THE OBJECTIVES OF DIAGNOSTIC IMAGING

- Reveal pathology
- Reveal the anatomic truth

IDEAL DIAGNOSTIC IMAGING STUDY

- Provides desired diagnostic yield
- Low risk to the patient
- Minimal cost
- Convenient to dentist and patient

LIMITATIONS...

- Inherent properties of x-rays
- Projectional nature of conventional imaging
- Misrepresentation

What is the problem?

Shadow casting
Plenty!

- Distortion in panoramic radiographs
- Superimposition of overlying structures
- Inaccurate measurements
- Inaccurate anatomical relationships
- Inability to visualize the Z-axis
The internal structure of an object can be reconstructed from multiple projections of the object.

Advantages of CT
- Elimination of superimposition of structures
- Improved contrast resolution
  - 1% difference in physical density differences vs 10% difference in conventional films
- Multiplanar reformatted image
  - This means that data can be viewed in either coronal, axial, or sagital planes

History
- Announced by Godfrey Hounsfield in 1972
- Initially called Computerized Axial Transverse Scanning
- Used a narrowly collimated, moving x-ray beam with a scintillation crystal detector.
- Resultant analog image was digitized and reconstructed by computer algorithm
- Able to detect soft tissue differences with greater sensitivity than conventional images

Sir Godfrey Hounsfield

Stereopticon
Buccal Object Rule

The EMI Brain Scanner

Early CT Images

Basics

- Computerized Tomography, or CT is the preferred current terminology.

Don't call it a CAT scan!

The Z axis

Image data

- Hounsfield Unit - specific to each pixel is the average of all density measurements for that pixel
- Scan Field of View: Area within the gantry from which raw data is acquired.
  - Small: 25cm - head
  - Medium: 35 cm - chest
  - Large: 42-50 cm - abdomen
The display field of view and the matrix determine the pixel size. The entire scan circle or a portion of the circle may be selected to display on the monitor. Pixel Size = Field of view / Matrix size

The displayed image is an array of pixels. The displayed density is proportional to the attenuation characteristics of that voxel. Each pixel is assigned a CT number. The CT number is also known as Hounsfield Units, in honor of Sir Godfrey Hounsfield. The scale ranges from -1000 (air) to 0 (water) to +1000 (dense bone).

Because we cannot see the difference between 2000 different shades of grey it would be pointless to produce an image which covered the whole range of Hounsfield numbers. In order to produce a useful image of the area of interest a system of windowing and levels is used. Windowing: The available grey scale is spread over the chosen range of Hounsfield numbers. The window defines the upper and lower limits of this range. To produce an image which shows up major structures a large window is used. For more detailed information about tissues with very similar density a small window is used. The smaller the window the more detailed the image but the range of tissue density that is seen is reduced. Levels: The level is the Hounsfield number at the centre of the window. This is chosen so that the window covers the type of tissue you are interested in. To image dense tissues a high level is used and to image low density tissues a low level is used.
Hounsfield Units

This image was produced with a window of 1000 HU at level -700 HU

This image was produced with a window of 500 HU at level +50 HU

www.atp.manchester.ac.uk/.../Hounsfield.GIF

Window width and window levels

- Increasing the Window Width allows structures with a large pixel range (i.e. bones and lungs) to be viewed. 400-2000 HU
- Decreasing the Window Level allows the lungs and airways to be viewed.
- Increasing the Window Level allows the denser bones to be viewed.
- DUAL WINDOW SETTINGS OR DOUBLE WINDOW SETTING

Windowing: Residual cyst with squamous cell carcinoma

Soft Tissue Window
Bone Window

Basics

- The basic approach is that of a x-ray tube emitting a thin, fan-shaped beam in the direction of an array of detectors. These are either scintillation detectors or ionization chambers.
- Different arrangements call for simultaneous movement of the source and detectors, or the source only may revolve around the patient to acquire the images.
Basics

- Third generation scanners are called Incremental Scanners, since the final image set contains a series of contiguous or overlapping images.
- The current generation of scanners provides a helical or spiral scan. The patient is moved through the gantry as the images are exposed. This creates a continuous spiral of data.

Terminology

**Continuous acquisition scanning**

- Spiral scanning - Siemens®
- Helical scanning - GE®

Basics

Benefits of spiral scanning including:
- Decreased acquisition time (12 seconds vs 5 minutes)
- Improved multiplanar reconstructions
- Decreased dose to patient

Basics

- The CT image is a computer reconstruction of multiple images.
- A scan consists of a 360 degree rotation around the patient.
- There may be projections at each 1/3 degree of rotation. This will give a total of 1080 projections.
- The image is displayed in a series of voxels (volume elements)
Basics

- The flat image is displayed as 0.1 mm squares called pixels (picture elements).
- The depth of each voxel is determined by the collimation of the beam, both at the tube head and the detector array.
- The voxel depth is analogous to the image layer (or focal trough) in a panoramic radiograph.
Cone beam CT

Cone shaped beam
One flat panel sensor

Advantages/ disadvantages over Medical CT

- Less radiation
- Lower cost
- Fixed imaging volume
- Limited to head and neck

I-CAT
(Imaging Sciences)

Cone Beam CT

NewTom

Cone Beam CT
Cone Beam CT

MULTI-PLANAR REFORMATTING

Planes

Multi-planar reformatting

Axial image/ slice
Multi-planar reformatting

Coronal (frontal) image/slice

Sagittal image/slice

Axial imaging

Axial imaging
**Coronal (frontal) imaging**

**CBCT applications**

<table>
<thead>
<tr>
<th>Pre-implant assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impactions</td>
</tr>
<tr>
<td>TMJ hard tissue assessment</td>
</tr>
<tr>
<td>Oral cancer F/U</td>
</tr>
<tr>
<td>Trauma</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>
Impactions

3D applications

Orthodontic applications
Facial asymmetry

Courtesy Dr. D. Hatcher

Orthodontic applications
Facial asymmetry

Courtesy Dr. D. Hatcher

Orthodontic applications
Facial asymmetry

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Orthodontic applications
Facial asymmetry

Courtesy Dr. D. Hatcher
Trauma

Pre-implant assessment

Computed tomography

(+)
- No shadows of surrounding structures
- Variable slice thickness and multiplanar imaging
- Evaluation of bone height, width and bone quality
- High contrast resolution
- Best imaging of the vital structures
- No magnification

(-)
- Streaking artifacts
- Higher radiation to the patient
- Not readily available

“Clinical observation and palpation have been proven to be inadequate for the estimation of the width of the ridge”… (Beeman 1989)

Presence of undercuts, especially in completely edentulous patients

Anatomical structures of interest, especially the mandibular canal do show better (Stella and Tharanon 1990)

Bone density estimation (with CT)
Identify the proposed implant sites:

RADIOGRAPHIC TEMPLATES

Radiographic guides

“Hollowed out” guides

Radiographic guides

Clear acrylic templates

Markers (metal or gutta-percha)
Remove gutta-percha markers immediately after completion of surgery.
1 week after surgery

Alveolar ridge variation

Mental foramen

Alveolar ridge variation
INTERPRETATION

Extraction of meaningful information, explanation...

Webster's dictionary
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