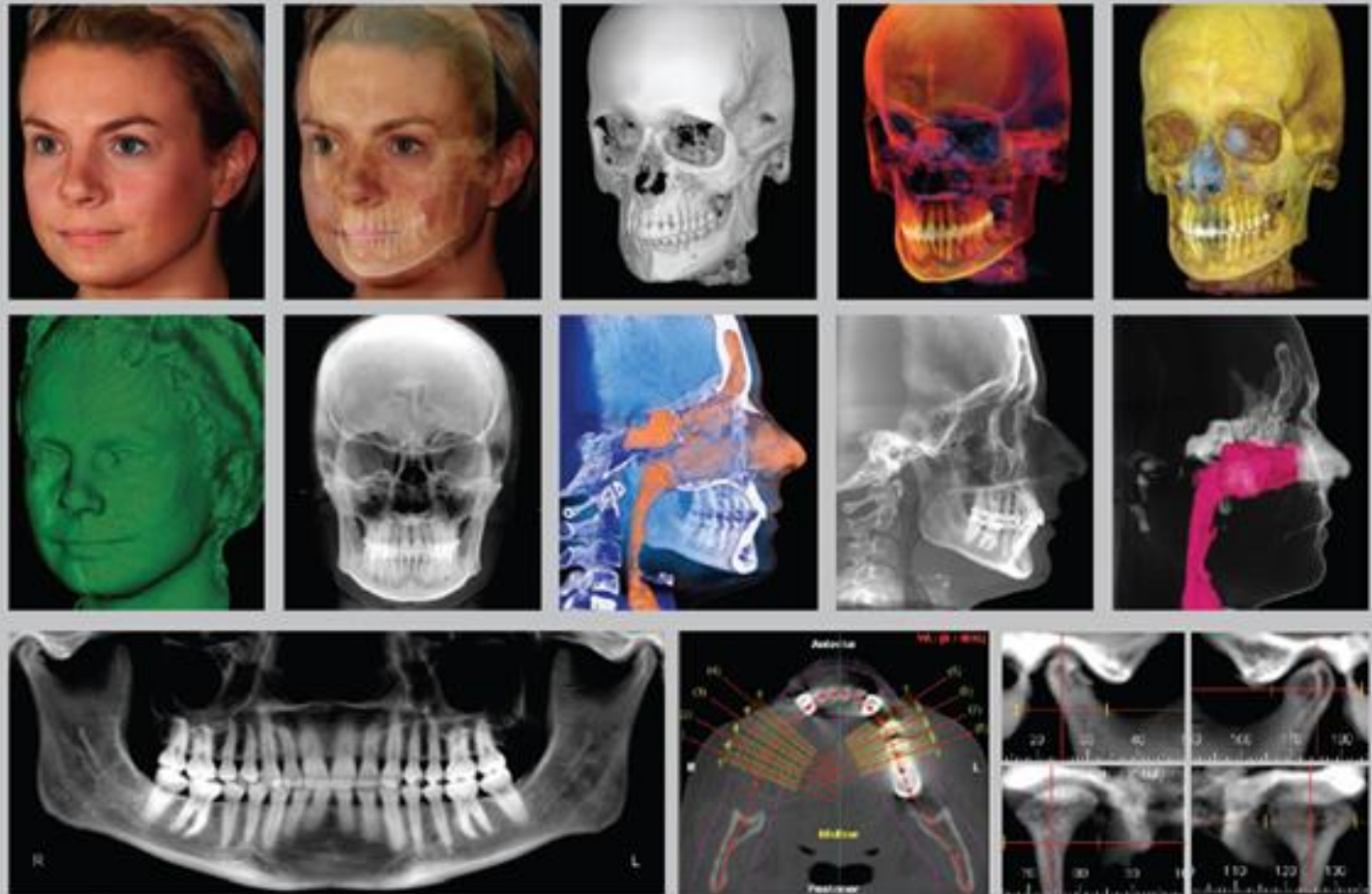
- **Implant Site Assessment**
- **Endodontics**
- **Orthodontics and Three-Dimensional Cephalometry**
- **Mandibular Third Molar Position**
- **Temporomandibular Joint**
- **Maxillofacial Pathoses**
- **Treatment Planning and Virtual Simulations**
- **Image-Guided Surgery and Additive Manufacturing**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

