Advances in Cephalometry in Relation to the Shift in Soft Tissue Paradigm for Orthodontic Treatment Planning

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Abstract

The discovery of imaging and its use in orthodontics is a subject of technology describing biology. Developments in arch-wires,brackets and composites changed the mechanics of orthodontic treatment. The developments in imaging technology have changed the perception of the clinician as well as the patient towards esthetics. The newer imaging technology helps to study the craniofacial growth pattern of younger patients and to know the effect of orthodontic treatment on this dynamicprocess of growth. Earlier, in 20th century, 2-dimensional (2D) radiography was used,but in 21st century, the new 3-dimensional (3D) scanners use less ionizing radiation and give more information than conventional radiographs. This article is a review of the imaging technology used in orthodontic diagnosis and treatment planning from the use of the cephalostat to the introduction of cheap,reduced radiation Cone Beam imaging of 3D cephalograms.

Keywords: *Imaging, video cephalometry, 3D cephalogram.*

Introduction

"Adsanitatemgradusestnovissemorbum"- a Latin proverb means that, "The first step towards cure is to know what the disease is". Diagnosis is a Greek word meaning to discern among, to know differences between: Diagnosis is the determination of the presence or absence of the abnormal or undesired.

In orthodontic diagnosis, during the beginning of 20th century, only plaster cast was used. With the cast, we can get three dimensional view of dentoalveolar region of the jaws, but we are unable to get a picture of the relationship between the jaws and the cranium. To overcome these limitations and to know precisely the interrelationship between the functional components of craniofacial complex, roentgenographic cephalograms were introduced in 1930. Cephalometry had its beginnings in craniometry. Craniometry is defined as "the art of measuring skulls of animals so as to discover their specific differences". Cephalometry is measurement of the head including the soft tissues. Due to varying thickness of soft tissues there result many inaccuracies.

Even though these cephalograms overcome the limitations of the previous diagnostic method, they have got their inherent drawbacks. Despite the drawbacks, cephalometric radiography remains a vital clinical tool. And so, advanced technologies are now being used to overcome the limitations and make the cephalometry as a more acceptable tool in orthodontic diagnosis and treatment procedures.

History: The earliest method used was to assess the facial proportions from an artistic point of view, with beauty and harmony as the guiding principles. An intricate quantitative system which defined the proportions of the human body (canon) was developed by the Egyptians. The top three squares were subdivided by horizontal lines into five parts to draw the face in accurate detail. Indian iconometry studied by Ruelius showed that face height was used as the module of Buddhist proportional systems.[2]

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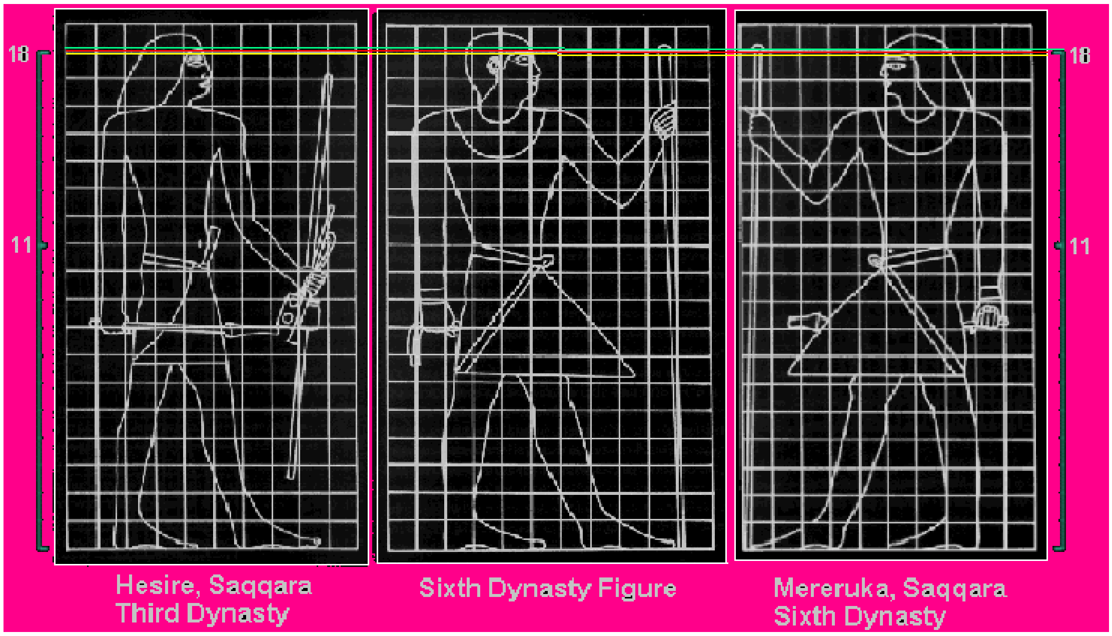

