Diagnostics records

(Photographs, 3D imaging and other views)

Orthodontic records may be required for a number of possible purposes:

- Diagnosis and treatment planning.
- Monitoring growth.
- Monitoring treatment.
- Medico-legal record.
- Patient communication and education.
- Audit and research.

Data required for orthodontic diagnosis are derived from routine essential diagnostic aids and also from supplemental aids when needed. The diagnostic aids has been categorized into essential and supplemental diagnostic aids.

Essential

As the name suggests, these aids are indispensable for appraisal of the condition and it's etiology for treatment planning. Essential diagnostic aids include: Case history, clinical examination, study models, certain radiographs, and facial and intraoral photographs.

Supplemental

Supplemental diagnostic aids may be needed in certain cases and these aids usually require specialized equipment. These include: Specialized radiographs (e.g hand-wrist radiograph). Electromyography to assess muscle activity, Endocrine tests, estimation of basal metabolic rate and Occlusograms.

✓ FACIAL PHOTOGRAPHS:

Facial photographs are the easiest to store, occupy the least amount of space and provide immense information to the clinician as well as the patient.

Photographs can be:

1- Extraoral photographs.

Extraoral photographs are considered essential records and should be taken before starting treatment and after completion of treatment. All extraoral photographs should be taken in the natural head position, preferably without any shadows appearing in the background. The ears should be exposed (for the purpose of orientation) and the patient should not be wearing eye ware. It would be ideal if the distance and magnification could be standardized.

Uses of extraoral photograph:

1. Evaluation of craniofacial relationships and proportions before and after treatment.

2. Legal point of view.

3. Assessment of soft tissue profile.

4. Proportional facial analysis and/or photographic analysis.

6. Monitoring of treatment progress (if standardized).

7. Invaluable for longitudinal study of treatment and post retention follow-up.

8. Detection and recording muscle imbalances.

9. Identifying patients.

It is recommended that at least three extra-oral photographs be taken for all patients.

This includes (see the figure below):

A-Frontal facial with lips relaxed.

B-Facial profile with lips relaxed.

C - Three-quarter view, smiling. or D- Frontal facial, smiling.

A B C D

Or facial photographs could involve more views to have a record of tooth–lip relationships in other views as seen in the figure below:

2- INTRAORAL PHOTOGRAPHS

Intraoral photographs are simple to take, maintain and store and of course useful, nevertheless, they are neither standardized nor three dimensional. Better to be taken before, during and after finishing the treatment.

These are used for:

1- Helpful in explaining and motivating the patient.

2- They are also used to monitor treatment progress and results.

3- They are also helpful in medico-legal cases involving the texture and color of teeth especially pre-operatively.

4- Assessing and recording health or disease of the teeth and soft tissue structures.

5- Study of relationships before, immediately following and several years after treatment, to improve treatment planning.

These intraoral photographs should be taken (see the figure below).

1. One frontal photograph in maximum intercuspation (B).
2. Two lateral views-right (A) and left (C).
3. Optional-two occlusal views-maxillary (D) and mandibular (E).

✓ RADIOGRAPHS

Any radiograph carries a low but identifiable risk, so each radiograph must be clinically justified. A radiograph is only prescribed after a full clinical examination to ensure that information cannot be gained by a less invasive method. When considering interceptive or active orthodontic treatment, a radiograph may provide additional information on:

• Presence or absence of teeth • Stage of development of permanent dentition • Root morphology of teeth, including root length and any existing root resorption. • Presence of ectopic or supernumerary teeth • Presence of dental disease • Relationship of the teeth to the skeletal dental bases, and their relationship to the cranial base.

A number of radiographic views are routinely used by the orthodontist and they are important diagnostic tool in assessing an orthodontic condition and in determining suitable treatment plan.

1) **Orthopantomograph (OPG) and Cephalometric radiograph**. (Discussed in details in previous lectures).

2) PERIAPICAL RADIOGRAPHS

A full set of ten periapical x-rays was recommended before the advent of the orthopantomogram (OPG). 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 lamina dura and/or the periapical region.

The advantages of periapical radiographs are:

1- Low radiation dose.

2- Excellent clarity of teeth and their supporting structure.

3- Possibility of obtaining localized view of area of interest.

The main disadvantages of the Periapical x-ray 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 periapical x-ray has reduced considerably. Yet, they are ideal for localized views in relatively small areas of interest because of the excellent clarity that they allow.