Image reconstruction in axial, sagittal and coronal plane

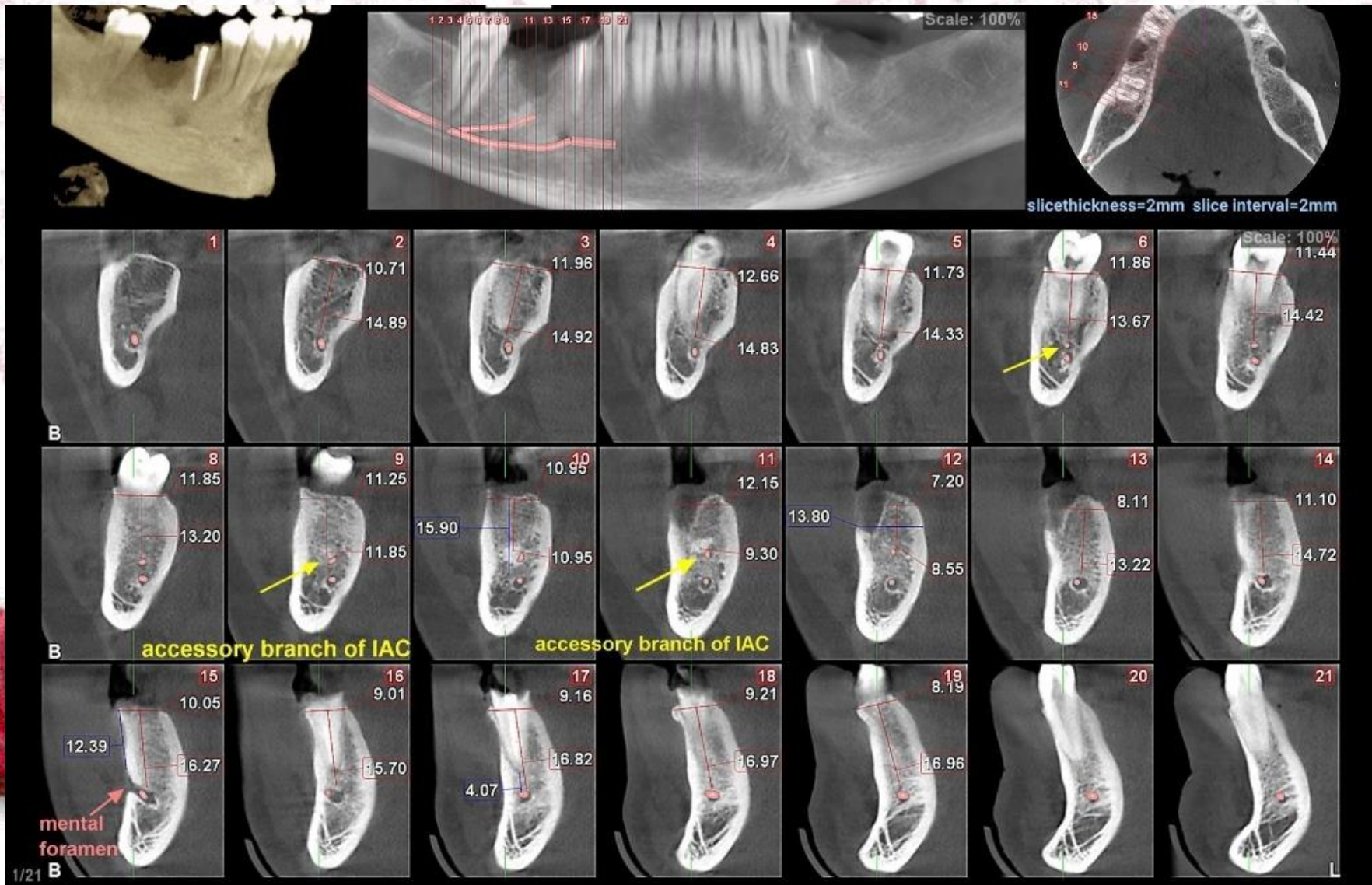


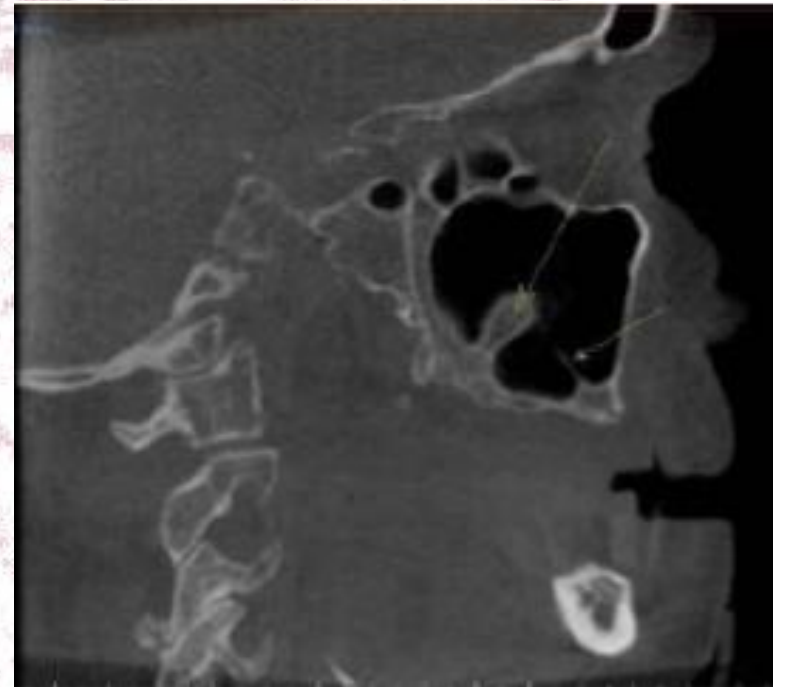
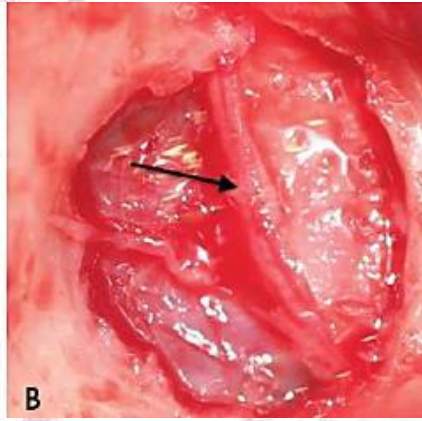
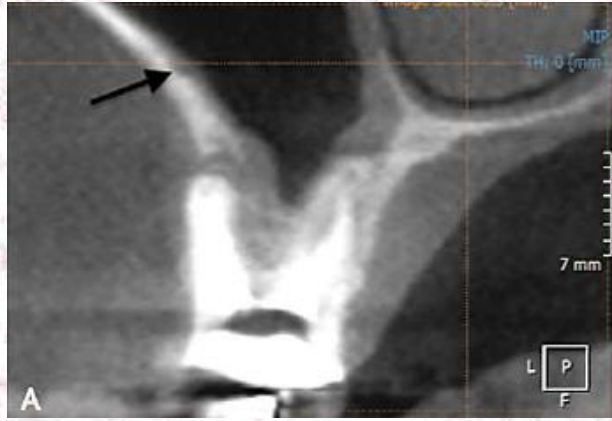


