Other views used in orthodontic diagnosis:

1-INTRAORAL RADIOGRAPHS

The intraoral radiographs are the easiest to take for most orthodontic patients. They formed the mainstay for all orthodontists till the advent of the orthopantomogram. Still they are the most frequently used as all centers may not possess the orthopantomogram.

They are also recommended for specific regions in all cases where a doubt remains regarding the clarity of the orthopantomogram as seen below.

The most frequently used views include:

- Intraoral periapical radiographs (fOPA)
- Bitewing radiographs
- Occlusal radiographs.

INTRAORAL PERIAPICAL RADIOGRAPHS

A full set of ten IOPAs was recommended before the advent of the orthopantomogram. They covered all the present teeth and the adjacent teeth. They are still ideal for the detection of anomalies related to changes in the size, shape and content of the tooth structure and / or the laminadura and/ or the periapical region.

The main disadvantages of the IOPAs includes the increased radiation that a person has to undergo to cover the full complement of his/her teeth. Also at times the patient is not cooperative, and may not allow the repeated placement of films in the desired manner in his/her mouth.

With the increased use of OPGs, the use of IOPAs has reduced considerably. Yet, they are ideal for localized views in relatively small areas of interest because of the excellent clarity that they allow.

BITEWING RADIOGRAPHS

They are seldom used but are ideal for the detection of proximal caries and the study of interdental bone height in these areas.

OCCLUSAL RADIOGRAPHS

lntraoral occlusal radiographs are of special interest to an orthodontist when dealing with impacted teeth or for the study of the labio-lingual position of the root apices in the anterior segments of the maxillary and the mandibular dentition.

They are particularly useful in the maxillary arch, for assessing root form of the incisors, the presence of midline supernumerary teeth and canine position, either alone or in combination with additional views using parallax.

2- Hand-Wrist Radiographs: Since orthodontist works primarily with teeth and bone, the skeletal age or bone age can provide reliable information while helping in accurate growth prediction.

Hand-wrist radiographs have been widely used to assess skeletal maturity. However, evaluation of cervical vertebrae on lateral cephalograms is gaining popularity in the recent years.

The basis of using hand-wrist radiographs for assessing skeletal age is that the skeleton in the hand-wrist region is made of numerous small bones (27 small bones + distal ends of long bones radius and ulna); these numerous bones in the hand-wrist region are derived from a total of 51 separate growth centers . The development of these bones from the appearance of calcification centers to epiphyseal plate closure occurs throughout the entire postnatal growth period and therefore provides a useful means of assessing skeletal maturity.

Correlation: Hand-wrist radiographs have been correlated to:

1- Dental development

2- Peak height velocity

3- Cervical vertebrae

4- Cranial base outline

5- Spheno-occipital synchondrosis

Three-dimensional imaging

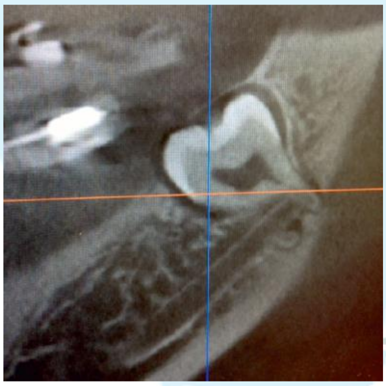
Plain film and cephalometric radiography are invaluable for accurate diagnosis and treatment planning, but they only provide a two-dimensional image of a three-dimensional structure, with all the associated errors of projection, anatomical superimposition, landmark identification, measurement and interpretation.

A number of three-dimensional imaging techniques have been developed over the past decade, which help to overcome some of these shortcomings and give the orthodontist greater information for diagnosis, treatment planning and research as:

A-Cone beam computed tomography:

Imaging of the hard tissues composing the jaws and dentition using conventional computed tomography (CT) is largely impractical, due to the high radiation dosage, lack of resolution and significant cost. The introduction of cone-beam computed tomography (CBCT) has resulted in the dosage being reduced and the resolution significantly improved, with its adaption and refinement for imaging of the teeth and jaws now providing a useful three-dimensional diagnostic tool.

