

*30 Years of
Leadership and Credibility*

Session 1:
Improving the Reliability of Computerized Reformatted Radiological Images

Professor William C. Scarfe
Louisville, Kentucky, USA



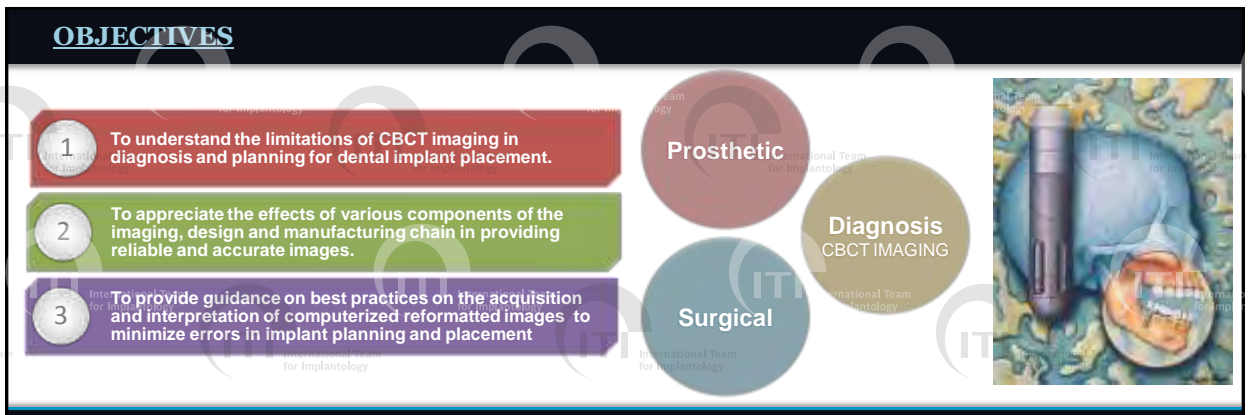
OBJECTIVES

- 1** To understand the limitations of CBCT imaging in diagnosis and planning for dental implant placement.
- 2** To appreciate the effects of various components of the imaging, design and manufacturing chain in providing reliable and accurate images.
- 3** To provide guidance on best practices on the acquisition and interpretation of computerized reformatted images to minimize errors in implant planning and placement

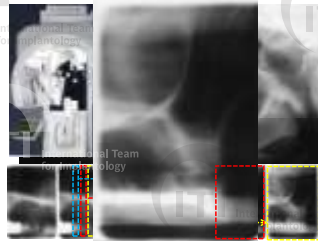
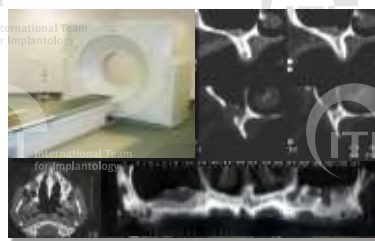
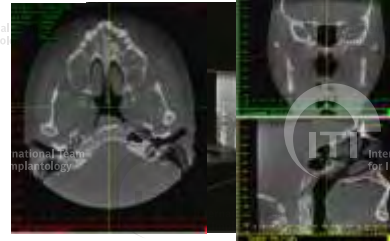
Prosthetic

Surgical

**Diagnosis
CBCT IMAGING**



CROSS-SECTIONAL IMAGING: *Evolutions in Pre-operative Assessment*

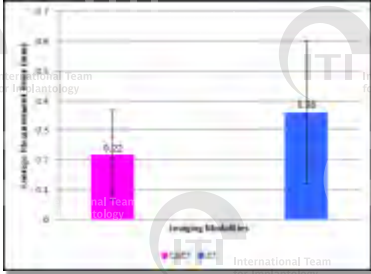
Tomography	Computerized Tomography (Conventional)	Computerized Tomography (Cone Beam)
		