Figure 1. History of Cephalometry

Leonardo da Vinci (1459-1519) studied facial proportions, projected a coordinate system on the face, indicated a preference for 'proportional analysis' and each face was posed in 'natural head position'.[2] Petrus Camper (1722-89) oriented cranium in space horizontally parallel to a line drawn from the center of the acustic meatus to a point below the nose. It is used as the reference line for different measurements used to characterize evolutionary change in facial form and aging. Spix (1815) modified the Camper horizontal as a line from the prosthion tangent to the occipital condyle, but the face was rotated upwards yielding slightly greater prognathism.[3] Retsiusintroduced the terms prognathic and orthognathic where the angle between the horizontal line and nasion- prosthion line was used to determine the facial type. Roentgen (1895) discovered the X-rays which revolutionized the dental profession. Pacini and Carrera (1922)first described a method for standardization of head radiography by using a large fixed distance from the x-ray source to the cassette. Hofrath and Broadbent (1931)both developed a method for standardization of radiographs by fixing a constant focal-spot to object distance & a constant object to film distance. They used special holders the 'cephalostat' to hold the head in position.[4] Krogman and Sassouni (1957) introduced the term roentgenographic cephalometry for measurement of the head from bony and soft tissue landmarks on the radiograph.[4]

Uses Of Cephalometry:

1. Growth and Development: The first and major use of cephalometry is to appraise the growth and development. With the cephalometrics, the orthodontists can time his mechanical procedures to coincide pubertal growthspurt sand predict with some degree of accuracy what the end result will be.

2. Craniofacial Abnormalities: Cephalometrics aid in diagnosing various craniofacial abnormalities like impactions, congenital absence of teeth, cysts, supernumerary teeth, tonsillar and adenoid tissue, cleft lip and cleft palate and mandibular prognathism etc.

3. Facial Type: Sometimes the patients with clinically excellent occlusions will be having difference in facial and dental components Cephalometrics is useful in gaining knowledge about the compensations.

Two important relationships decide the facial type:

I. Position of maxilla anteroposteriorly in the face with reference to the cranium.

II. Relation of mandible to maxilla

4. Case analysis and Diagnosis There are three basic components a Cephalometrics analysis

I. **Skeletal Analysis:** It includes facial type anteroposterior apical base relationship.

II. **Profile analysis:** It is primarily an appraisal of the soft tissue adaptation to the profile of lip size, shape and posture; of soft tissue thickness over the chin; of nasal structure contour and relationship to lower face.

III. **Denture analysis:** It is an appraisal of tooth relationship with each other and with their respective bony bases.

5. **Progress Report:** Serialtracings offer much more information on developmental changes and on stability of orthodontic accomplishment. Usually, it is recommended to take the cephalograms for every three to four months.

6. **Functional Analysis:** For the functional analysis, the following cephalometric records are recommended.

I. Cephalogram in postural resting position, initial tooth contact and occlusion used to view the amount of interocculsal clearance and path of closure.

II. Wide open mouth cephalogram used to view the outline of the condyle

III. Cephalogram in end to end bite or Incision used to analysis the curve of free and amount of space between the posterior segments when the incisors in the contact.