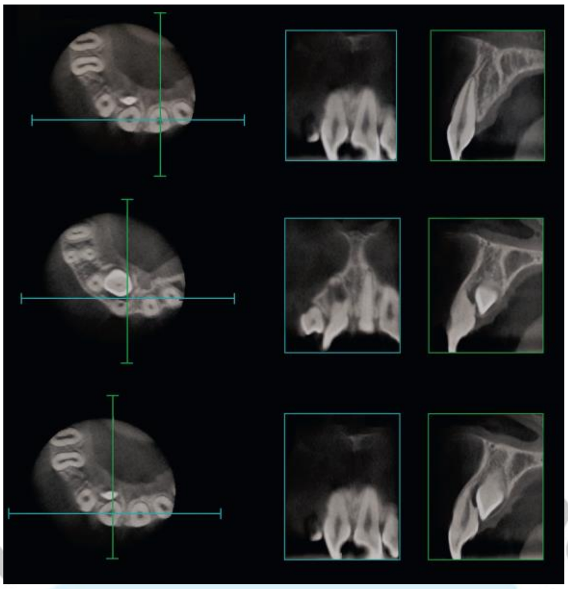
There is little doubt that the images that can be obtained from CBCT are impressive, allowing accurate visualization and analysis of the teeth and jaws in three-dimensions.



Cone-beam computed tomography image of an impacted LL8 demonstrating an intimate relationship between the roots and inferior alveolar nerve.

CBCT can also be very useful for airway analysis, assessment of alveolar bone height and volume prior to implant placement and imaging of temporomandibular joint morphology.

In orthodontics, it is particularly useful for the diagnosis of impacted and ectopic teeth, allowing their accurate localization and the visualization of any associated resorption (Fig. below).



Cone-beam computed tomography images of an impacted maxillary canine causing resorption of the central incisor.

However, it should not be forgotten that the radiation dose from traditional intraoral and extraoral radiography is significantly less than that from CBCT imaging of the same area (see Table below).

Table 6.1 Radiographs used in orthodontics and dose equivalence

Radiographic examination	Effective radiation dose (µSv)	Equivalent background radiation (days)	Risk of fatal cancer (per million)
DPT	3–38	0.5–5	0.2–1.9
Cephalometric lateral skull	2–5.6	0.3–0.45	0.34
Upper standard occlusal	8	1.2	0.4
Bitewing/periapical	0.3–2.2	0.15–0.27	0.02–0.6
Conventional CT scan (maxilla)	100–3000	15–455	8–242
Conventional CT scan (mandible)	350–1200	53–182	18–88
Chest	14	3	2
CBCT (small volume)[a]	10–67	4–10	
CBCT (large volume)[a]	30–1100	10–42	

Figures are based upon Radiation Protection 136, (2004). European Guidelines on Radiation Protection in Dental Radiology. The Safe Use of Radiographs in Dental Practice. European Commission. It should be emphasized that these only represent a guide and are regularly updated as new recommendations are made, particularly with regard to tissue weighting factors in the calculation of effective doses.
CBCT, cone-beam CT; CT, computerized tomography; DPT, dental panoramic tomograph.
[a]Cone-beam CT data is based upon Pauwels et al (2012) and the 2011 SEDENTEXCT publication.

Therefore, it is important for the orthodontist to satisfy themselves that a particular question cannot be answered with conventional radiography, before prescribing a CBCT.

The European Commission funded SEDENTEXCT (Safety and Efficiency of a New and Emerging Dental X-ray Modality) project has developed evidence-based guidelines on the use of CBCT in dentistry, focusing on referral criteria, quality assurance and optimization strategies. A set of definitive guidelines was published in 2012, which reiterated that CBCT examinations have to be justified for each individual patient, with sufficient clinical information required to demonstrate that the potential benefits of such an examination outweigh the risks.