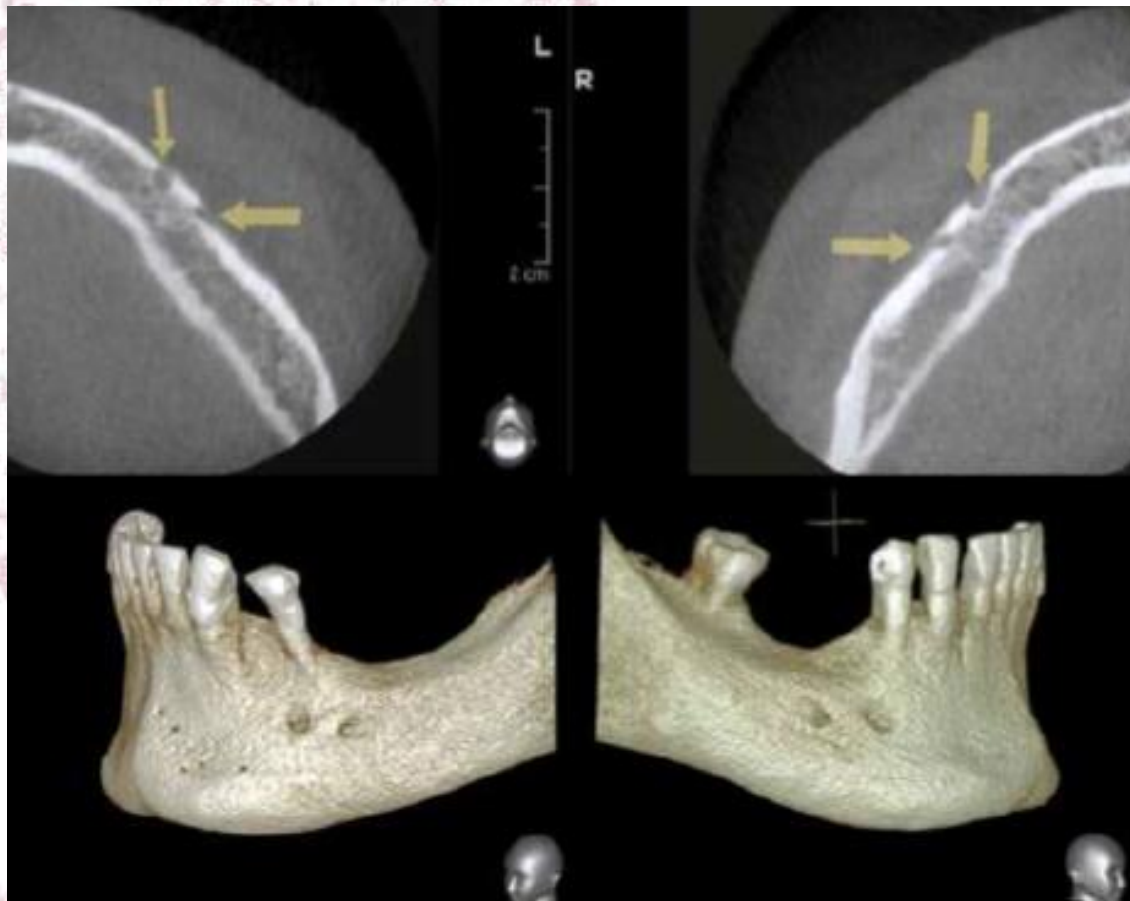
3D and airway analysis



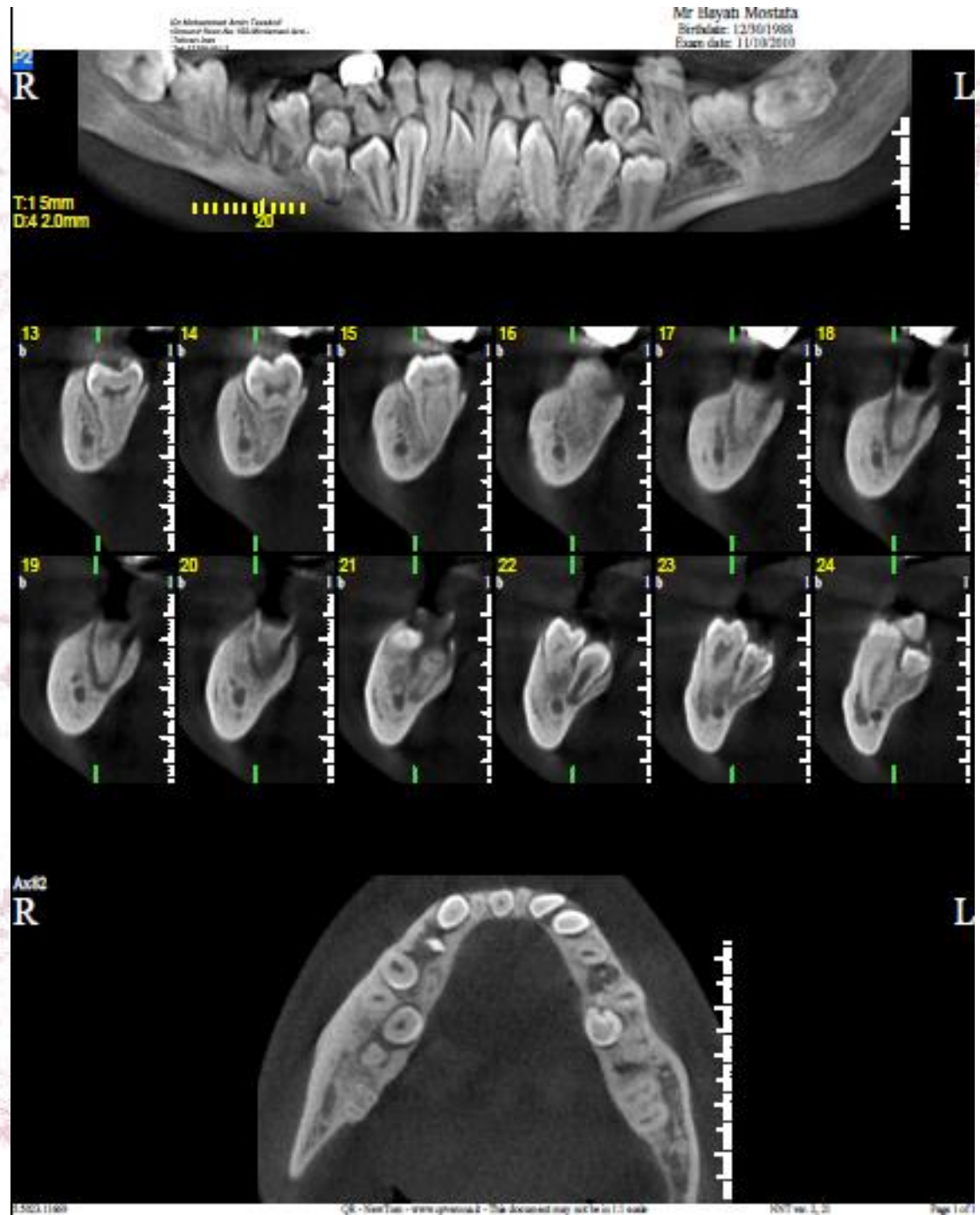
• Implant Site Assessment