IV. Phonetioncephalogram used to show the tongue and soft palate position and may assist the speech therapist.

V. Special view with barium, Iodochloral or other radio opaque media to determine the soft tissue function. They are particularly useful in cleft lip, cleft palate patients helping to analyze velopharyngeal function. Radio opaquing paste over the profile will assist in visualizing the soft tissue outline which is useful in cephalometric profile analysis.

Advantages of Conventional Cephalograms

I. Anteropostero and Vertical jaw discrepancy can be diagnosed with cephalometry.

II. The jaws are related to cranium only with the aid of cephalometry.

III. Predictions of growth and treatment outcome are made possible with cephalometry.

IV. Cephalometry is an important tool in assessing the growth and development and it is useful in research field.

V. Diagnosis and treatment planning in the field of orthodontics is improved to a significant level with the aid of cephalometry.

Disadvantages of Conventional Cephalograms:

I. Cephalometry is two dimensional; we are viewing the three dimensional objects in a two dimensional image where there will be uneven magnification of structure.

II. Identification of landmarks is difficult; there is always intra and inter examiner discrepancy in identifying the landmarks.

III. Conventional cephalometry is time consuming because of the dark room processing, time taken for identification of landmarks and construction of planes and then performing the cephalometric analysis.

IV. Difficulty in merging these cephalograms with the presents developing 3D imaging techniques.

V. Double registration of points is not possible

VI. Storage of cephalograms demand sufficient space and staff.

VII. The orthodontist finds difficulty in communicating the patient regarding the diagnosis & treatment plan.

VIII. There is no room for the patient to take part in the treatment plan processing.

Need for Development: Necessity is the mother of inventions. Three basic necessities in the field of orthodontics, that evolved in the 21st century required developments in conventional cephalometry. They are:

1. The soft tissue paradigm
2. Shift from paternalistic approach to autonomy
3. A significant development in understanding of inherent errors and drawbacks in conventional cephalometry.

1. **The Soft Tissue Paradigm:** The twentieth century was mainly dominated by the Angle's view, i.e. the 1st aim of orthodontic treatment was to achieve the dental occlusion and the 2nd aim was to correct skeletal jaw relationships. In that view the soft tissues were thought to be taken care by themselves. When the hard tissues were correct, the soft tissues

also were presumed to be correct and no treatment was needed for them. Unfortunately, this is not happening in all cases, especially when the teeth are displaced to a good occlusion without correcting the skeletal problem.[4] In the soft tissue paradigm, the 1st aim of treatment is to obtain the best possible adaptation and proportions of the soft tissues and the 2nd aim is functional dental occlusion. So, to incorporate soft tissue goals in diagnosis and treatment planning conventional cephalometry needed modifications and innovations.

2. **The Concept of Autonomy:** Diagnosis now has changed according to the functional and psychosocial ramifications of dentofacial deformity. Similarly, the treatment planning which has become a more interactive process to set up the priorities, between the patient and/or parents and the orthodontist. The ethical understanding of the doctor-patient relationship has changed. Previously the orthodontist chose the preferred treatment plan for the patient (paternalistic or father-like approach), and the patient (or parent) accepted or rejected the plan, with little room for consideration for alternatives. Today the orthodontist is expected to outline the patient's problems, use inputs from the patient to establish priorities in dealing with the problems, present reasonable treatment alternatives, and explain the risk-benefit considerations of each alternative, including the option of no treatment.

In the past decade, technology that facilitates communication with patients has been developed, particularly computerized graphic imaging to permit visualization of the facial effect of treatment before final treatment decisions are made. This technology and the personal interaction it promotes allow the orthodontist to "design the face first and measure what is needed to get there". In designing the face the patient is now given the chief priority. This approach is called Autonomy. Patients do not understand cephalometry and when cephalometry changes are shown along with the soft tissue changes the patients understand the scenario better.