3) BITEWING RADIOGRAPHS

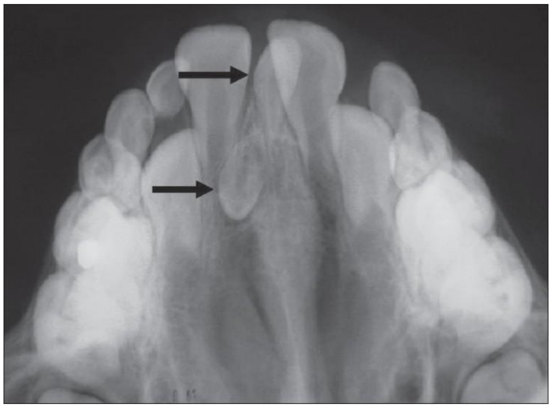
They are seldom used but are ideal for the detection of proximal caries, assessment of existing restorations and the study of interdental bone height in these areas.

4) Occlusal radiograph

Occlusal radiographs are used in patients who are unable to open their mouth wide enough for perapical radiographs and are selected in special cases. Intraoral 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. In cases of cleft palate or other congenital anomalies of the maxilla, occlusal radiographs can provide valuable information for treatment planning.

Periapical radiograph

Bitewing radiograph



Occlusal radiograph (showing supernumerary teeth (arrowed)

5) Hand-Wrist and cephalometric Radiographs for skeletal maturity:

The level of maturity attained and the amount of growth potential remaining is an important consideration while treating malocclusions. The maturational status of the patient has a strong bearing on orthodontic diagnosis, treatment planning, outcome of the treatment and post-treatment stability. The prepubertal growth spurt is considered to be an advantageous period for certain types of orthodontic treatment, such as growth modification procedures using orthopedic and functional appliances; while orthognathic surgeries are best carried out after the cessation of growth.

Chronological age is an unreliable guide for the assessment of children's maturational status due to the wide individual variation observed in terms of timing, duration and velocity of growth. Children of same age may vary in their maturity status a great deal; therefore, maturity indicators have been developed using other parameters, such as height gained, secondary sex changes, dental development and skeletal ossification.

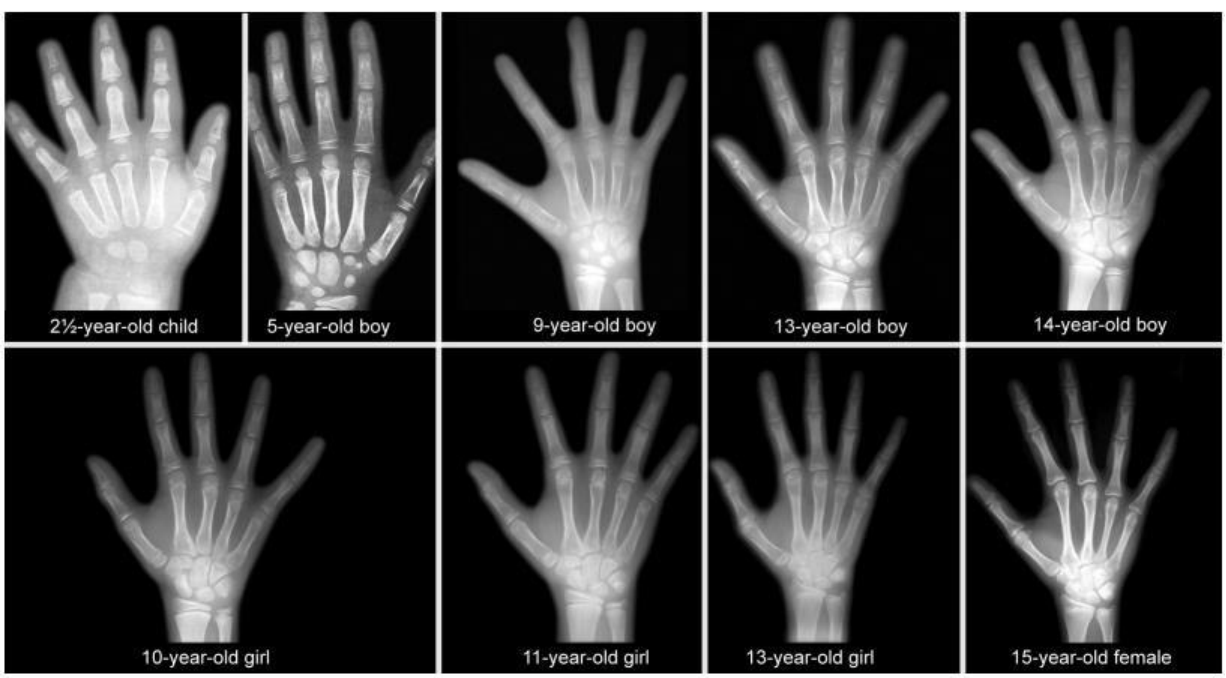
Since orthodontist works primarily with teeth and bone, the skeletal age or bone age can provide reliable information while helping in accurate growth prediction. Hand-wrist radiographs have been widely used to assess skeletal maturity. However, evaluation of cervical vertebrae on lateral cephalograms is gaining popularity in the recent years.

