RADIOGRAPHY IN PERIODONTOLOGY

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AIM OF THE LECTURE

- To understand the diagnostic benefit and biological cost of radiographic imaging
- To understand the prerequisites for prescribing a radiological test
- Discuss the imaging modalities used in periodontology
- Interpreting radiographs for periodontal diagnosis

BENEFITS OF RADIOLOGY IN PERIODONTOLOGY

- Evaluation of health and pathology of hard tissues- teeth and surrounding bone .
- Essential aid in diagnosis in addition to the clinical periodontal assessment
- Important in determining prognosis
- Facilitates treatment planning
- Important to exclude non-inflammatory conditions
- Prerequisite for pre-surgical planning
- Assists in monitoring treatment outcomes

LIMITATIONS OF RADIOLOGICAL IMAGING

- **Ionizing radiation mostly only reveals alteration in calcified tissues**
- **It doesn't reveal cellular (disease) activity**
- **Shows only historical bone** destruction
- **Limited value in soft tissue analysis**
- After regenerative procedures, difficult to distinguish between bone graft and regenerated bone.

BIOLOGICAL COSTS and the effects of ionizing radiation

- Ionizing radiation can induce cellular and chromosomal damage in 2 main ways-
- Deterministic effect- dose has to be over a certain threshold to cause damage, severity then increases with dose- fetal abnormality, skin damage, hair loss.
- Stochastic effect- not dose dependent but risk increases with higher dose- induction of chromosomal damage which can develop into specific cancers, leukemias ,salivary gland, thyroid, breast, brain.. Can occur years after radiation.
- Radiation dose protection principles very important–justification, optimization , (Alara) dose limitation

PREREQUISITES

- Sound knowledge of anatomy and radiological anatomy in the field of view of your radiograph
- Knowledge of the disease conditions you are looking for and its radiographic presentation
- The principle of Alara (as low as reasonably achievable) and pros and cons of each imaging modality
- Training in taking a good radiograph

IMAGING MODALITIES IN PERIODONTOLOGY

- Ionizing radiation- intra/extraoral sensors
- Bitewings, periapicals, occlusal
- Panoramic , cephaholometric views
- 3D imaging – cone beam computed tomography
- Multislice / multidetector computed tomography

- Non-ioning radiation
- Ultrasound
- MRI

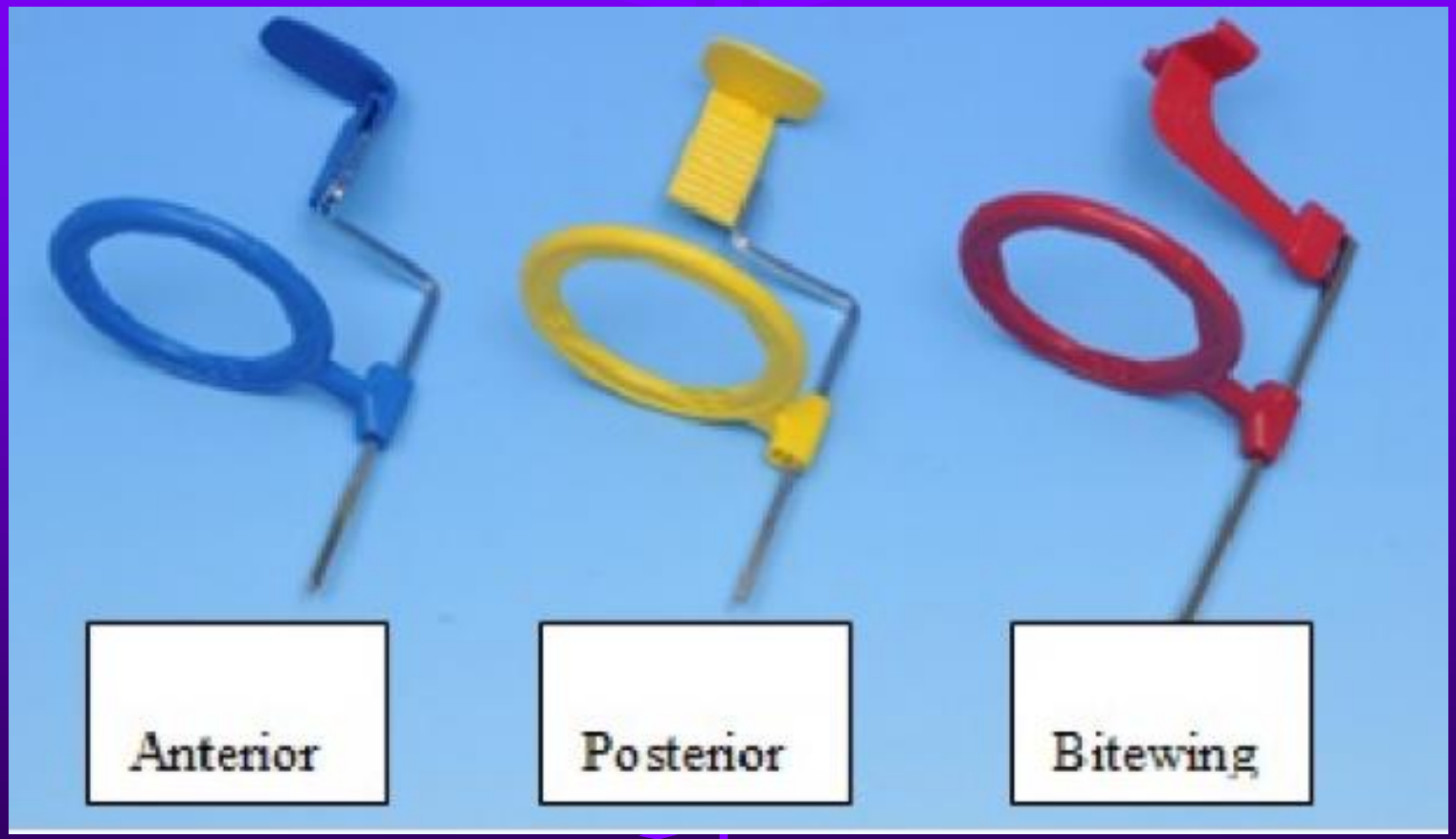
PERIODONTAL Radiographic Examination–WHAT YOU WANT TO LOOK AT

- Bone destruction, bone loss pattern and bone defect morphology.
- Roots –anatomy, length, crown/root ratio, hypercementosis
- Restorations-deficiencies, caries, overhangs
- Calculus if abundant
- Pulp/periapical conditions, perio-endo conditions,
- Furcations
- Periodontal ligament space
- Tooth impactions, root remnants, unerupted teeth
- Any pathology of the root or adjacent structures
- Bone deficiencies

INTRAORAL RADIOGRAPHS

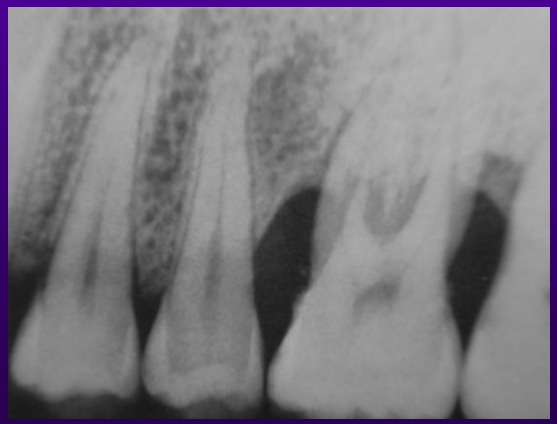
- Standard imaging modality for periodontal evaluation, mostly diagnostic of interdental bone changes
- Periapical and bitewings use various sized films / digital sensors intraorally attached to a localising ring.
- Not as accurate as 3D imaging but much lower radiation dose.
- Ideally aim to standardize technique- exposure time, film size, angulation

Film holders and positioning devices



Periapical views

- Various sized small digital sensors positioned ideally parallel to the tooth being examined- ideal for viewing the whole root, used for evaluating periapical and periodontal/peri-implant status -even with holders you can over- or underestimate calculations



BITEWING RADIOGRAPHS

- Used for caries detection and early crestal bone loss
- More accurate than PAs because x-ray projection more perpendicular to teeth but records only coronal third of tooth
- Ideally no overlap of teeth, cusp tips clear

- **How do you it's a good intraoral radiograph?**

- Clear Cusps of molars
- Enamel and pulp chambers seen and distinct.
- Interproximal spaces should be open.
- Interproximal contacts should not overlap (unless crowding present)

LIMITATIONS OF PA AND BWS- 2D IMAGES

- Superimposition
- Buccal/lingual bone and roots

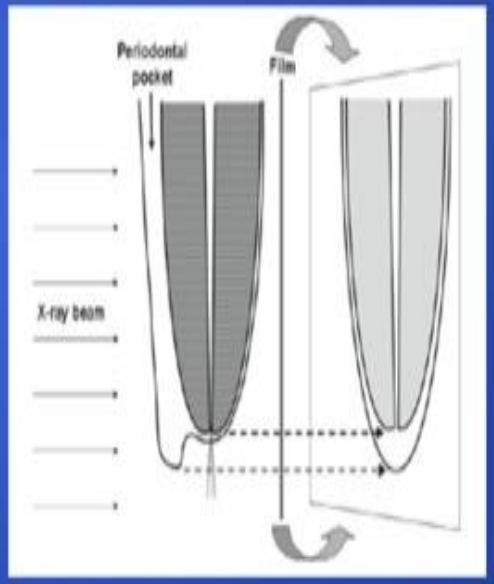
Effect of varying the angulation-

Vertical and horizontal shifting of the x-ray tube will change the configuration of the PDL space, furcation, interdental bone, position of roots

An endodontic infection?