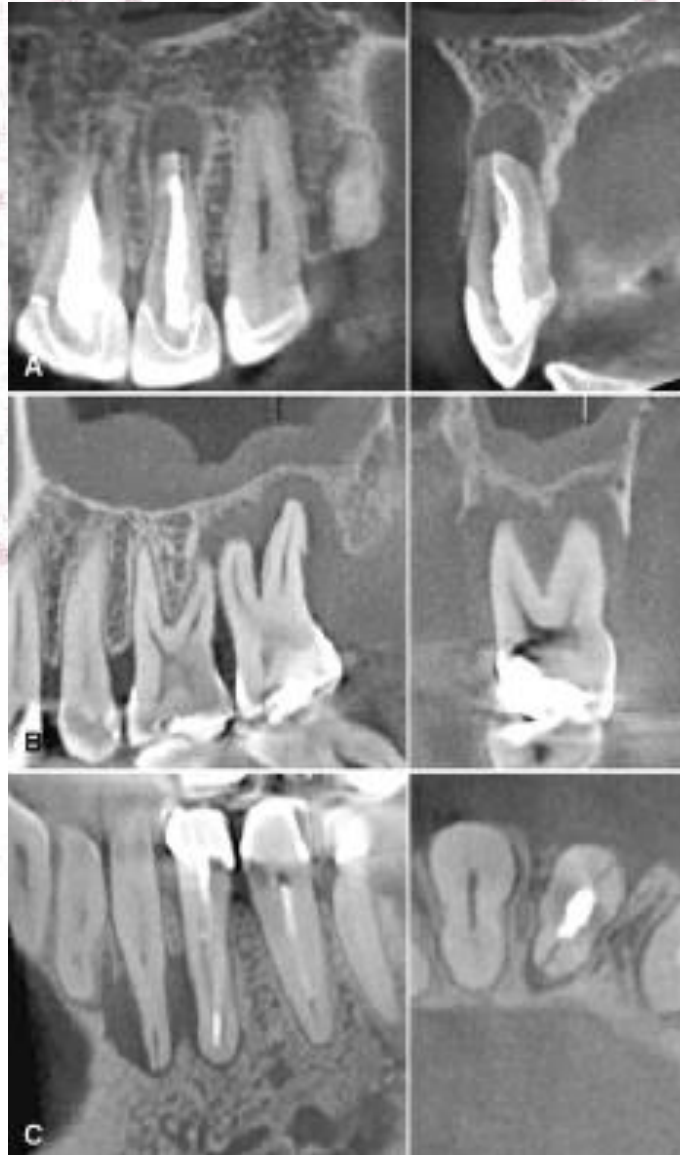


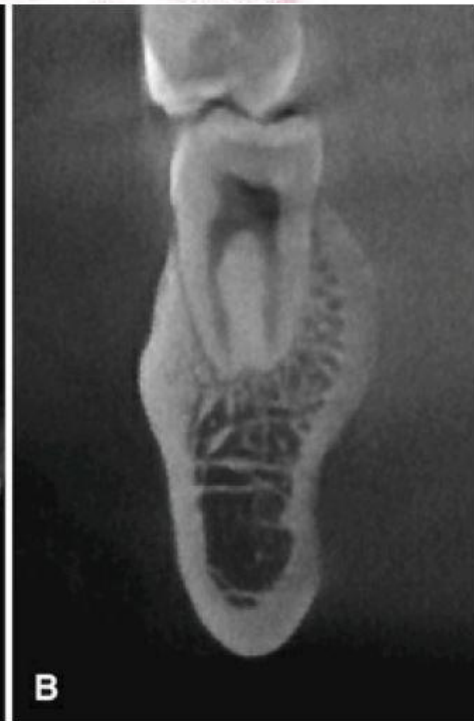
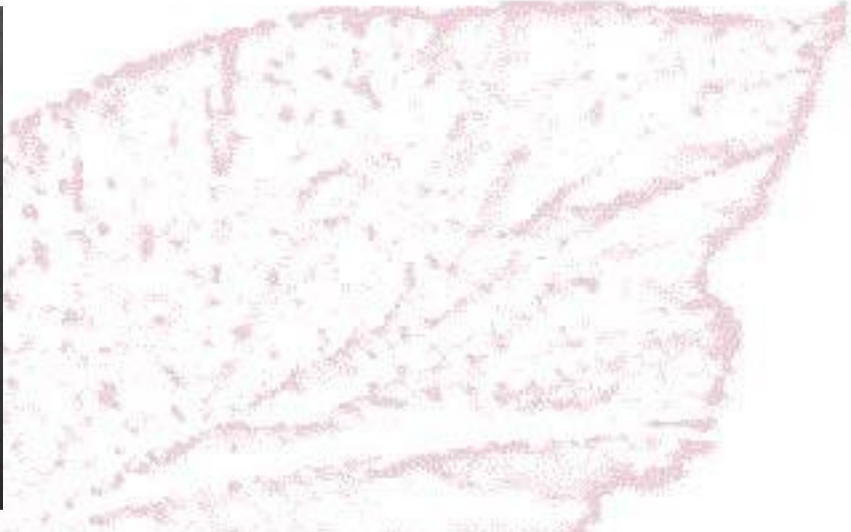
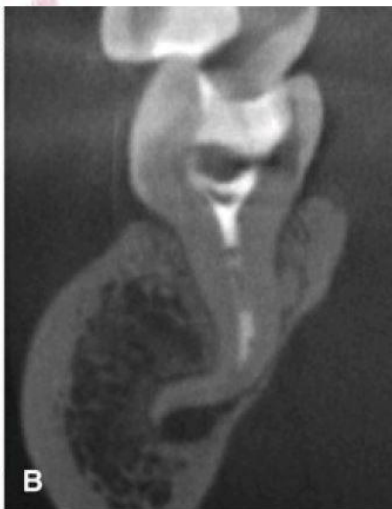