Advances in Cephalometry: The advances in radiography which in turn revolutionized the conventional cephalometry in great extent. These are to be dealt under the following headings;

1. Digital radiography
2. Digitization of conventional cephalograms
3. Digital cephalometry
4. Computerized cephalometry
5. Video cephalometry
6. 3-dimensional cephalometry

1. **Digital Radiography:** Digitization of radiographs has been widely used in medicine since long time. But in dentistry, its use started in 1980s after the development of intra oral sensors. Unfortunately, it could not take extra oral radiograph like the panoramic and cephalometric image. So, its use became limited. Again, the development of low-cost, time saving, intra- and extra-oral digital radiographic technicand increased use of computer, has made digital imaging a major alternative to standard film imaging.

It became more advantageous both for the orthodontist and the patient in many aspects like the ability to gain cephalometric analysis and superimposition immediately on the chair side computer, can manipulate the images to aid diagnosis and patient motivation, decreased radiation exposure, and the ease of storage.

Principles:

Conventional Imaging: Standard intraoral film usually contains silver halide grains which are sensitized on exposure to x-ray photons and turned to black in the processing. Here the radiographic film acts both as the radiation-detector and the image display.

Digital imaging: In digital radiography, pixels or small light sensitive elements are used. These pixels are arranged in grids and rows on the sensor and are of different shades of grey according to the amount of exposure. Here the radiation detector (sensor) and image display (monitor) are different.[2]

Image Acquisition:

Indirect acquisition: In this method a conventional radiograph is scanned using a flatbed scanner with a transparency adaptor, or by using a charge-coupled device video camera to produce a digital image. This image can then be manipulated with the help of different software packages.

Semi-direct digital imaging: A photostimulable phosphor storage plate (PSP) is used for the image production. It emits light when put in the laser scanner after exposure to produce the desired image. The scanner stimulates the phosphor plate and stores a record of the number of light photons detected. Helium-Neon lasers with wave length of 600nm are commonly used. The plate should be scanned as early as possible to prevent any loss of data, though it can store energy for a longer period. Then the plate is exposed to view box light to clear the latent image.

Image plates are of similar size in comparison to conventional films and come with disposable plastic barriers. Image plates are reusable and can be reused for thousands of exposures provided there are no surface damage.

Direct Digital Imaging: In this method the image is acquired using a Charged Coupled Device, Complementary Metal-Oxide Semiconductor, or other Electronic Device. The sensor used is a charged coupled device (CCD) but it can't store information and should be connected to monitor. The CCD contains silicon crystals and are arranged in a lattice which converts light energy into an electronic signal and the image is visible in the monitor.

The main advantage of this system is the gain in time as the image is directly visible on the computer monitor immediately after the radiation exposure. Earlier the sensors size was very small and were unable to produce the required image but recently the size of the sensors are of similar to conventional film sizes.

Extra-oral digital imaging: Both direct and semi-direct digital imaging system is available for extra oral imaging but the direct system is very expensive and required extra armamentarium. So semi-direct digital system (PSP method) is widely used. Naslund et al. studied the effect of dose reduction obtained with PSP on the identification of cephalometric landmarks. They found that even if the dose reduced up to 75% it did not affect the localization/identification of cephalometric landmarks.

Merits of Digital Imaging:

1. **Dose reduction:** Up to 90% dose reduction reported by some authors as compared to conventional E-speed films in the diagnosis of caries.
2. **Image manipulation:** By using the software provided by the manufacturer the image can be manipulated according to the need. The following can be manipulated:
   - **(a) Contrast enhancement:** to compensate for over or under exposure.
   - **(b) Measurements:** by using digital callipers, rulers and protractors for image analysis.
   - **(c) 3-D reconstruction:** to reconstruct intra- and extra- oral images.
   - **(d) Filtration:** by the addition of filters to the airspace around the face
3. **Time:** Much time is saved as the image can be seen immediately after exposure.
4. **Storage:** The images can be stored in CD/DVD/ HARD DISK memory for a quite longer period of times.
5. **Teleradiology:** The digital image file can be compressed to reduce the size of the memory and can be shared by internet or other electronic medium.
6. **Environment friendly:** No chemicals are used for developing the images. Both CCD and PSP plates can be used for thousands of images.