Or a severe periodontal infection

Diagnosis: Combined Endo-Perio?



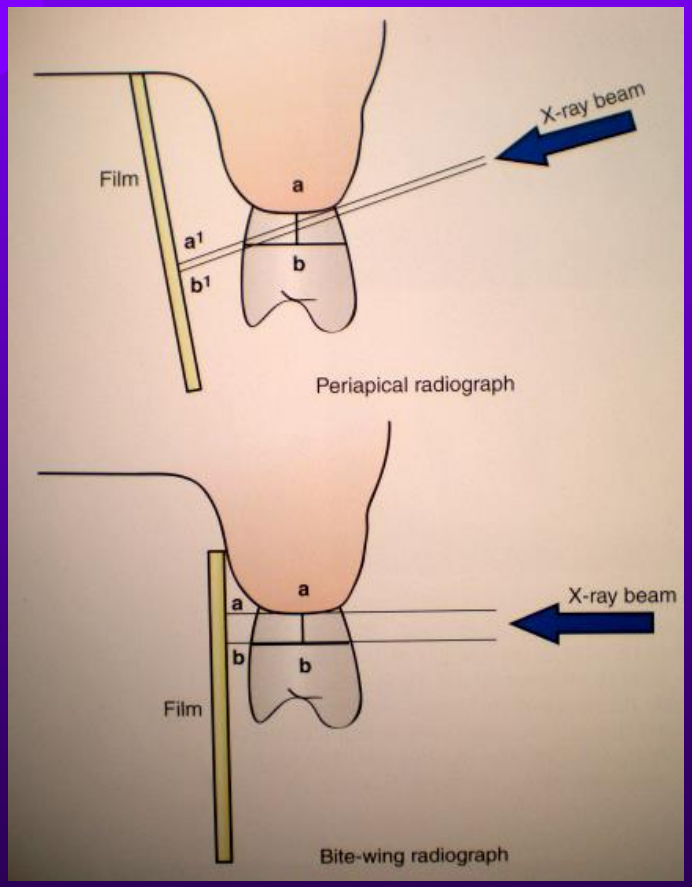
- Or a root perforation?

A perfect rootfilling?

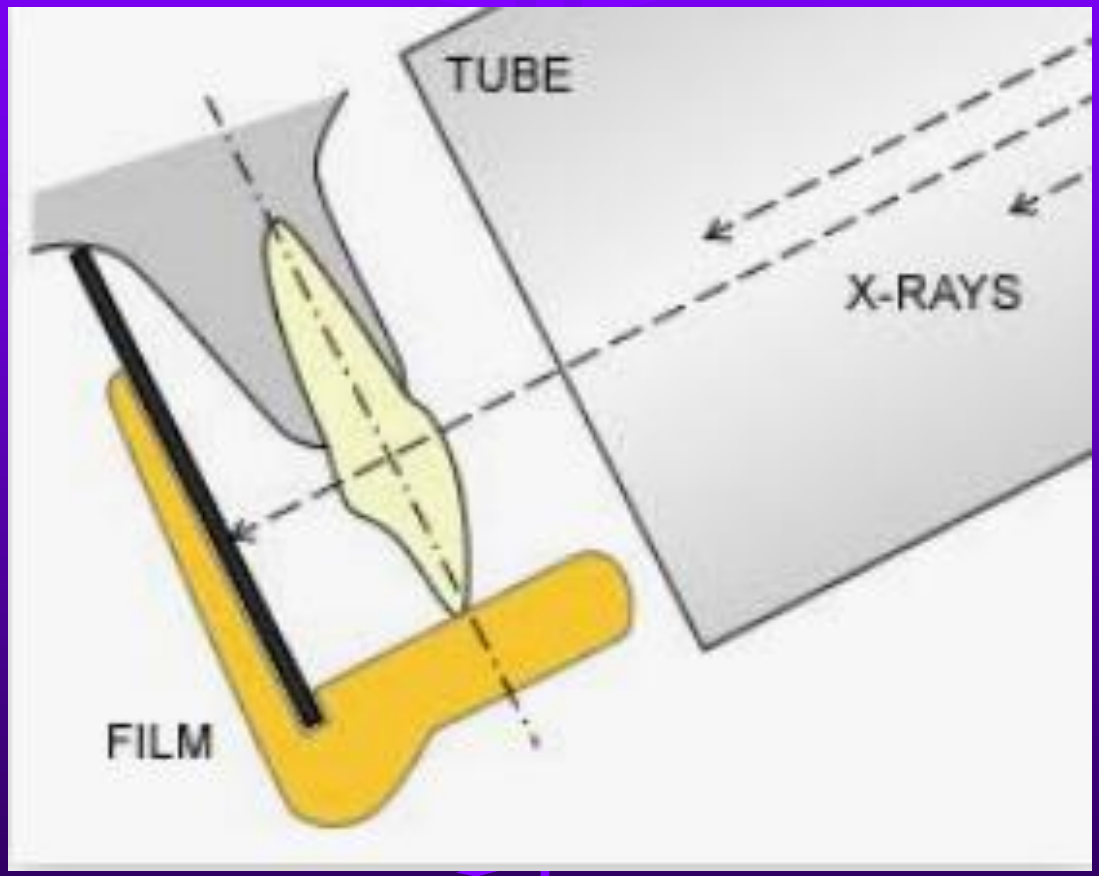
RADIOGRAPHIC TECHNIQUE DISTORTIONS- by vertical/horizontal shifting

- **BISECTION TECHNIQUE:**
  - Increases projection
  - Bone closer to crown
  - Distortion of facial and Lingual bone
  - Long cone technique better

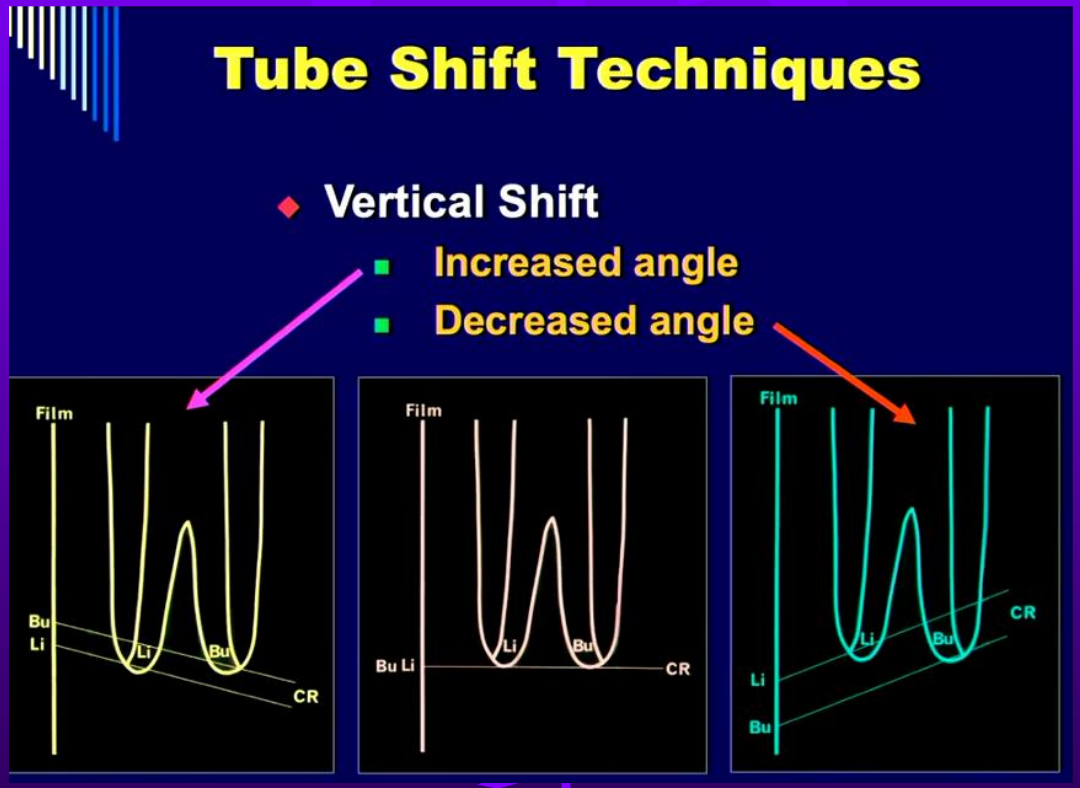
- **MESIAL OR DISTAL SHIFTING**
  - Changes the shape of interdental bone
  - Changes PDL space width
  - Changes lamina dura
  - Furcation involvement changes