- Unerupted permanent teeth

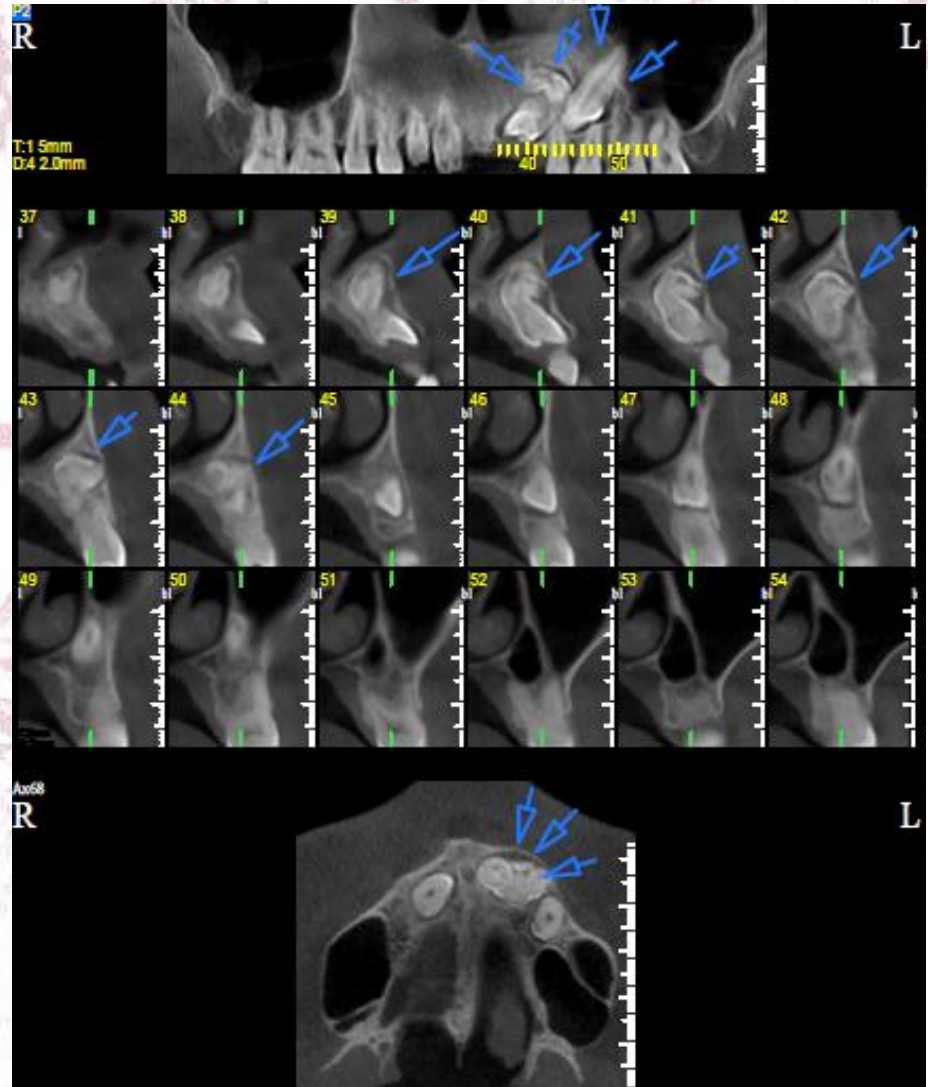


Endodontics

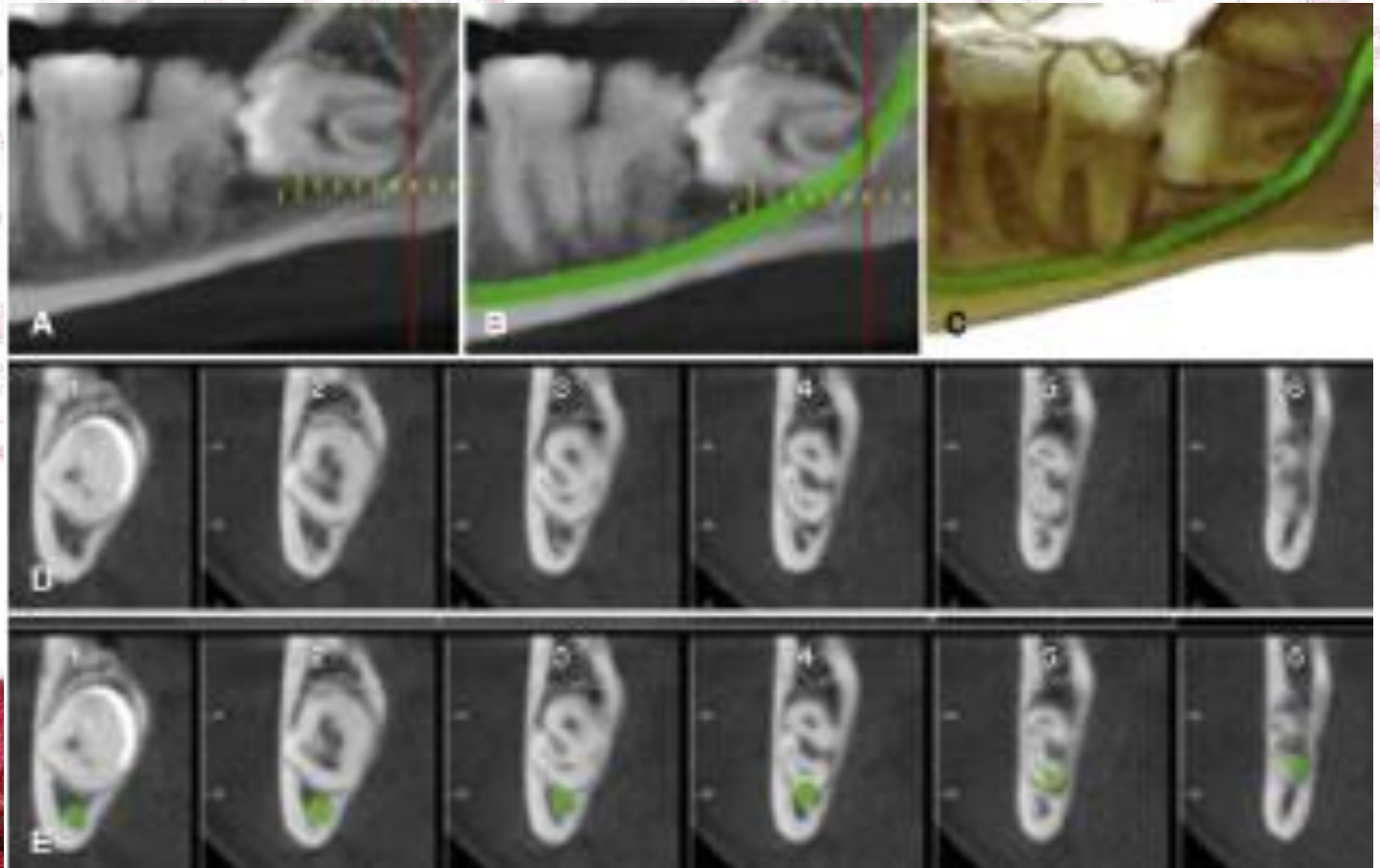