Demerits of digital imaging

1. **Cost:** Costlier in comparison to conventional system of imaging.
2. **Sensor dimensions:** Earlier CCD size was bulky to position it correctly but now conventional film size sensors are available.
3. **Cross-infection control:** As the same sensor is used for many patients, there is every chance of cross infection if proper asepsis is not maintained.
4. **Medicolegal:** Image can be manipulated for fraudulent purpose. So,different manufacturers have developed software like 'audit trails', to track and recover the original image.

Digitization of Cephalograms: There are three method of cephalometric radiographic analysis.

1. Manual tracing and direct measurement
2. Direct computer digitization
3. Indirect computer digitization

1. **Manual tracing and direct measurement:** The cephalometric radiograph is traced on an acetate tracing sheet with the help of pencil. Then measurement of required angles and distances is done for different analysis with the help of ruler and protractor.

2. Direct computer digitization

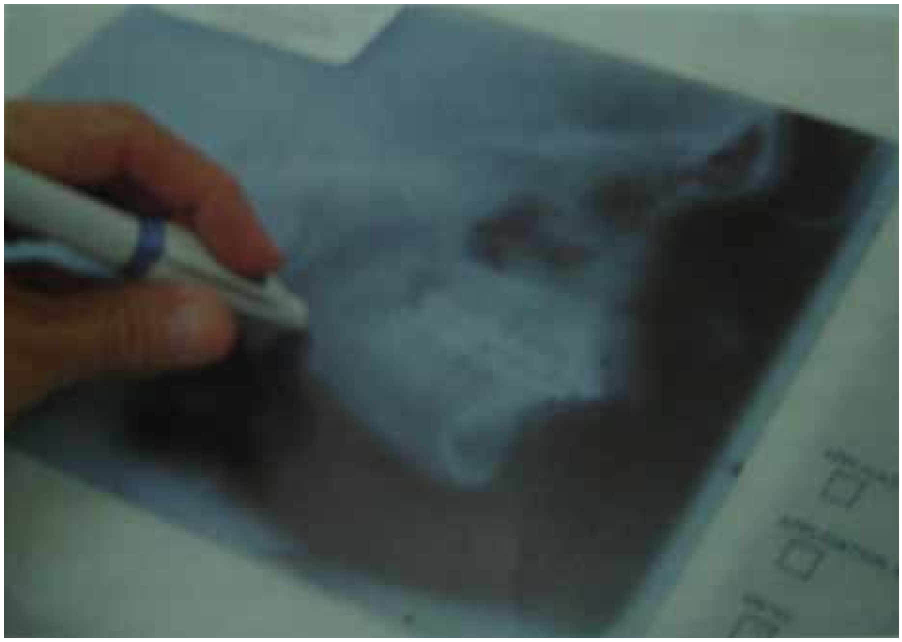

Figure 2. The radiograph is placed on a digitizing tablet and the landmarks are marked with a potentiometer which is electronic pen or “Cross hair” cursor.

Advantages of direct computer digitization: It allows the clinician to identify points directly on the film in the conventional manner, but relieves him of the tedious task of measuring lines and angles. The direction of development and improvement of technology is to programme the computer to identify the anatomy and point which relieves orthodontist of the task of identifying this structures themselves. This might be accomplished through the use of a scanner frame grabber to acquire the cephalometric image for computer storage and analysis. Moustafa et al gathered cephalometric radiographs with a video camera & frame grabber and described software for the detection of soft tissue contour and automated hard and soft tissue landmark location, which they reported to be as reliable.[5]

3. **Indirect computer digitization:** The image is stored in the computer through a video camera (or) scanner or through digital radiography. Then it is displayed on the monitor to digitize by a ‘mouse’ or electronic pen.

The future of digital radiography: In the current digital world, everything is moving towards digitization and to work almost paper free. Now patient records, photographs, radiographs, and study models can be stored digitally and can be shared online for consultation or discussion. It is always important to accept the new technology and used wisely to improve the patient care and save time and energy in clinical practice.