CROSS-SECTIONAL IMAGING: *Unique Features of CBCT for Implant Site Assessment*

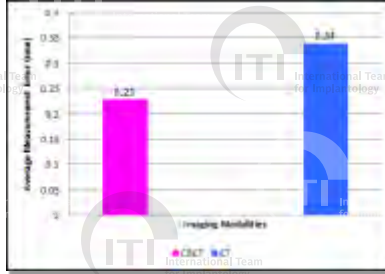
		
<p>IMAGING</p> <p>Acquisition and Display Assessment of bone characteristics and anatomic structures</p>	<p>PLANNING</p> <p>Software-based design Implant selection and prosthetic design</p>	<p>PLACEMENT</p> <p>Surgical Procedures Fixture placement and surgical guidance</p>

CONE BEAM CT CROSS-SECTIONAL IMAGING: *Lessons from the Literature*

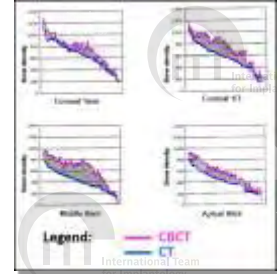
AVE. HEIGHT MEASUREMENT ERROR



AVE. WIDTH MEASUREMENT ERROR



BONE DENSITY MEASURES



Ebrahim F et al., Cone Beam CT For Preoperative Dental Implant Site Assessment: An Evidence-Based Review of the Literature. http://www.utoronto.ca/dentistry/newsresources/evidence_based/EBR09/22EBLREPORT-2009.pdf

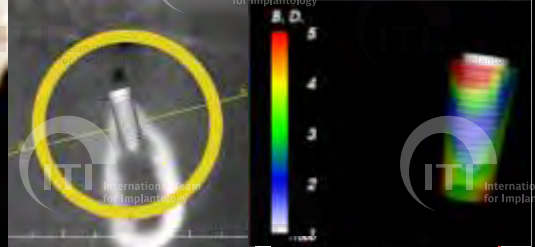
LIMITATIONS OF CBCT: *Grey scale Value ≠ Hounsfield Unit*

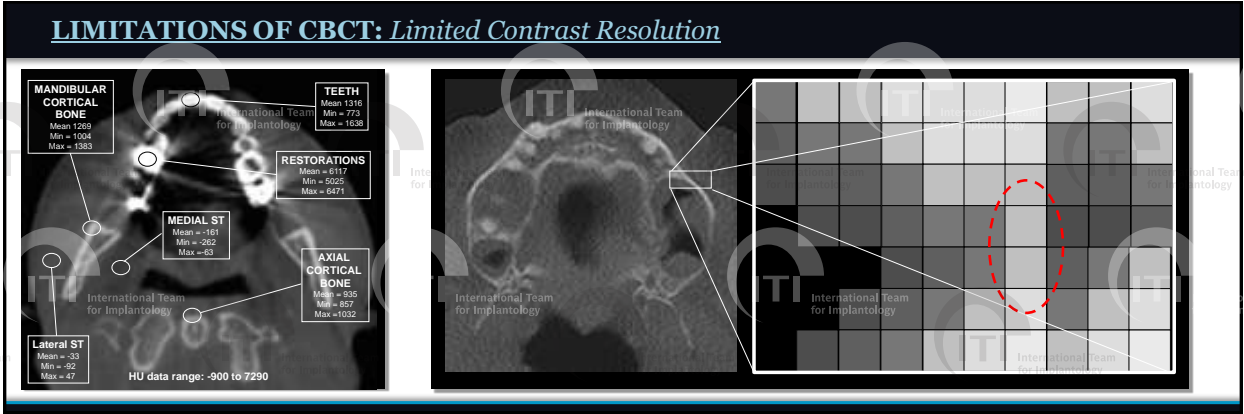
IMPORTANT DETERMINANT

- **Cone beam geometry**
- Bryant, 1999
- Fruhlar et al., 1997, 1994 (N=2,633)
- Hutton et al., 1995 (N=510)
- Fugazzotto et al., 1993 (N=513)
- Jaffin & Berman, 1991 (N=1,054)
- **RELATIONSHIP**
- Misch et al., 1999 (N=975)
- Ivanoff et al., 2000 (Benchmark, N=299)
- Kline et al., 2002 (N=495)