In all cases, CBCT examinations should ideally add new information that will aid patient management. This means that there is a requirement to accurately interpret all the anatomy, both normal and abnormal, of any CBCT imaging that has been prescribed, something that not all prescribing clinicians may have the competence to do.

This document also focused more specifically on the role of CBCT in orthodontic diagnosis, making a number of recommendations:

1- The routine use of CBCT in orthodontic diagnosis is to be discouraged;

2- CBCT may be indicated for the localized assessment of an impacted tooth (including consideration of resorption of an adjacent tooth) when the information cannot be obtained adequately by lower dose conventional radiography.

3- CBCT is not normally indicated for planning the placement of temporary anchorage devices(miniscrews).

4- CBCT is indicated for orthognathic surgical planning where bone information is required for obtaining three-dimensional datasets of the craniofacial skeleton; For complex cases of skeletal abnormality, particularly those requiring combined orthodontic and surgical management, large volume CBCT may be justified for use in planning the definitive procedure, particularly where conventional CT is the current imaging method of choice.

5- Where the current imaging method of choice for the assessment of cleft palate is conventional CT, therefore CBCT may be preferred if the radiation dose is lower.

6-Where the existing imaging modality for examination of the temporomandibular joint is conventional CT, so CBCT is indicated as an alternative where the radiation dose is shown to be lower.

CBCT in orthodontics, based upon the quantification of benefit in patient outcome. A key factor in many cases is whether the additional information provided by CBCT imaging actually influences treatment.

For example, despite the advantages of CBCT in tooth localization and the identification of root resorption, and some evidence that this information can change treatment planning, there is little or no evidence as to whether this actually improves treatment outcome (Botticelli et al, 2010; Katheria et al, 2010).

Cone beam computed tomography (CBCT) now allows the acquisition of detailed 3D images of the face in high resolution. Using this 'virtual' 3D information, software is being developed that could revolutionize the way that orthognathic planning and surgery is undertaken.

Computer-aided surgery (CAS) is now being introduced that will allow surgical planning and simulation using the information captured from CBCT.

This technology offers a number of potential exciting possibilities:

• A more detailed appreciation of the anatomy of the patient in three dimensions (Fig. a).

• The data from CBCT can be combined with the data captured from 3D facial camera systems. This allows the clinicians to see the relationship of the soft tissues with the underlying hard tissues (Fig. b). Virtual surgery can then be undertaken on this 3D model and the eff ect on the overlying soft tissues assessed (Fig. c).

The accuracy of these 3D predictions will improve as we gather more data on the 3D effects on soft tissues of combined orthodontics and orthognathic surgical treatment.

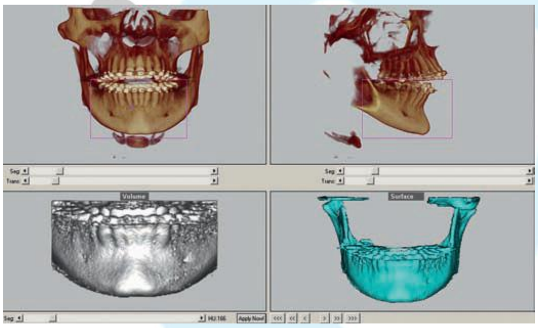
• Virtual surgery will allow the surgeon to calculate the most appropriate and safest osteotomy lines in advance of the operation (Fig. d).

• Once the team is happy with the final virtual surgery, this virtual setup

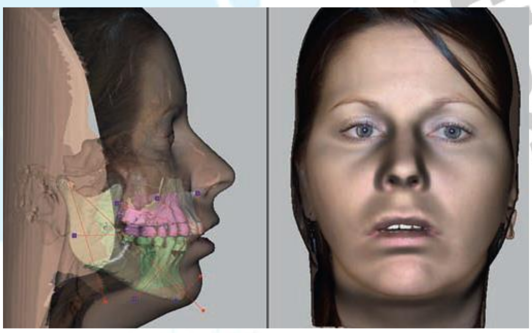
canbe used to manufacture positioning splints (Fig. e) and construct customized fixation plates.