Long cone parallel technique



Taken from an endo lecture



Tube Shift Techniques

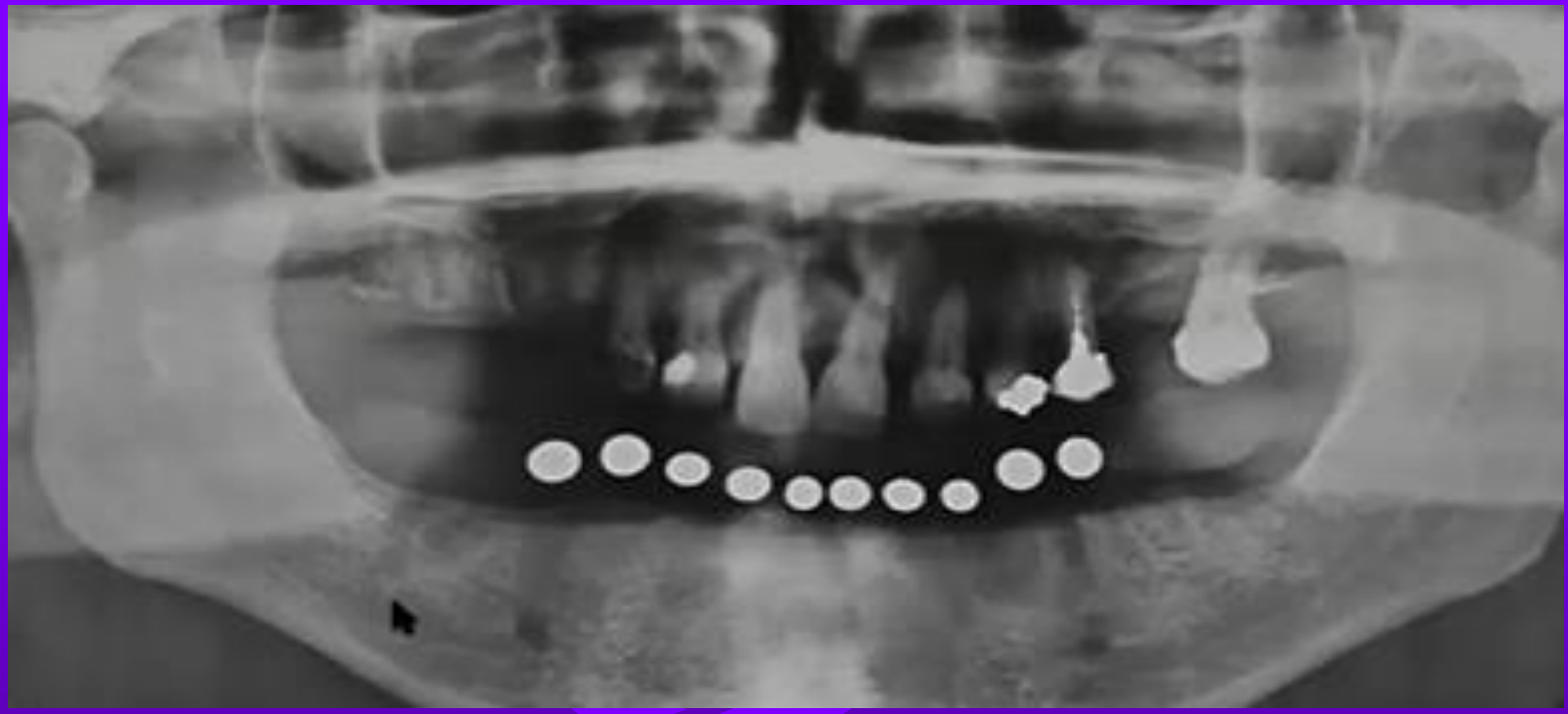
Horizontal shifts

- Mesial
- Distal

- Used to separate objects that are otherwise superimposed over each other
- Can help to indicate the “3rd dimension”

PANORAMIC RADIOLOGY

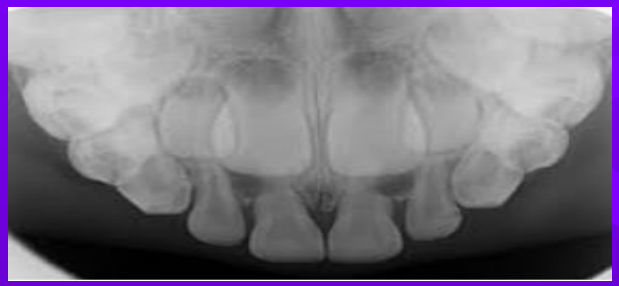
- Extraoral rotating x-ray source and image receptor moves around the patients head- produces a curved image of patients jaws, teeth, TMJ.
- Useful as a screening tool, especially if intraoral views not possible/uncomfortable.
- Problems- image magnification, ghost and double images, distortion, superimposition, low resolution
- Lower radiation dose compared to full mouth periapical radiographs

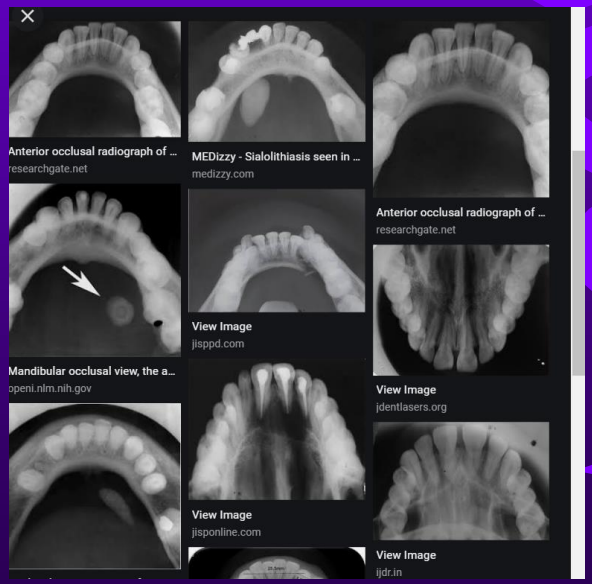


Variations in panoramic machines – magnifications are uneven and unpredictable

Image distortions, variable shortening and elongations , lingual objects more superior

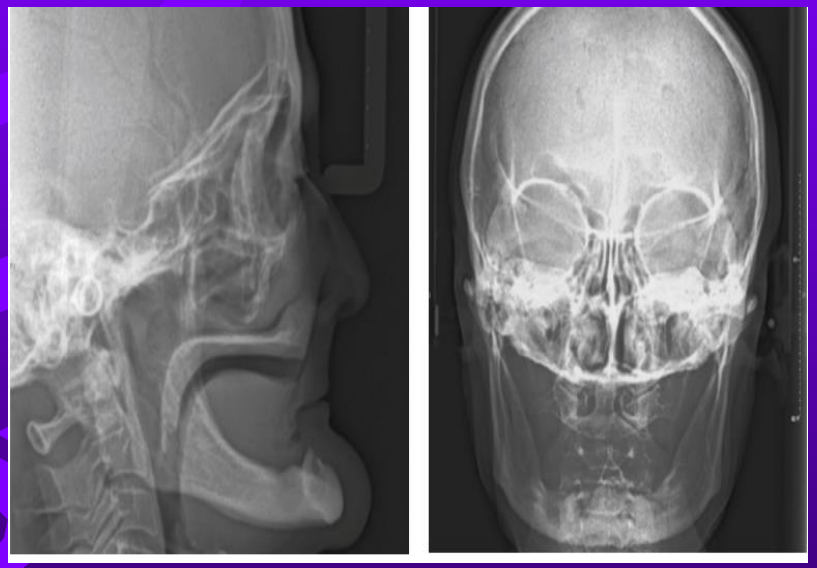
Occlusal radiographs- used in perio to locate impacted /unerupted teeth (also in dental trauma, locate bone lesions , fractures)





CEPHALOMETRIC RADIOLOGY

- More useful in orthodontic therapy and orthognathic surgery
- Occasionally used in perio for full arch implant rehabilitation



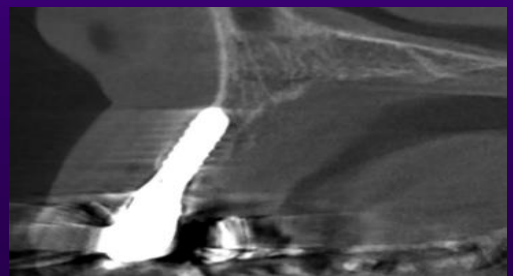
All 2D and OPG have significant limitations

1. Superimposition of structures
2. Geometric alteration
    - Elongation & foreshortening, even with holders
3. Anatomic obstacles
    - Unable to show complex root morphology

Cone Beam Computed Tomography

- Introduced into the dental field in 1998, rapidly growing in popularity.
- Uses a cone beam to capture image in one rotation around a patient- less radiation compared to mdct
- Spatial resolution lower than 2D images but higher by 2-8 times than a MDCT.
- Radiation dose higher than an OPG by 5-10 times (machines in envision)

- But low contrast resolution (poor for soft tissues and low density structures) big problems with movement and metallic artifacts.