Fan beam geometry

DENSITY	HOUNSFIELD UNITS
D1	≥1250
D2	850-1250
D3	350-850
D4	150-350
D5	<150





LIMITATIONS OF CBCT: *Physics-based Artifacts*

Beam Hardening

Beam Hardening

Photon Starvation

Photon Starvation

Scatter Radiation

Photon Starvation "defect"

Photon Starvation

Beam Hardening "shadow"

LIMITATIONS OF CBCT: *Patient-based Artifacts*

Beam Hardening

Beam Hardening

Photon Starvation

Photon Starvation

Scatter Radiation

Photon Starvation "defect"

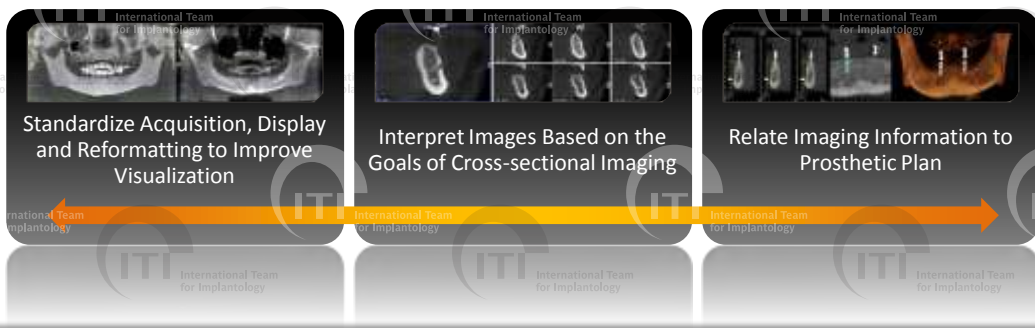
Photon Starvation

Beam Hardening "shadow"

LIMITATIONS OF CBCT: *Minor Motion Artifact Correction*



CONE BEAM CT CROSS-SECTIONAL IMAGING: *Improving Reliability*



CROSS-SECTIONAL IMAGING: *Imaging Goals*

1) AVAILABLE BONE CHARACTERISTICS

- **Bone Dimensions**
 - Height
 - Width
 - Length
- **Bone Morphology and Quality**

Quality: 1 2 3 4

International Team for Implants 8.9% 45% 37.2% 8.3%

Upper jaws: A B C D E

Lower jaws: A B C D E

* Data from: Truhlar et al., J Oral Max Surg 1997;55:38-45 (suppl 5)

International Team for Implantology

CROSS-SECTIONAL IMAGING: *Imaging Goals*

1) AVAILABLE BONE CHARACTERISTICS

- **Bone Dimensions**
 - Height
 - Width
 - Length
- **Bone Morphology and Quality**