Computerized Cephalometric Systems:

Computerized cephalometric have two components.

1. Data Acquisition
   - Through
   - ionizing radiation & digitizer
   - sonic technology with microphones
2. Data Management-Various analyses, predictions can be done in those data with the use of different computerized cephalometric systems.

Available Computerized Cephalometric Systems: There are a lot of computerized cephalometric systems are available. These include different software programs which use one or more of the cephalometric analyses, comprehensive hardware and software packages.

1. **Jiffy Orthodontic Evaluation:** Rocky Mountain Orthodontics was the first to provide computer-aided cephalometric diagnosis to the dental profession in late 1960s. Then they developed a new software package known as JOE (Jiffy Orthodontic Evaluation). JOE is a static analysis programme. JOE generates tracing of lateral and frontal

Cephalogram, do the measurements for Ricketts, Jarabak, Sassouni-plus, Steiner and Grummons analysis.Thus, generates the amount of deviation from norms and the number of orthodontic problems.

In 1975, Greenberg and Johnston tested the accuracy of the RMDS (The Rocky Mountain Data System) and found it to be equal in accuracy to estimates using constants from an independent growth sample.[2]

2. **PorDios:** PorDios (Purpose on Request Digitizer Input Output System) is a cephalometric system which is very easy to manipulate according to the need of the individuals.

PorDios can correct the measuring problems if any in the two dimensional cartesian co-ordinate system. It has a library of mathematical procedures (both angular and linear) for arranging and estimating projections and points.

PorDios works with a digitizer in normal way, and capable of working with Scanner and Video camera also. It can perform different cephalometric analyses, including Downs, Steiner, McNamara, Ricketts, Tweed, Bjork, Burstone, and Coben and can produce occlusograms from photocopies of dental casts.

PorDios has built in calculations for showing any discrepancies from the norms. The user can change the standard deviation and mean values for different ethnic groups. The main system can alter the orientation of a picture in order to have the profile looking to the left or right side of the screen. It is available in different languages like English, German, French, Italian, Spanish, Danish and Greek.[1]

3. **Dentofacial Planner:** Dentofacial Planner is a software used in diagnosis & treatment planning for orthodontics and orthognathic surgery, introduced by Dentofacial Software Inc, Canada.

The Software is divided into orthodontic subsystem and Surgery subsystem. The skeletal and soft tissue regions can be manipulated by both the subsystems.

Orthodontic subsystem is cando superimpositions,facial growth prediction, simulate the tissue effects of usingorthopaedic and orthodontic appliances. The programmehas the pre-programmed analyses like Steiner, MacNamara, COGS, Downs, Ricketts, Grummons, Harvold, Legan and Jarabak.

The surgery subsystem estimates the skeletal and soft tissue effects of orthognathic surgery and create a so-called Surgical Treatment Objective. Dentofacial Planner has facilities of displaying a treatment planning tracing superimposed over the load-state tracing, an option for reverting the tracing to its state at load time, CO-CR registration of the mandible, whichhelps in customization of sections for tempomandibular joint tomograms for each patients by means of analyzing a sub-mental vertex x-ray.

4. **Quick Ceph Image:** Quick Ceph Image is a software package designed to do cephalometric analysis and mapping. There are thirteen different types of analyses can be doneby this programme namely Ricketts, Steiner, Jarabak, MacNamara, Downs, Iowa, Roth, Burston, Sassouni, Frontal and SMV and Model analyses like arch length & Bolton discrepancies.

Other functions this programmeare CO-CR conversion, prediction of facial growth, Steiner box for arch length discrepancy, treatment simulation for both orthodontic and orthognathic cases and superimpositions.

Quick Ceph Image can take both intra- and extra-oral pictures using a video camera and can store them.

Advantages:

1. Curvature in cephalometric lines can be accurately edited.
2. Performs orthodontic and surgical movements in single window.
3. Integrates Model Analysis Measuring ALD: Bolton discrepancy.