A) Hand-Wrist radiograph

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. Different ossification centers in hand and wrist appear and mature at different times. The appearance and progression of ossification in various ossification centers follows a predictable and scheduled pattern which can be standardized. To do this, a hand–wrist radiograph of the patient is simply compared with standard radiographic images in an atlas of the development of the hand and wrist. It has been shown that stages of hand–wrist development correlate reasonably well with the adolescent spurt in growth of the mandible.

For example the phalanges are ossified from a primary center for the shaft and a proximal epiphyseal center. Ossification in the shaft (primary center) begins prenatally. The epiphyseal centers (secondary centers) appear postnatally around two to four years of age. Ossification in the epiphyses continues progressively and the fusion of the epiphyses with their respective diaphyses is completed during puberty at about 15th–16th year in females and 17th–18th year in males. The phalanges appear to ossify in three stages (Figure 1). Stage 1: The epiphysis and the diaphysis are equal. Stage 2: The epiphysis caps the diaphysis by covering it like a cap. Stage 3: Fusion occurs between the epiphysis and the diaphysis.

Figure 1: Stages in ossification of phalanges; (A) Stage 1: The epiphysis and the diaphysis are equal; (B) Stage 2: The epiphysis caps the diaphysis by connecting it like a cap; (C) Stage 3: Fusion occurs between the epiphysis and the diaphysis.



Development of numerous small bones of the hand-wrist region occurs throughout the entire postnatal growth period and thus provides a useful means of assessing skeletal maturity

Correlation: Hand-wrist radiographs have been correlated to:

- ✓ Dental development.
- ✓ Peak height velocity.
- ✓ Cervical vertebrae.
- ✓ Cranial base outline.
- ✓ Spheno–occipital synchondrosis.

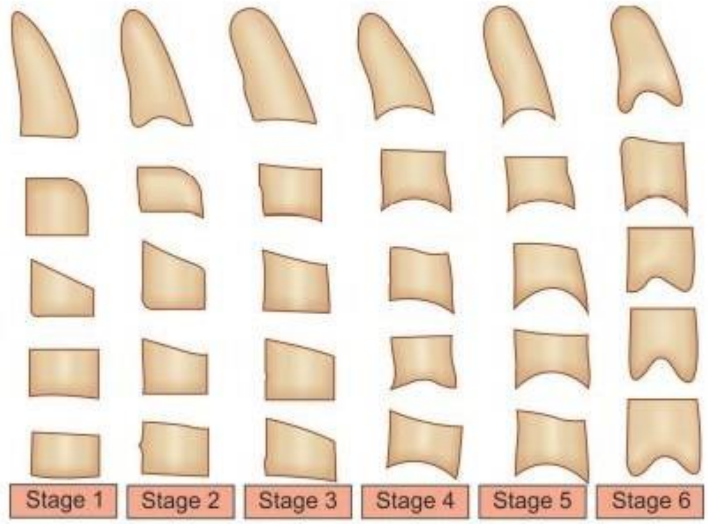
B) Cervical vertebrae skeletal maturity indicator.

Hand-wrist radiographs have been used conventionally as the standard method of evaluating skeletal maturity. Although accurate, this method necessitates additional radiation exposure to patients. Furthermore, the handwrist site is far removed from the jaw, which is the site of orthodontic correction. In recent years, evaluation of cervical vertebrae has been increasingly used to determine skeletal maturation. A new system of skeletal maturation assessment using the cervical vertebrae was first developed by Hassel and Farman. A number of subsequent studies have shown significant correlation between developmental or maturational changes occurring in the cervical vertebrae than that of the hand-wrist region. Cervical vertebrae maturity indicator (CMVI) method is increasingly being used in the recent years instead of the conventional hand-wrist radiograph method. One of the main reasons for the rising popularity of the method is that cervical vertebral maturation can be assessed on lateral cephalograms, which is used regularly in orthodontic diagnosis, thus, precluding the need for an additional radiograph.

Most methods of cervical vertebral maturation are based on morphologic changes that occur in cervical vertebral bodies as growth progresses. Hassel and Farman developed a method of skeletal maturation assessment using cervical vertebrae in which there are six stages of development.