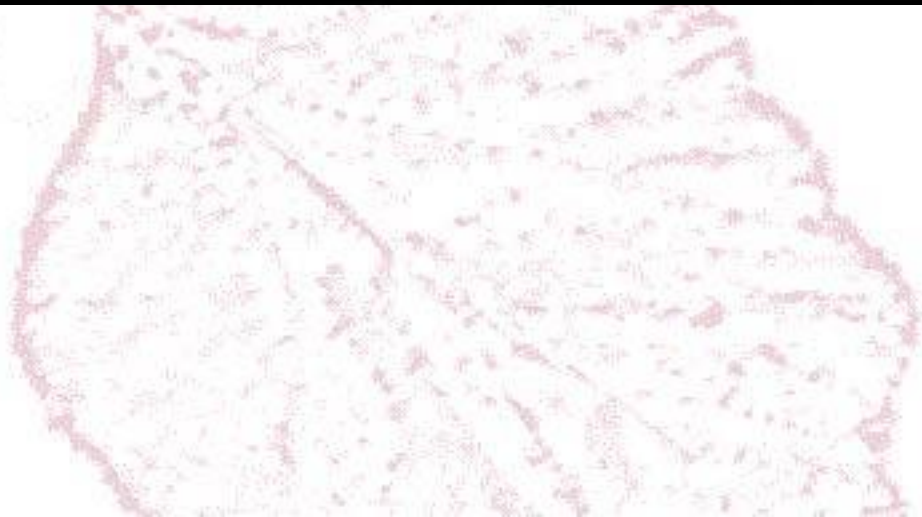
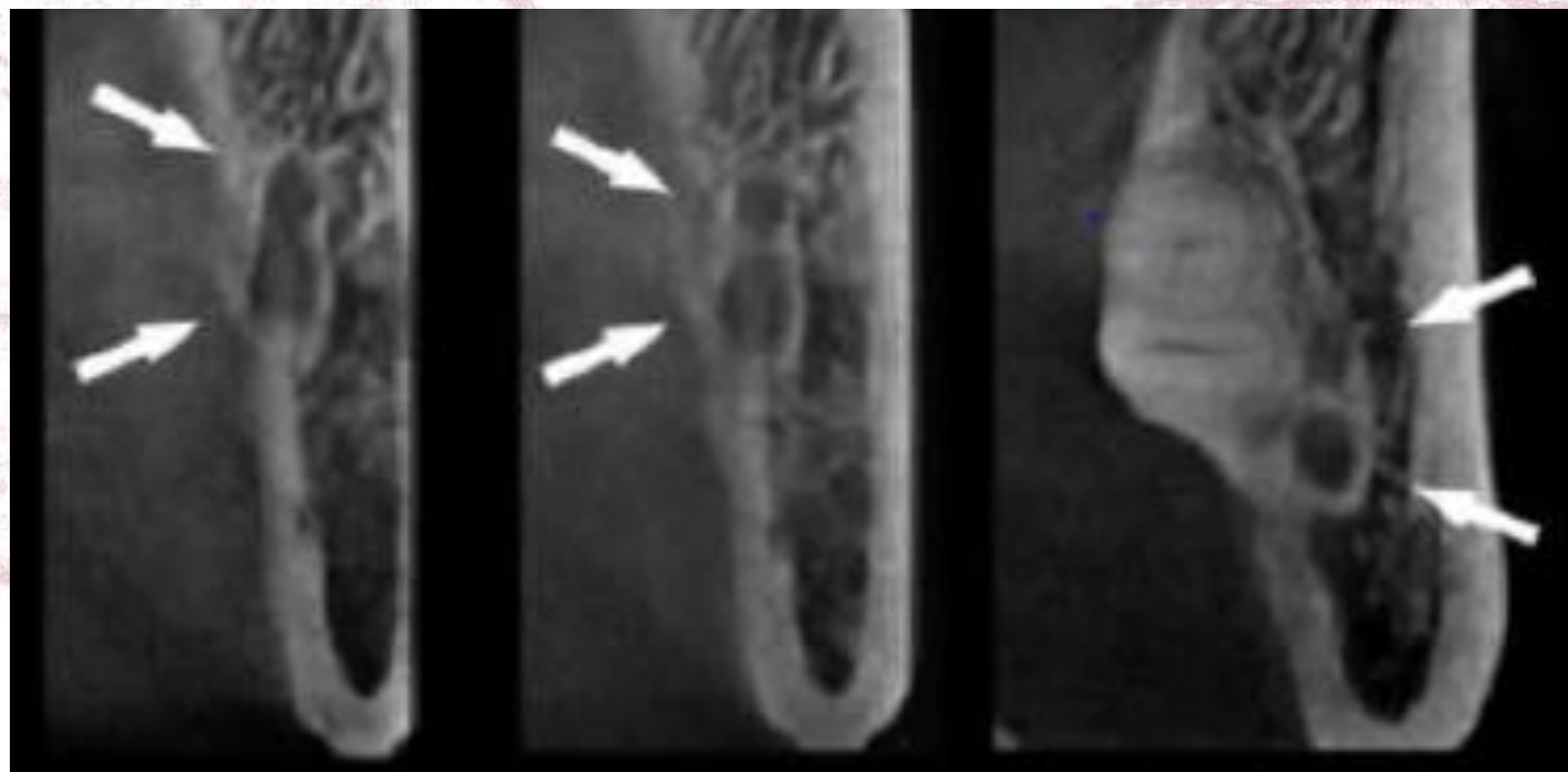