MultiDetector Computed Tomography

Already commonly used in medicine- fan beam x-rays to take axial slices from top to bottom.

Superior soft tissue contrast compared with cone beam.

Less accessible for dentists, high cost and radiation dose (up to 15 times more than a CBCT)

When is VOLUMETRIC ANALYSIS useful IN PERIO

- To determine the extent and pattern of periodontal bone loss, including infrabony defects , dehiscences, fenestrations
- Furcation morphology ie width of entrance, pattern of bone loss in furcations
- Root morphology
- Root fractures
- Periapical status
- Origin of infection
- Pre-surgical/ implant planning
- Pre-ortho in thin phenotypes/ perio patients
- BUT INTRAOPERATIVE ANALYSIS MOST ACCURATE

USES IN TREATMENT PLANNING AND IMPLANT PLACEMENT

- Software available to manipulate the axial images into other plains and views (sagittal , coronal..) MPR or multiplanar reformation
- Software can be used to plan and form an implant surgical guide pre-op along with computer assisted treatment planning
- CBCT not useful to monitor peri-implant bone loss (metallic artifacts)- OPG and periapicals better for interproximal bone evaluation

Approximate radiation doses

- IO PA/ BW= 2 uSv
- OPG=20 uSV
- CBCT= 40-80 uSv
- Chest xray =14 uSv
- Background radiation in the UK=7 uSv/daily
- Flight-UK to US= 80 uSv

MRI

- Radiofrequency pulse used in a chamber with a static magnefetic field.
- Excellent for TMJ and soft tissue analysis
- However expensive, claustrophobic, severely affected by metal artifacts
- Increasing interest in developing its use for perio because of ability to differentiate between healthy and inflamed soft tissue

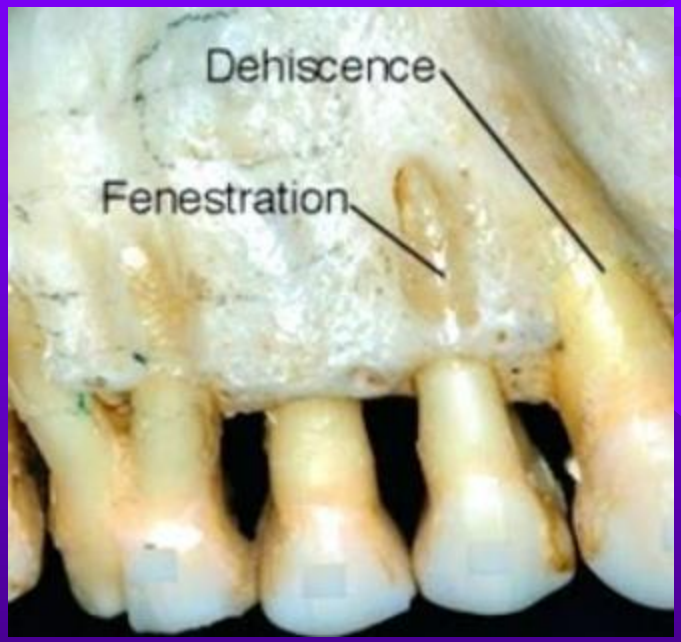
ULTRASOUND

- Uses sound ways and a tranducer to generate an image.
- large transducer head limits current application to TMJ, salivary glands, lymph nodes, head and neck muscles, thyroid gland, carotid vessels
- Smaller transducers more useful intraorally and currently being developed – useful for teeth and implant soft tissue measurements.
- Not affected by metal artifacts so useful for peri-implant evaluation.
- Useful for cosmetic injectables (fillers) to avoid vascular occlusion and evaluate longevity and migration of fillers.

FILLER COMPLICATIONS- VASCULAR OCCLUSION AND TISSUE NECROSIS

NORMAL RADIOGRAPHICAL FEATURES ON A 2D IMAGE (PA and BWS)

- Interdental bone/septa width varies between different teeth , but should be radiopaque and smooth and horizontal.
- Alveolar crest 0.5 to 2 mm to CEJ,
- Lamina dura –dense cortical bone- appears as a white line, which may or not be continuous
- Periodontal ligament space may be widened if the teeth are mobile
- Buccal/ lingual bone not possible to examine on 2D imaging- buccal bone deficiencies may be present in health (dehiscences/fenestrations)
- If teeth have supraerupted , distance between CEJ and crestal bone is more


Dehiscence
Fenestration

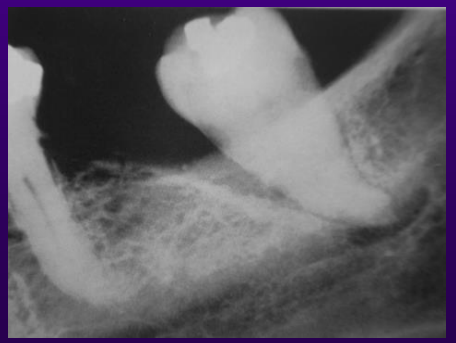
Interpreting bone destruction in periodontal disease

Periodontal bone loss starts at the alveolar crest

Initial phase, reduced density of cortical bone

Slight radiographic changes in bone height means progression to early stages of periodontitis

- Hence the earliest signs are easier to detect clinically by probing
- X-ray underestimates bone loss compared with clinical assessment
- Average distance from CEJ to interproximal alveolar crest is 1.5 to 2 mm hence bone loss is determined by measuring the distance from the crest to the CEJ



SEVERITY and the Classification stages

- Mild -stage I (less than 15%)
- Moderate -stage II (15-33%)
- Stage III and Stage IV (extends to mid 1/3 and beyond)
- Advanced bone loss-stage III - IV
- % of bone loss and root length

Severity and the radiographic report in your perio eform

- Mild- less than 33% bone loss
- Moderate – between 33 and 66%
- Severe- more than 66%
- Pattern- horizontal / vertical
- Distribution- localized or generalized.

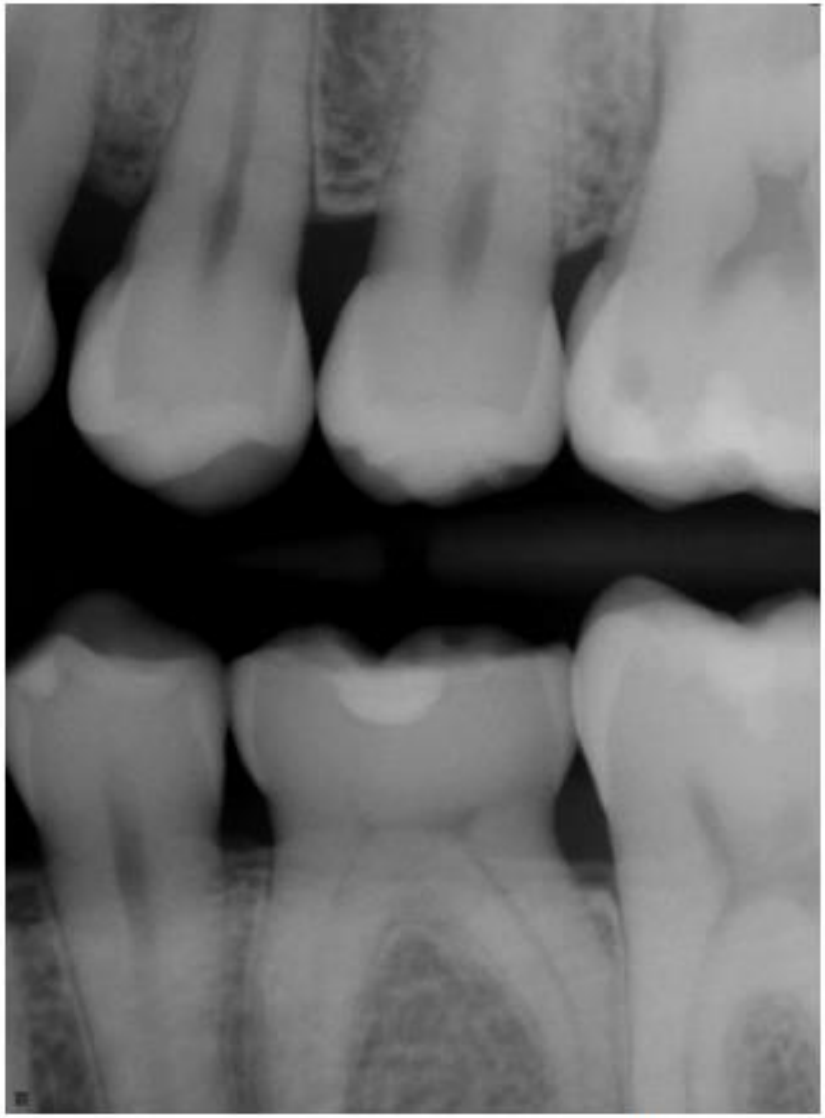


Fig. 11. Stage 1 Periodontal Disease (mandibular + maxillary right posterior) bitewing radiograph: Radiographic bone loss limited to the coronal third (<15%). Image provided by authors.