They take into account the morphologic characteristics of the cervical (C2, C3 and C4) vertebrae, such as: Shape of the vertebral bodies, Height of the vertebral bodies and the concavity of the lower border of the cervical bodies. The changes in the shape of cervical vertebral bodies of C3 and C4 at each level of skeletal development are assessed.

Cephalometric radiograph



Assessment of skeletal maturity using cervical vertebrae

Stage 1: 80–95% of pubertal growth is remaining.

Stage 2: 65–85% of pubertal growth remains.

Stage 3: 25–65% pubertal growth is remaining.

Stage 4: 10–25% of pubertal growth is remaining

Stage 5: 5–10% pubertal growth remaining.

Stage 6: Pubertal growth is complete with no more growth potential remaining.

The advantages of using this method of assessment include the following:

1) **Ease of Use:** The assessment of CVMI is relatively straightforward. Orthodontists can quickly evaluate the patient's skeletal maturity by analyzing the shape and developmental stage of the cervical vertebrae on cephalometric radiographs.

2) **No Need for Additional Imaging:** Since cephalometric radiographs are routinely used in orthodontic diagnosis and treatment planning, there is no need for additional imaging procedures, reducing the patient's exposure to radiation.

3) **Patient Engagement:** CVMI results can be used to educate patients and their families about the expected timing and duration of orthodontic or orthopedic treatment. This can improve patient engagement and compliance with treatment recommendations.

6) 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:

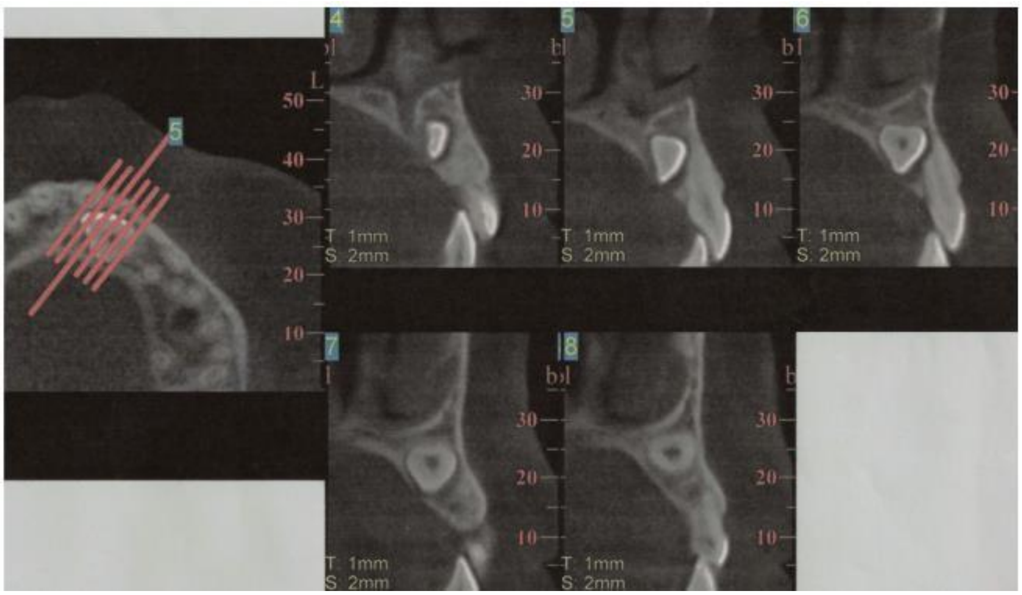
A) Cone-beam Computed Tomography (CBCT)

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) for views of the face and jaws in the early 21st century 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. CBCT can also be very useful for airway analysis, assessment of alveolar bone height and volume prior to implant placement and imaging of temporo-mandibular joint morphology.

Orthodontic Applications of Cone Beam Computed Tomography:

Conventional computed tomography (CT) imaging involves the use of rotating X-ray equipment, combined with a digital computer, to obtain images of the body. Using CT imaging, cross-sectional images of body organs and tissues can be produced. CBCT is a faster, more compact version of traditional CT with a lower dose of radiation. Through the use of a cone-shaped X-ray beam, the size of the scanner, radiation dosage, and time needed for scanning are all dramatically reduced. The three dimensional (3D) views produced may be useful in certain orthodontic cases:

- Accurate location of impacted teeth and a more accurate assessment of any associated pathology, particularly resorption of adjacent teeth.
- Assessment of alveolar bone coverage, height and volume.
- Severe facial asymmetry, especially asymmetries involving roll and yaw.
- Syndromes, congenital deformities, and sequelae of facial trauma.
- Planning of some complex combined orthodontics and orthognathic surgery cases



Cone-beam computed tomography (CBCT) of the patient with the impacted canine, confirming that there is a small amount of root resorption occurring on the palatal aspect of the upper left lateral incisor, close to the apex of the tooth.