Orthodontics and Three-Dimensional Cephalometry

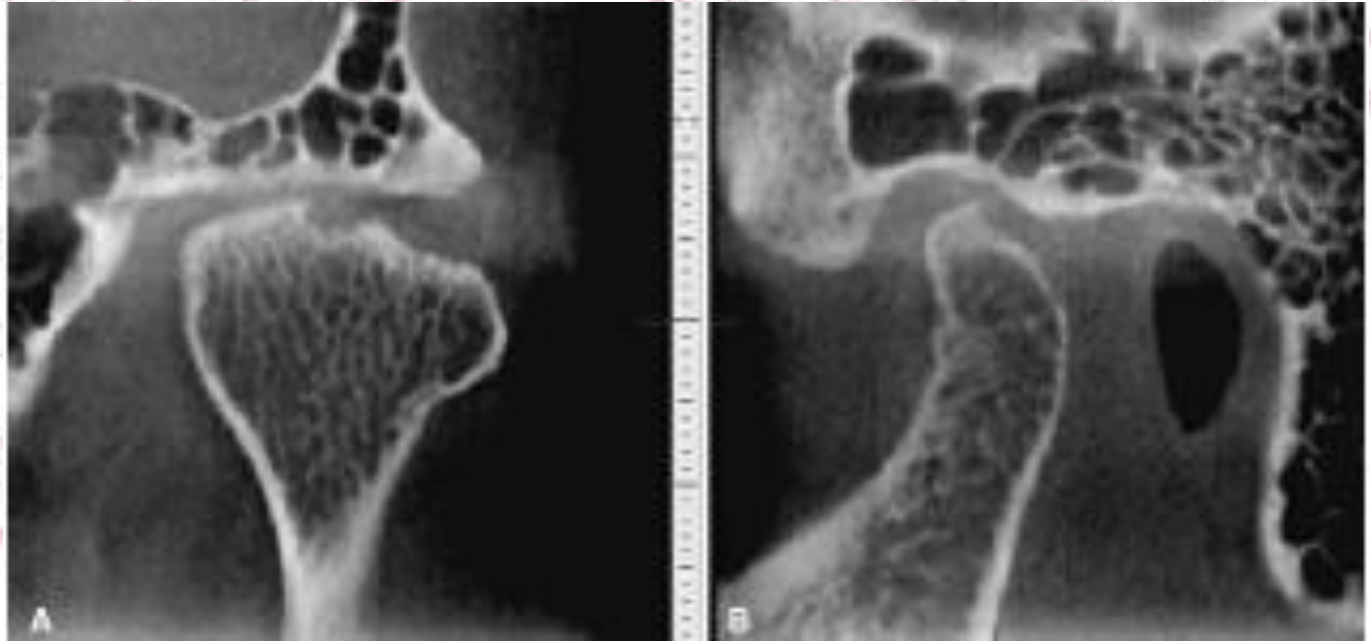


Mandibular Third Molar Position





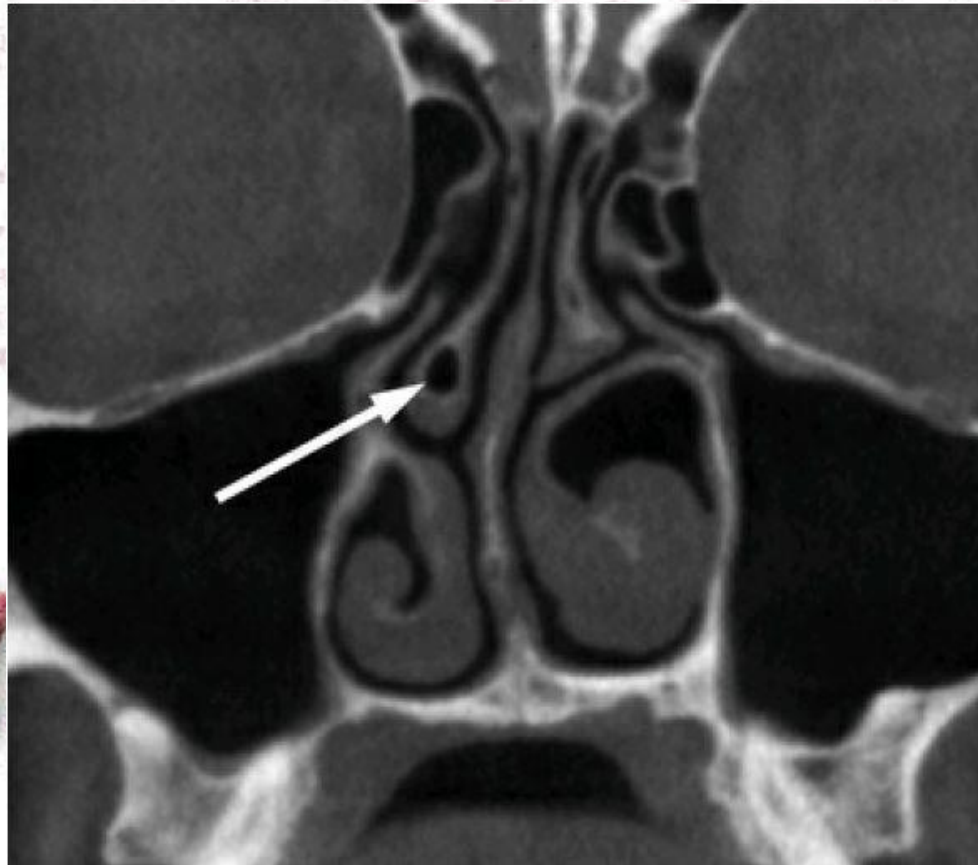
Temporomandibular Joint



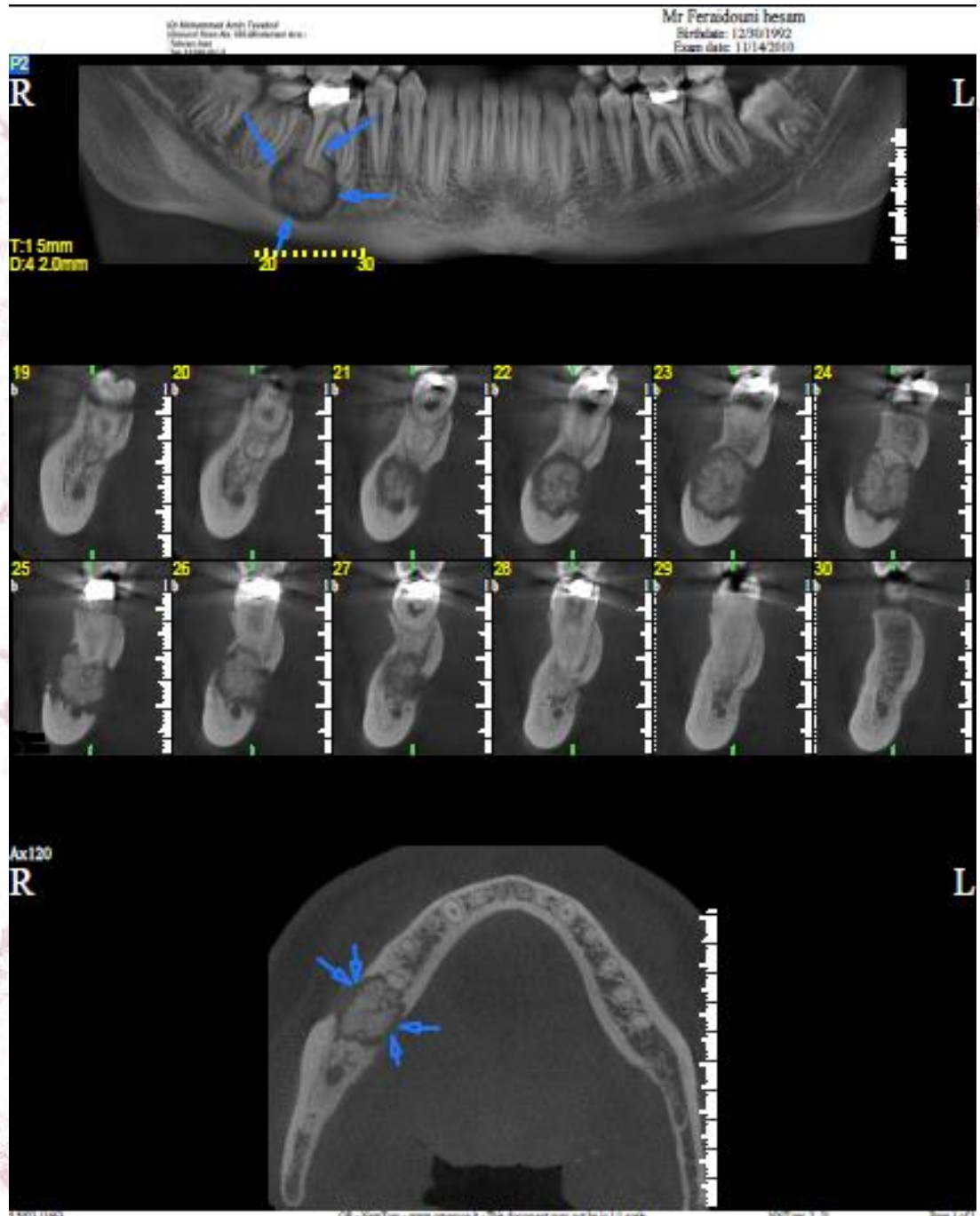
Maxillofacial Pathoses