• The developments described so far have been based on the surgery being planned and executed virtually. However, the surgeon, not the computer, will perform the actual surgery, so the next challenge is to ensure the surgeon follows the virtual plan. Surgical navigation systems are being developed to help transfer the information from the virtual plan into the operating room. They will use tracking devices to follow surgical instruments and the patient’s changing anatomy, and using a navigation screen will help to guide the surgeon in making the appropriate cuts and ensure correct positioning and fixation of the bone segments.

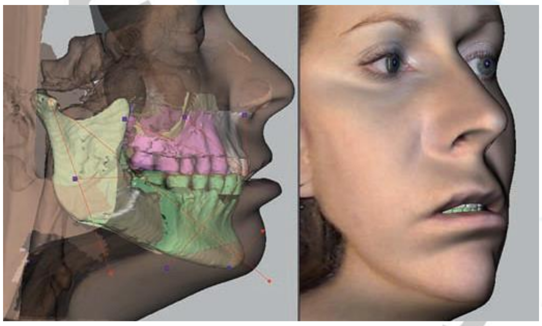
Future developments in 3D technology are likely to fundamentally change our approach to combined orthodontic and orthognathic treatment in the future, in terms of diagnosis, treatment planning and, eventually, in the execution of the surgery.



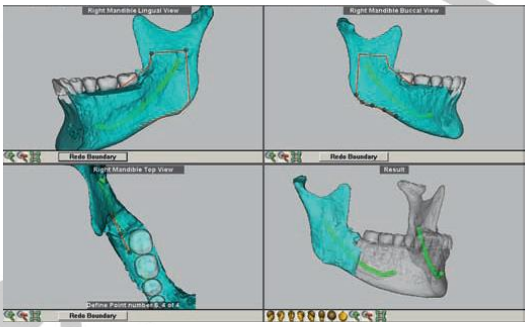
a- Detailed 3D information of the anterior mandible captured from CBCT



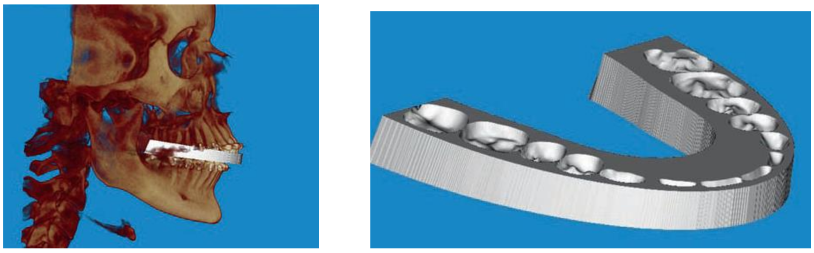
b- Information from the CBCT has been combined with information from 3D facial camera system



c- 3D prediction of bimaxillary osteotomy.



d- Virtual osteotomy cuts in the mandible. Note the inferior alveolar nerve clearly marked in green.



e,f- Designing a surgical splint to be used during the operation.

B-Optical laser scanning and stereo photogrammetry

Other less invasive techniques for generating three-dimensional images of the facial soft tissues have also been developed. Optical laser scanning utilizes a laser beam, which is captured by a video camera at a set distance from the laser and produces a three dimensional image.

Fig.:An example of a 3D stereophotogrammetry system (3dMDcranial™ System) in a clinical research setting

The mechanical bed offers a safe surface upon which to secure a booster seat, while allowing the photographer to adjust the participant to ensure an optimal image capture.

More recently, stereo photogrammetry has been developed, which involves taking multiple pictures of the facial region simultaneously . This allows the creation of a three-dimensional model image using sophisticated stereo triangulation algorithms. These techniques are now being used to :

1-Study facial growth

2- Soft tissue changes in normal populations

3- Investigate the effects of orthodontic and surgical treatment.