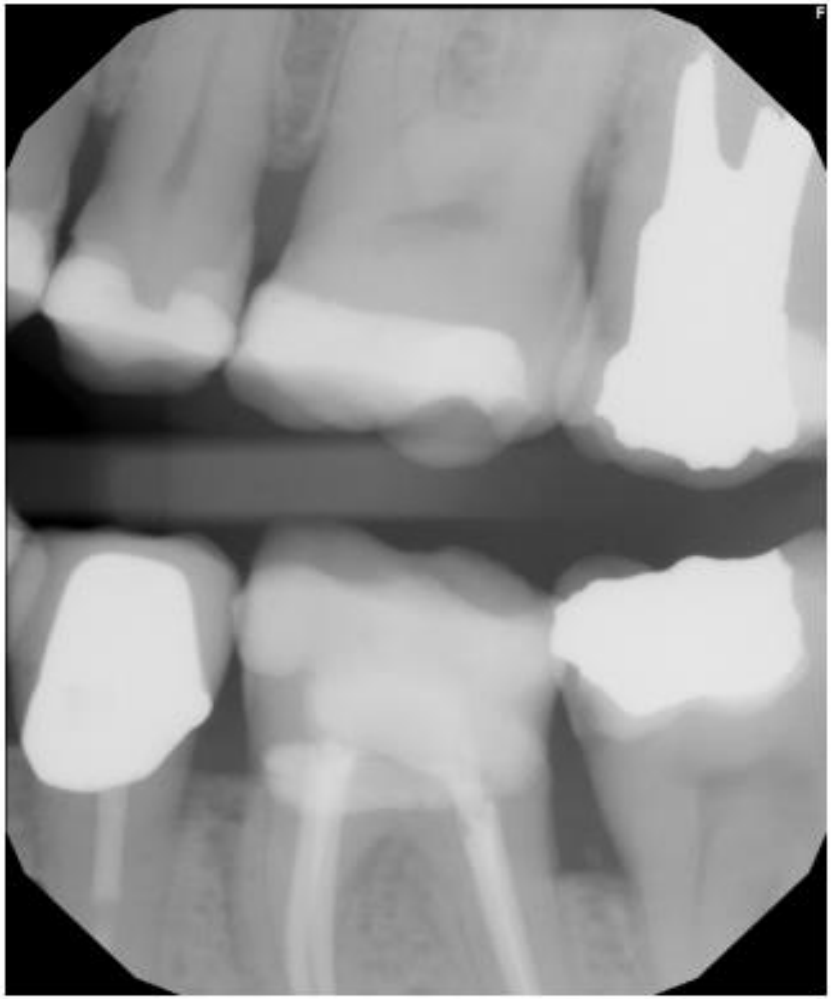


Fig. 12. Stage 2 Periodontal Disease (mandibular + maxillary left posterior) bitewing radiograph: Radiographic bone loss limited to the coronal third (15%–33%). Image provided by authors.

Normal implant bone levels

ig. 23. Mucositis (maxillary anterior incisor) periapical radiograph: Alveolar crest levels ppear radiopaque. Bone level appears normal at level of implant platform. Image provided y authors.

Peri-implantitis

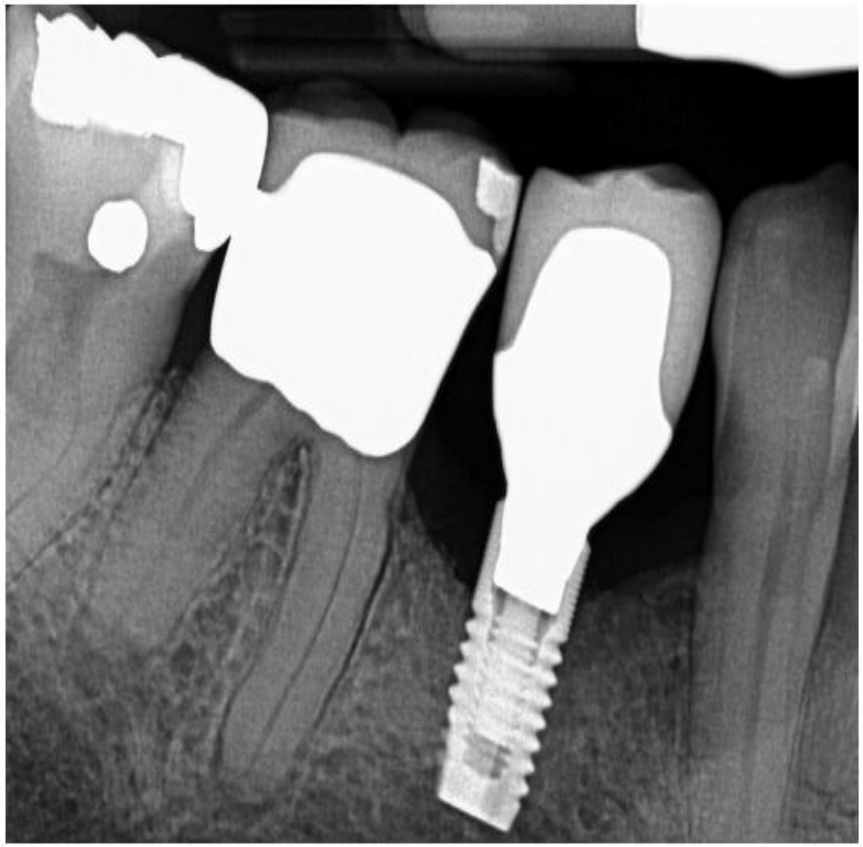


Fig. 29. Peri-implantitis, Lack of Keratinized Tissue Etiology (mandibular right premolar) periapical radiograph: Alveolar crest levels appear diffuse. Horizontal bone loss pattern noted. Image provided by authors.

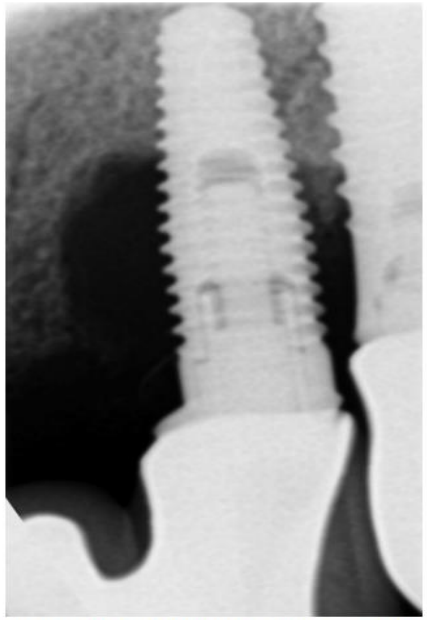


Fig. 27. Peri-implantitis, Bacterial Etiology (maxillary anterior incisor) periapical radiograph: Alveolar crest levels appear radiopaque. Severely reduced abrupt vertical bone loss noted at mesial and distal aspect of implant housing. Image provided by authors.