2) ALVEOLAR RIDGE ORIENTATION

- *With respect to anatomy*

3) INTERNAL ANATOMY

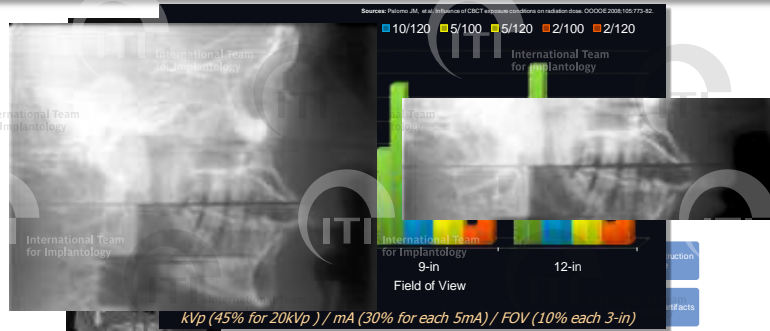
- *Maxilla and Mandible*

4) REGIONAL ANATOMY /PATHOLOGY

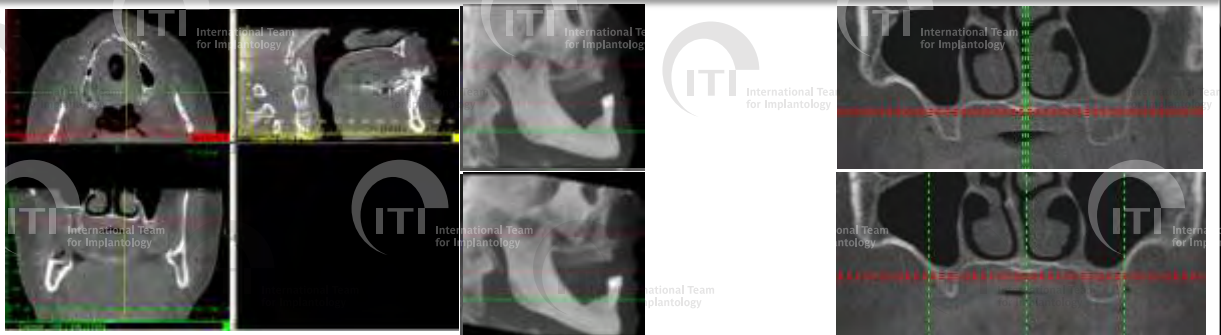
International Team for Implantology

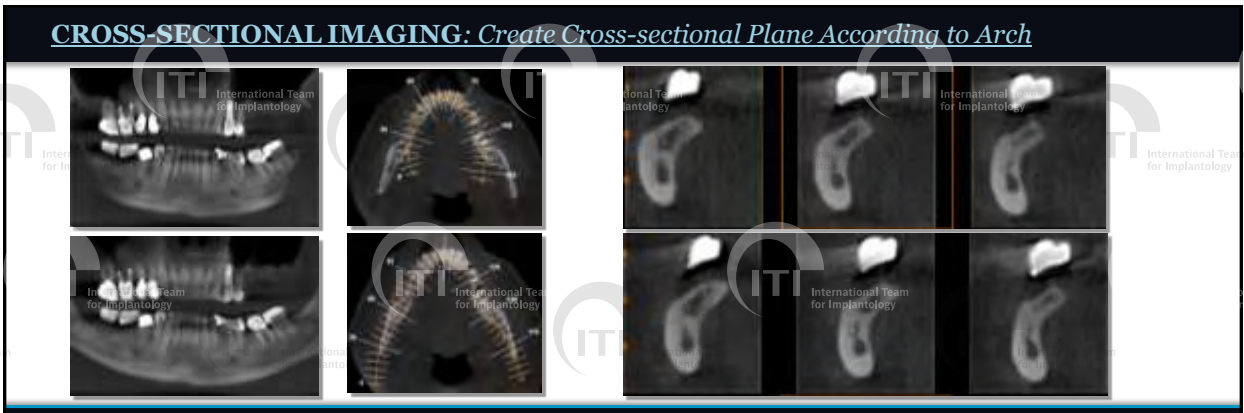
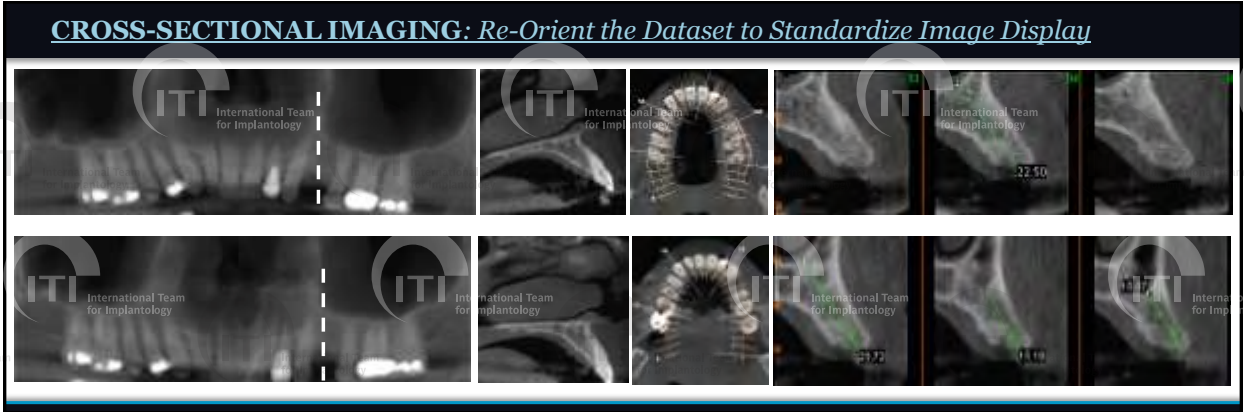
CROSS-SECTIONAL IMAGING: *Effects of Acquisition Parameters*