There is a consensus that it provides new information that could improve the treatment plan in certain situations, and enough enthusiasm to lead some orthodontists to advocate use of CBCT on all orthodontic patients, replacing panoramic, cephalometric, and occlusal radiographs, as well as tomograms of the TMJ. There is a significant radiation dose increase in doing this. 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.

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.

Tooth Morphology and Relative Position within the Alveolar Bone

High-resolution images that include an arch quadrant or both upper and lower arches are needed to evaluate buccal and lingual plates of the alveolar bone, bone loss or formation, bone depth and height, presence or absence of unerupted teeth, tooth development, tooth morphology and position, amount of bone covering the tooth, and proximity or resorption of adjacent teeth. CBCT findings may lead to modifications in the treatment planning (e.g., avoid extraction, help decision of which tooth to extract, evaluate dilacerated roots or placement of bone plates and miniscrews), reduced treatment duration, and additional root resorption control and in the orthosurgical planning. Before placing temporary anchorage device (TADs), CBCT is being used as a clinical tool to identify optimal position and to avoid damage to roots. The use of surgical guides based on CBCT data has also been suggested.

Temporomandibular Joint Health and Disease

High-resolution images that include one joint at separate right and left acquisitions yield the best quality of images for TMJ assessments. The spectrum of the clinical and pathologic presentation of TMJ osteoarthritis ranges from structural and functional failure of the joint with disc displacement and degeneration to subchondral bone alterations and sclerosis and bone erosions.

Dentofacial Deformities and Craniofacial Anomalies

CBCT images offer the ability to analyze facial asymmetry and anteroposterior, vertical, and transverse discrepancies associated with complex craniofacial problems. The virtual treatment simulations using 3D virtual or printed surface models constructed from CBCT or CT images can be used for treatment planning in orthopedic corrections and orthognathic surgery and for printing surgical splints after performing virtually simulated surgery.

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.

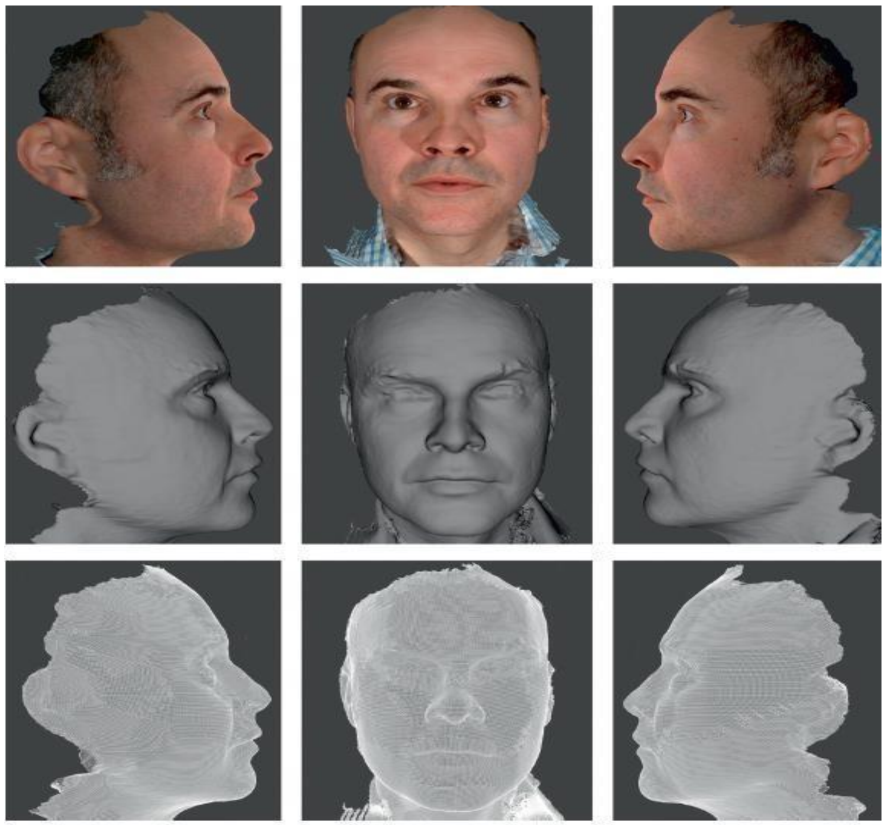
The mechanical bed offers a safe surface upon which to secure a booster seat, while allowing the photographer to adjust the participant to ensure an optimal image capture.

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.



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Good Luck