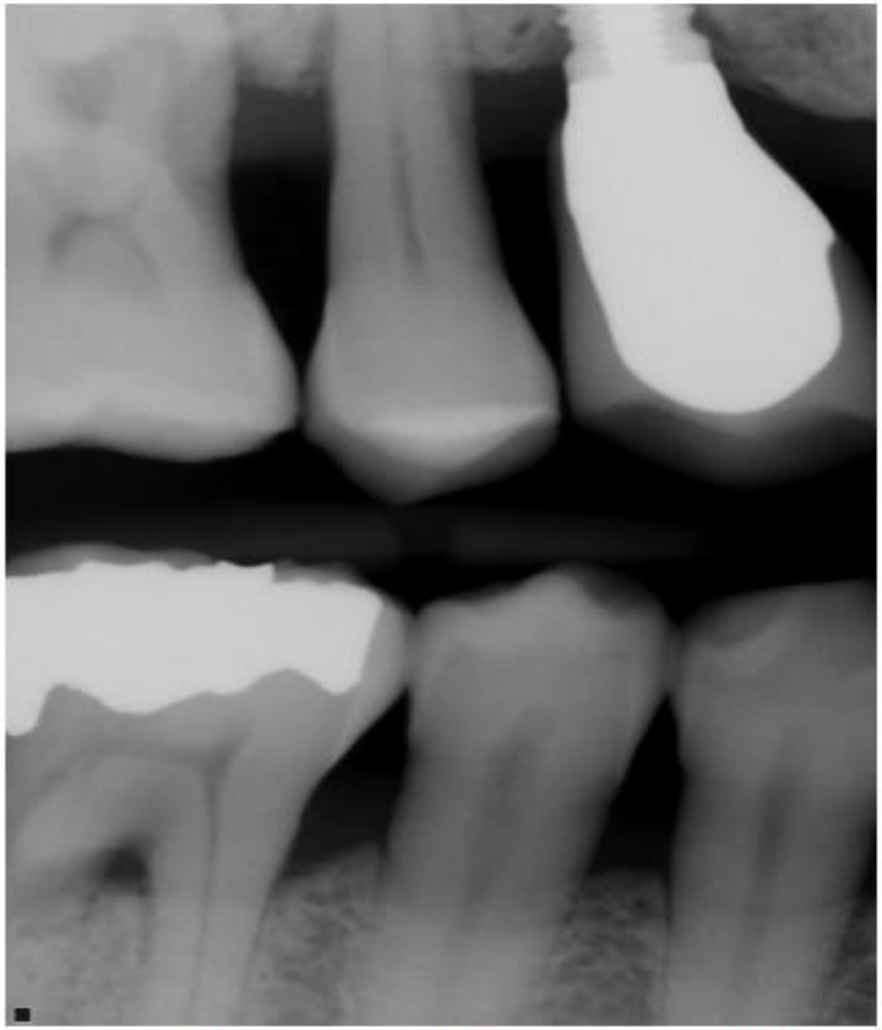


Fig. 14. Stage 3 Periodontal Disease (mandibular + maxillary right posterior) bitewing radiograph: Radiographic bone loss extending to the middle third of root and beyond. Furcation involvement class II and class III. Image provided by authors.

Occlusal trauma-widened PDL space, thickened lamina dura

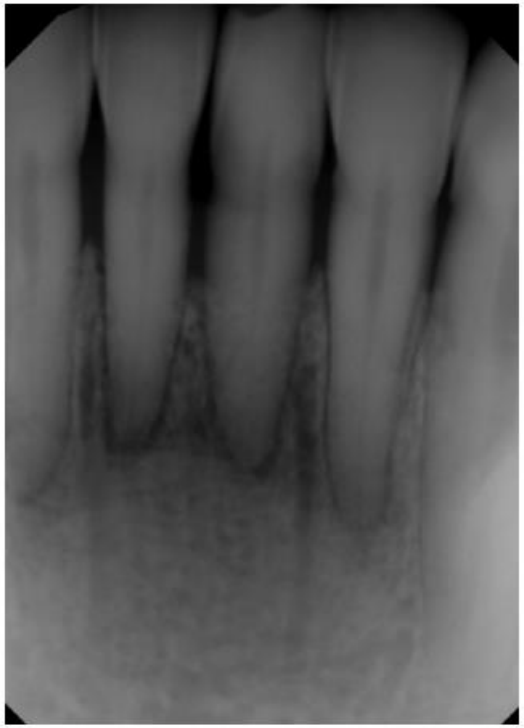
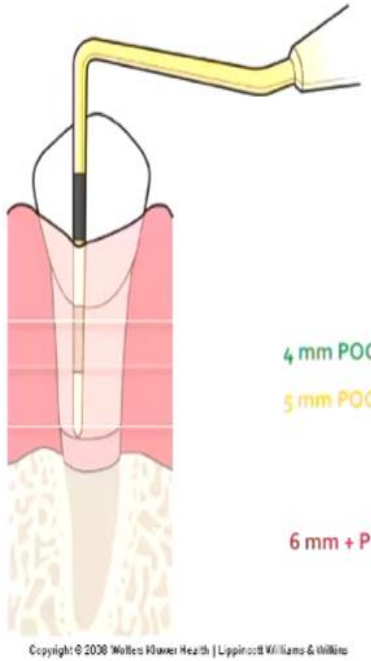


Fig. 17. Occlusal Trauma (mandibular anterior) periapical radiograph: Wear facet at occlusal aspect of central incisor. PDL spaces appear widened with reduced alveolar bone support. Image provided by authors.

STAGE	CAL PERSPECTIVE	POCKET PERSPECTIVE
Stage I	CAL 1-2 mm	4 mm POCKET
Stage II	CAL 3-4 mm	5 mm POCKET
Stages III & IV	CAL 5 mm +	6 mm + POCKET



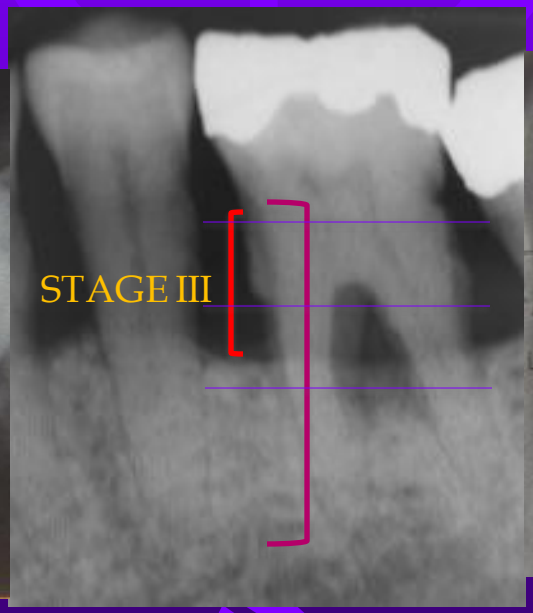
BONE LOSS PERSPECTIVE

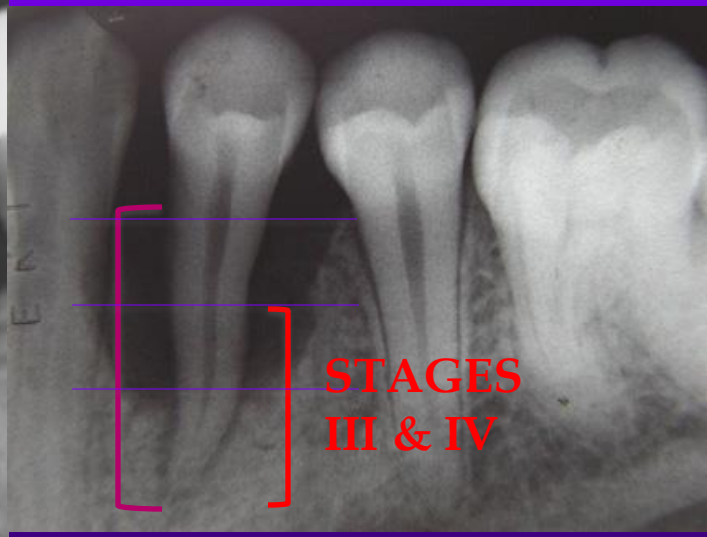
1-15%

15-33%

33 to 100%

Severity





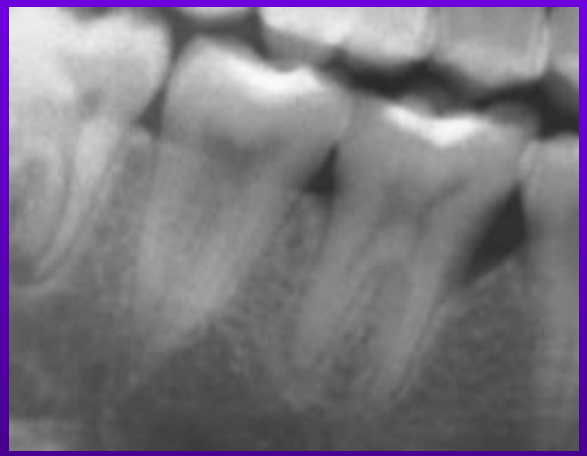
Radiographic Interpretation-
MORPHOLOGY OF BONE LOSS

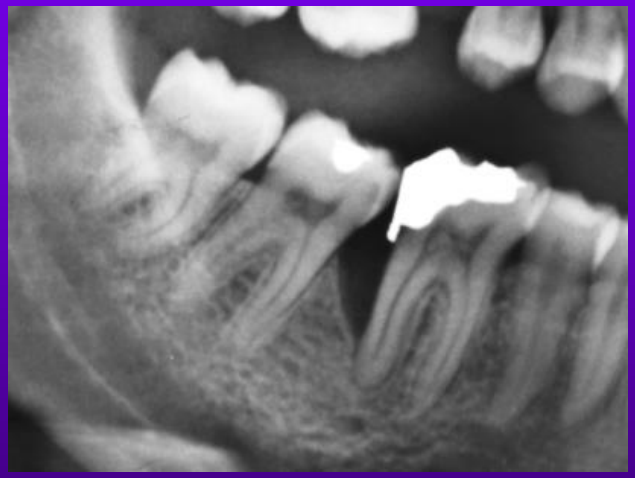
- Bone loss type
  - Horizontal bone loss
  - Vertical bone loss

Assessing bone loss more difficult on 2D images

Fig. 7. Periodontal Disease (maxillary right anterior) periapical radiograph: Alveolar crest levels appear indistinct, with vertical (angular) bone loss that is not parallel to the CEJs of adjacent teeth. Image provided by authors.