- 1) **EXPOSURE SETTINGS (mA, kVp)**
 - $\uparrow \rightarrow \uparrow$ Radiation Dose
- 2) **SPATIAL RESOLUTION**
 - No effect on dose
 - $\uparrow \rightarrow$ Data size and reconstruction time
- 3) **FIELD OF VIEW**
 - $\uparrow \rightarrow \uparrow$ Radiation Dose
 - Should be limited to the Region of Interest
- 4) **SAMPLING (# Basis Images)**
 - $\uparrow \rightarrow \uparrow$ Radiation Dose




CROSS-SECTIONAL IMAGING: *Re-Orient the Dataset to Standardize Image Display*



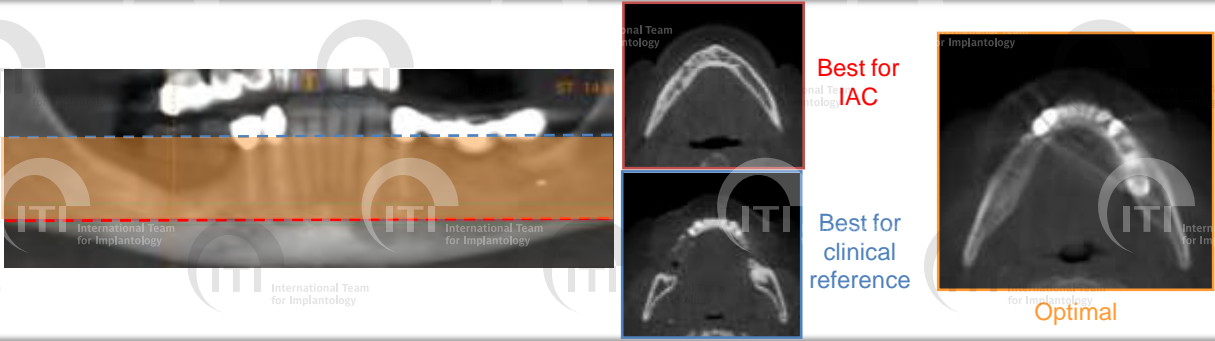


CROSS-SECTIONAL IMAGING: Use Multiple Nodes to Create Panoramic MPR



International Team for Implantology

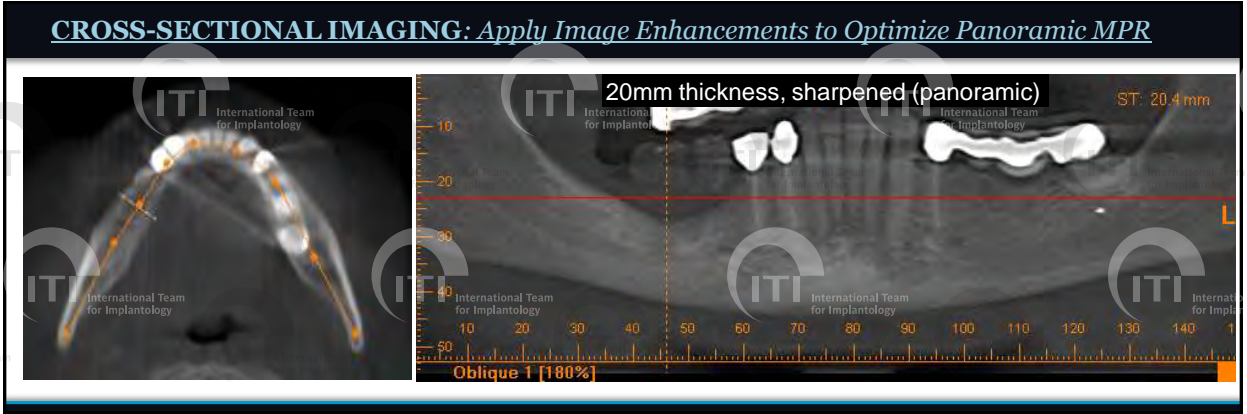
CROSS-SECTIONAL IMAGING: Apply "Thick slab" to Determine Optimize Axial Reference