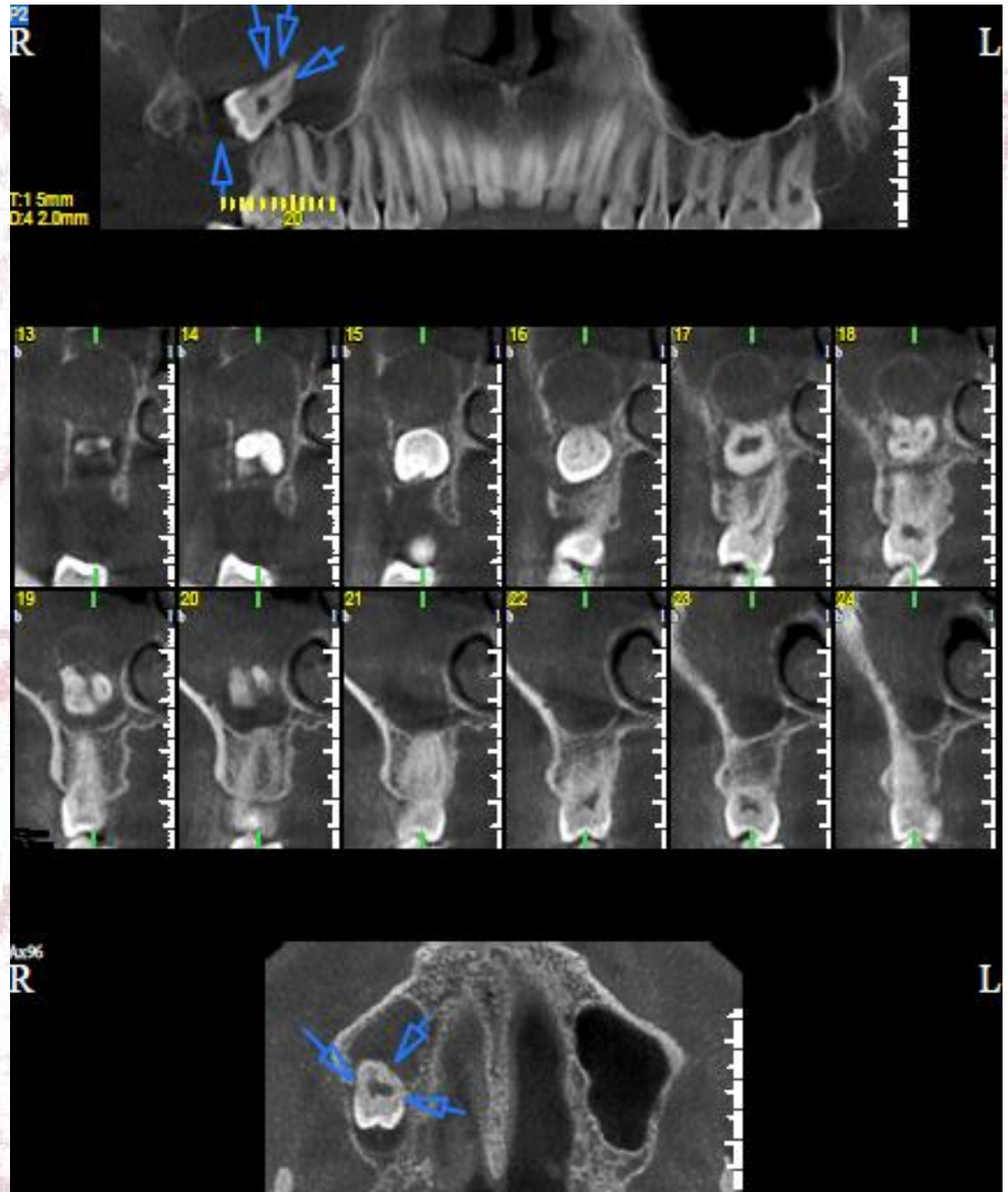
Concha bullosa: pneumatization of the middle concha



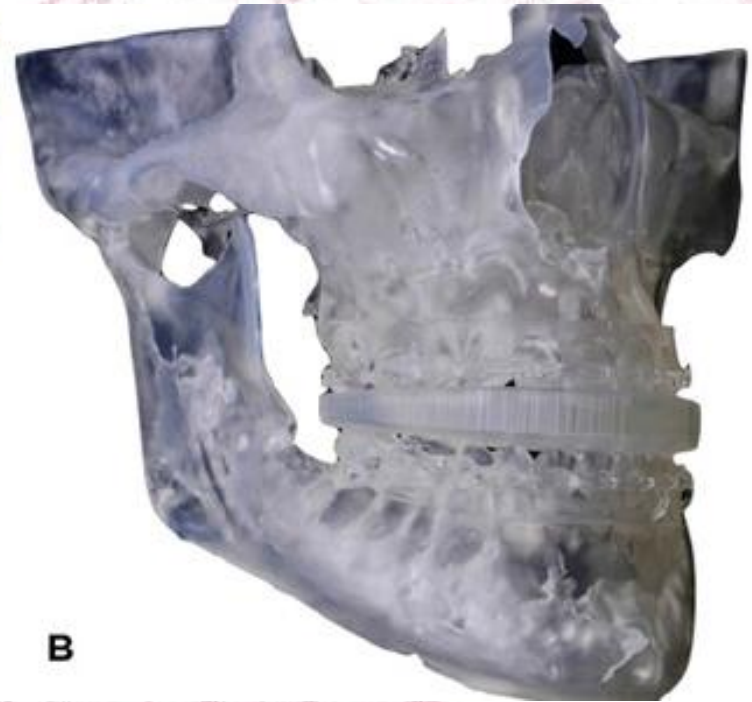
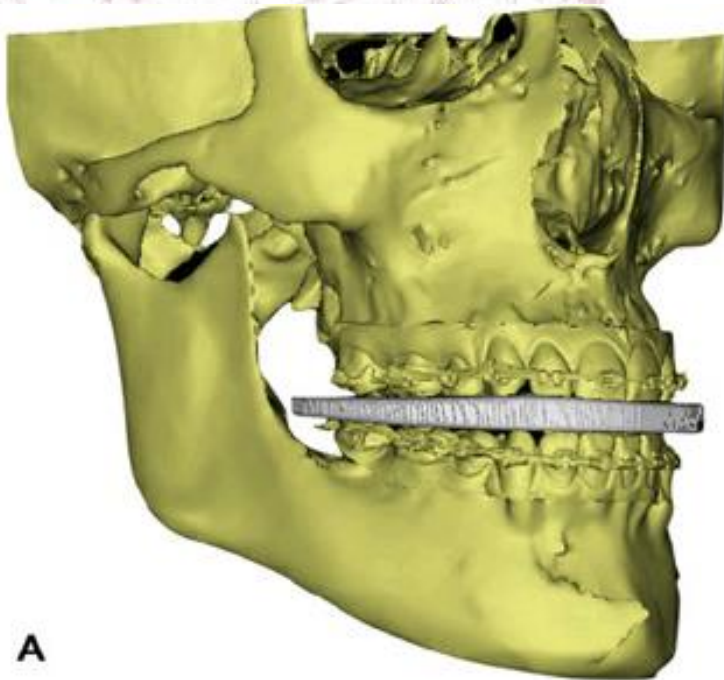
cementoblastoma



3rd molar in
max. sinus
+ sinusitis



Additive Manufacturing for Orthognathic Surgery



Thanks ...