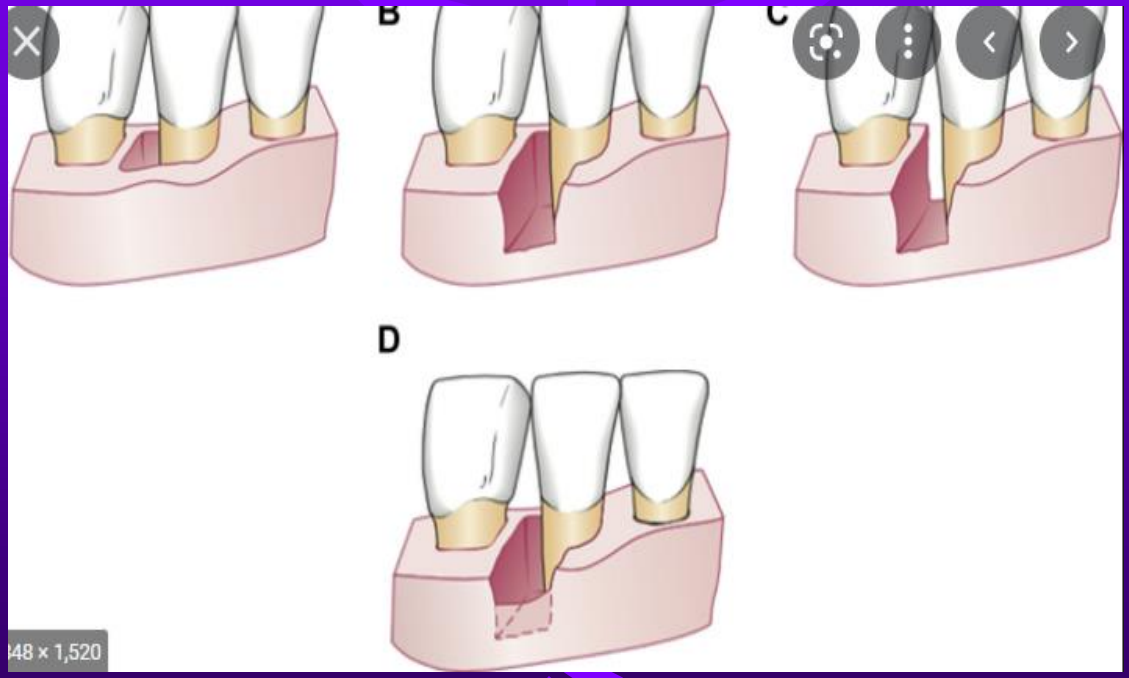
Vertical/ angular/intrabony/infrabony/crater bone defects- different types





PATTERN OF INTRABONY DEFECTS; 1,2, 3 WALLED DEFECTS

NUMBER OF REMAINING WALLS



CRATER DEFECTS

Buccal and lingual plate higher than the base of a defect- difficult to detect on 2D imaging- may appear as more radiolucent except if B/L bone very thick

RADIOPAQUE HORIZONTAL LINE FOR LABIAL OR LINGUAL BONE LEVEL

DISTRIBUTION

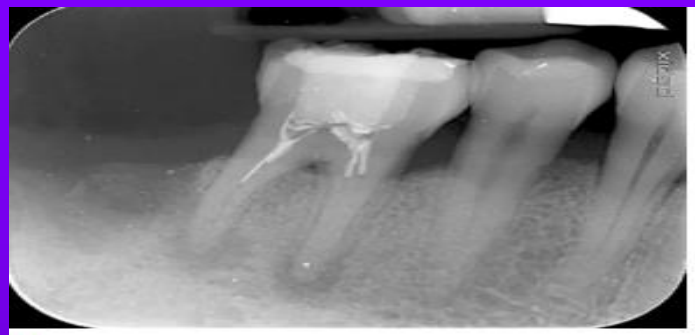
Localised less than 30%

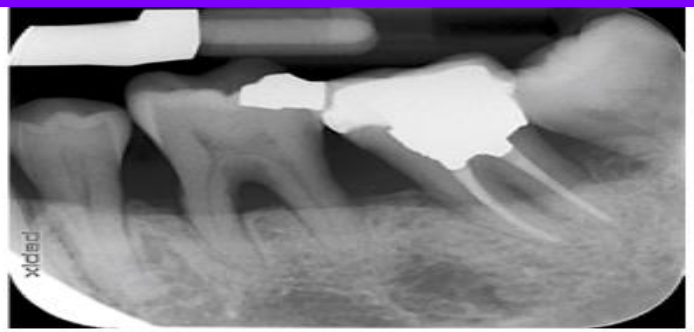
Generalised more than 30%

FURCATION DEFECTS

- In multirooted teeth, hard to see bone loss in furcations on 2D images because of superimpositioning of bone and roots
- Variations in radiolucency may help detect bone loss
- Inverted J shape on maxillary molars- sign of distal furcation bone loss
- Unless the radiograph is standardised and reproducable, very hard to compare before and after treatment/ deterioration.
- CBCT more accurate as a diagnostic tool but not recommended for follow-up and monitoring

Interpretation of Furcation defects in 2 D imaging





(c)

Fig. 23-18 Various stages of furcation involvement as depicted on periapical images. (a) The radiograph shows a slight radiolucency in the most coronal aspect of the furcation of tooth 46. (b) This periapical radiograph shows radiolucency in the furcation of tooth 36 that reaches the middle-third of the root. Different crestal bone levels may mimic no radiolucency in the furcation of tooth 37. (c) This radiograph exhibits a radiolucency of the furcation of tooth 26 that extends up to the apex of the respective roots.

Fig. 23-19 A periapical image demonstrating a radiolucent triangle superimposed over the distal roots of tooth 26 and demonstrating the hooks of the "J" shaped radiolucency on the distal root of tooth 27, both of which indicate bone destruction extending into the furcation of the respective regions (yellow circles).

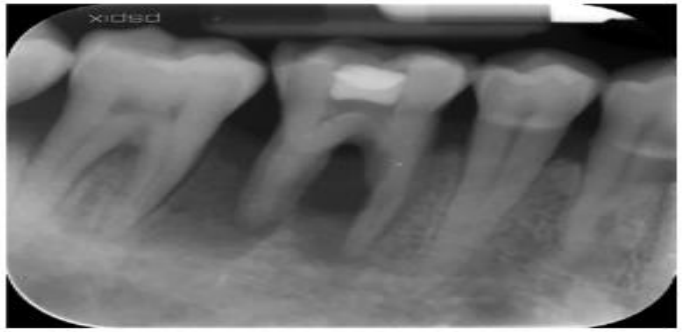
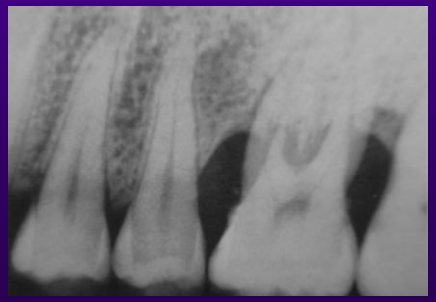


Fig. 23-20 This periapical image shows an extended radiolucency from the alveolar crest to the periapical region of tooth 46. This points towards the presence of periodontal and periapical inflammatory pathologies (perio-endo lesion).