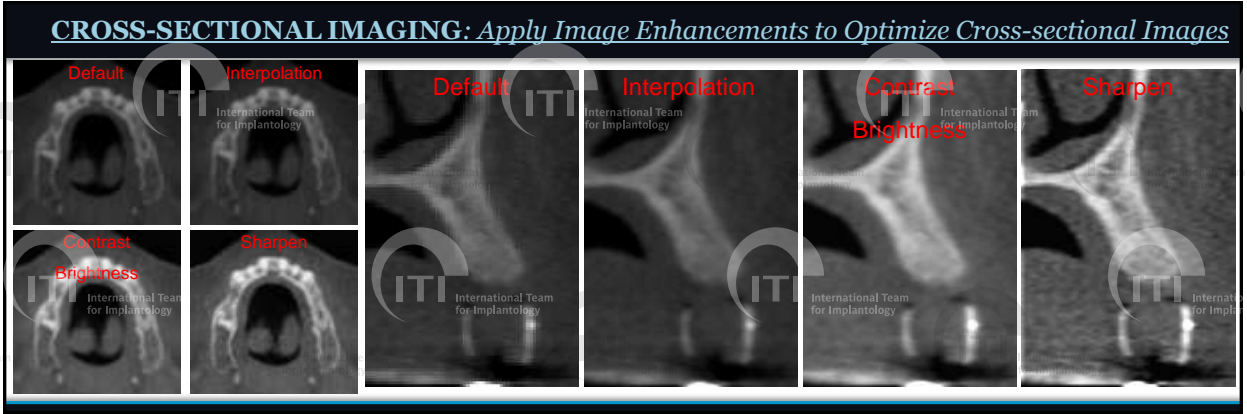


Best for IAC

Best for clinical reference

Optimal





CROSS-SECTIONAL IMAGING: *Translating Planning to Surgery - the Use of Software*

Inter-foraminae Distance

Maximum # = Distance / (implant width + 2)

- Reduction
- In Width
- e Height
- Length
- e

CROSS-SECTIONAL IMAGING: *Translating Planning to Surgery - the Use of Surgical Guides*

Cawood JI, Howell RA. Int J Oral Maxillofac Surg 1988;17: 232-236

CROSS-SECTIONAL IMAGING: Translating Planning to Surgery - the Use of Surgical Guides

RESTRICTIVE

NON-RESTRICTIVE

Early modification	Number of patients	% of patients
Modified implant	26	33
Modified surgery	26	33
Modified implant and surgery	26	33
Modified implant, surgery and bone grafting	26	33
Modified implant, surgery and bone grafting and bone grafting	26	33
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Modified implant, surgery and bone grafting and bone grafting and bone grafting and bone grafting and bone grafting and bone grafting and bone grafting and bone grafting and bone grafting	26	33

Schneider D et al. A systematic review on the accuracy and the clinical outcome of computerized implant dentistry. Clin. Oral Impl. Res. 2009;2 (Suppl. 4):73-81

Implant Site Designation

Vaughn WS. Comparison of Clinically Projected Implant Site Designation. Masters in Oral Biology Thesis, Graduate School, University of Colorado, Colorado Springs, CO, USA, 2007. 4/10/10

SUMMARY: Improving CBCT Reliability Requires...



UNDERSTANDING...

- **Imaging Goals Direct Cross-Sectional Image Interpretation**
- **Bone Characteristics and Orientation**
- **Local and Regional Anatomy**

APPLYING...

- **Standardized Protocols to Acquire, Display and Reformat Images**
- **Re-orient, reformat and enhance**
- **Dynamic viewing**

VISUALIZING...

- **Prosthetic and Surgical Considerations**
- **Interactive Planning Using Software**
- **Surgical Guides**