PERIODONTITIS RADIOGRAPHIC APPEARANCE

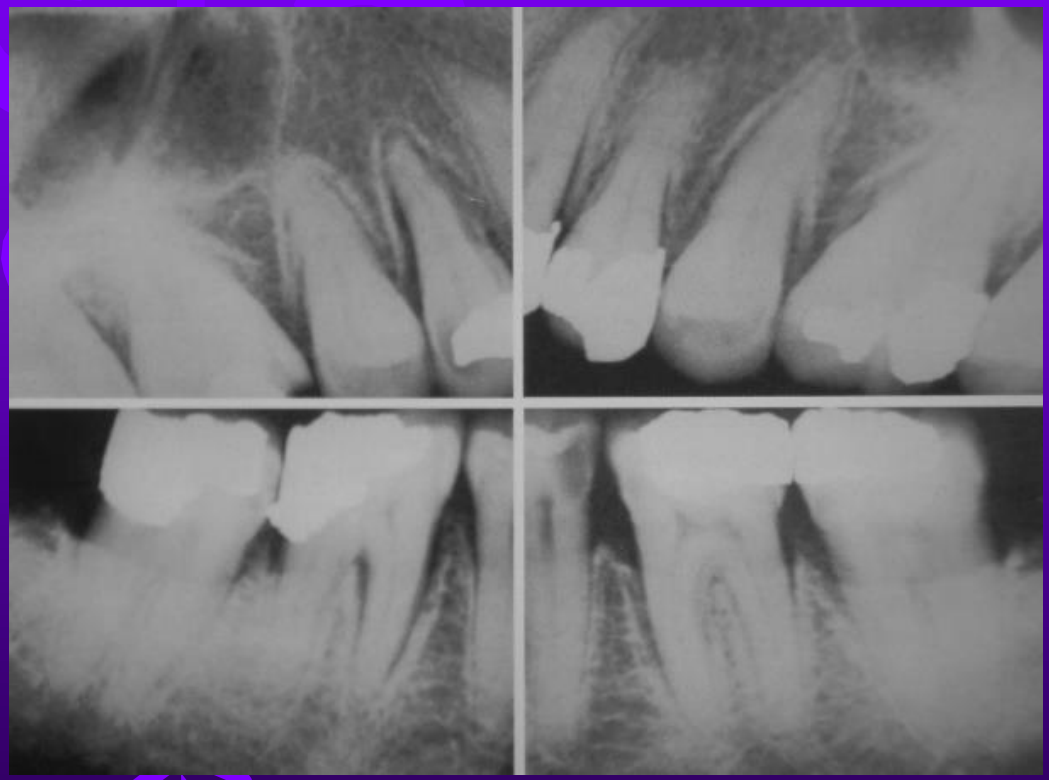
- Depends or radiographic technique, tube angulation and film placement
- Also depends on anatomical variations thickness and density of interdental bone, position of teeth
- Presence of an intact lamina dura indicates health but its absence doesn't mean disease
- Furcations may appear as a wedge shaped radiolucent area mesial and or distal with apex pointing to the crown

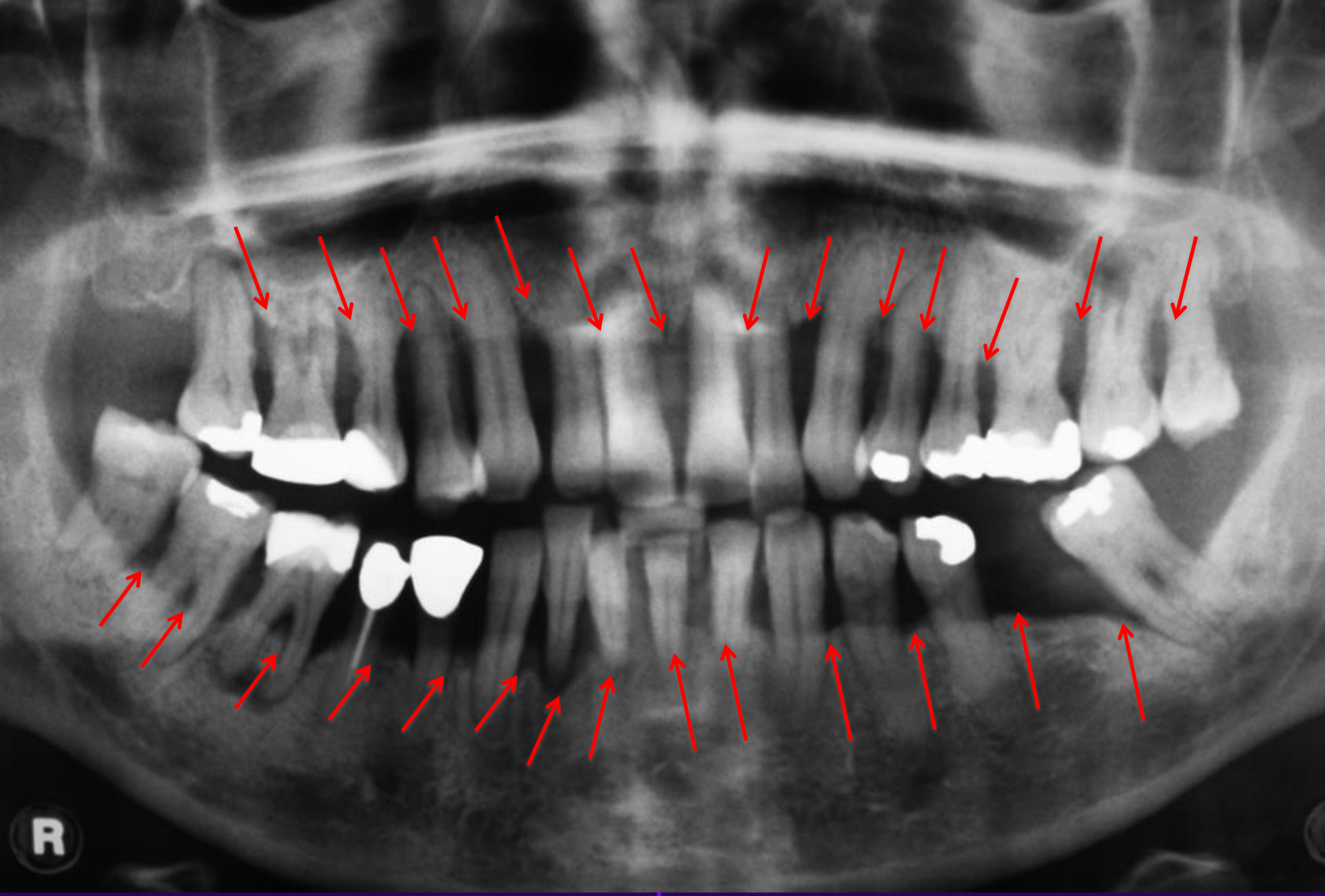


HEALING AFTER TREATMENT

Some Systemic conditions can present with periodontal manifestations radiographically

- OSTEITIS FIBROSA
- PAGET' S DISEASE
- FIBROUS DYSPLASIA
- HISTIOCYTOCIS
- OSTEOPETROSIS
- SCLERODERMA
- MALIGNANCY
- CARCINOMA OF THE JAW
- OSTEOSARCOMA

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Recommendations for Periodontal disease assessment

- OPG is sufficient for an overview- occasionally and alternatively full-mouth periapicals can be used .
- Additional intraoral views can be used for more detail on bone levels and root morphology- however limited detail on furcation and intrabony defects.

- CBCT/MDCT provides a lot more detail if accuracy is important in evaluation of prognosis and treatment planning- but not recommended for follow-up examinations

When is VOLUMETRIC ANALYSIS useful IN PERIO

- To determine the extent and pattern of periodontal bone loss, including infrabony defects , dehiscences, fenestrations
- Furcation morphology ie width of entrance, pattern of bone loss in furcations
- Root morphology
- Root fractures
- Periapical status
- Origin of infection
- Pre-surgical/ implant planning
- Pre-ortho in thin phenotypes/ perio patients

To conclude

- Justification- Prescribe radiological exam only if clinical exam does not provide sufficient diagnostic information

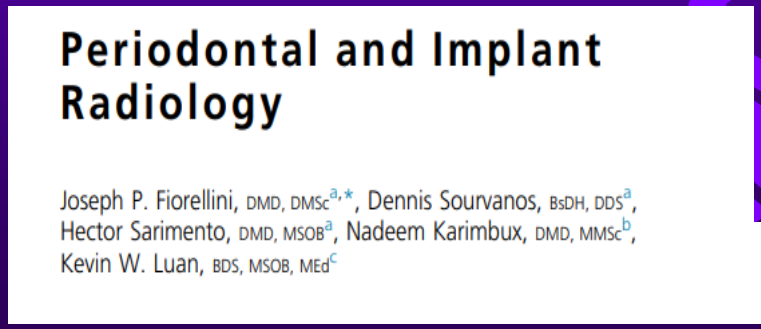
- Optimization- Follow the lowest dose protocol to achieve the diagnosis

Keep updated in theories and techniques of radiological assessment

- THANK YOU!

- RECOMMENDED READING -

Lindhes Clinical Periodontology and Implant Dentisty 7th edition Chapter 23.



Periodontal and Implant Radiology

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