Drawbacks:

1. Requires high-resolution digital cameras
2. Optical disc storage preferred.
3. Expensive.

Schwartz (1993) evaluated Quick Ceph Image diagnostic system and found that computer generated surgical prediction tracing was 22% greater than the outcome. Lew, using Quick Ceph found that computer generated soft tissue prediction were accurate except in the lower lip area.[2]

5. **The DigiGraph:** The DigiGraph is a product of

Dolphin Imaging Systems, USA. It is a combination of video imaging and three-dimensional sonic digitizing. Spiro J. Chaconas, G. A. Engel, Marc S. Lemchen and Anthony A. Gianellyintroduced it to the Orthodontics in 1990. [6-8]

The DigiGraph Work Station is a unique device that allows the clinician to perform non-radiographic cephalometric tracings and analyses, video imaging, and treatment planning, including manipulation of the patient's tracing overlaid on the video image. It also takes facial, intraoral, and model photographs. It is capable of generating a 2-D or 3-D facial analysis. The system contains monitor, keyboard, RGB video camera with light source, a sonic digitization probe with receptor microphones and a head holder. With the DigiGraph, any point can be located in three planes of space.

Figure 3. DigiGraph.

The machine has the following capabilities:

1. A landmark can be identified as point in three dimensions;
2. A cephalometric analysis can be made independently of the head position;
3. Neither parallelism of the x-ray in the midsagital plane nor the symmetry of anatomic morphology between left and right sides is necessary (Lim, 1992).

Advantages of using DigiGraph:

The DigiGraph Work Station is a powerful clinical tool that offers advantages in a wide range of orthodontic activities:

1. **Non-Radiographic Cephalometrics:** Lateral and frontal cephalometric tracings and virtually any set of measurements can be produced in moments without radiation. Progress records can therefore be taken as often as desired. Tracings from different treatment stages can be superimposed and manipulated on the screen.
2. **Video Imaging:** Live patient images can be displayed on the computer screen. A non-radiographic tracing can be superimposed over the corresponding facial image, giving the practitioner and patient the opportunity to see the tracing and facial soft tissues together. Live intraoral and dental cast video images can also be displayed and recorded for future reference. Paper or photographic copies can be generated in second, and images can also be stored to be recalled at any time.
3. **Treatment Planning:** The orthodontist can alter any screen image, using computer "cut and paste" procedures, to derive a Visual Treatment Objective. As the clinician modifies the facial

image, the superimposed cephalometric tracing and measurements change correspondingly.

4. **Patient and Parent Consultations:** During a patient's initial appointment, the staff can obtain all records within a few minutes. The orthodontist can then evaluate the data and be fully prepared for an immediate consultation.

6. **The indigenous system- Digi -Ceph:** Digi-ceph is an advanced system for computerized cephalometric digitization, automatic analysis, plot superimposition, storage and retrieval. This system has been developed by Department of Dental Surgery at the All India Institute of Medical Sciences, New Delhi with the help of Center for Biomedical Engineering, IIT, New Delhi.

This advanced system is capable of producing 13 cephalometric analyses following digitization of the cephalometric landmarks either directly in cephalogram or indirectly on the cephalometric tracing. User can create his own analysis. The output data shows values and their comparison with the selected Indian ethnic group.

The software has 10 data banks (one temporary and 9 permanent). The temporary data bank can be used for casual information, while other data banks 0-9 can be used for different users or can be used for different modalities of treatment. The data can be retrieved even by partial information about the subject. The system has been in use at AIIMS since 1990 and is being used for routine case analysis and research work that involves cephalometrics.

Video Cephalometry: By using video imaging technology orthodontist can take both frontal and profile images and manipulate them to provide anesthetic treatment goal. In orthognathic surgery case, patients can visualize what they will look after the treatment which helps them motivated for the surgery. The video image looks more realistic than the conventional photograph simulation in which gaps in between photo cuts will be there and also dental movements can't be simulated.

Esthetic awareness and videoimaging: Video imaging is the newer technology which gives more realistic simulation of images for the esthetic point of view. Its use in the treatment planning will be of great help in modern clinical practice. Studies shows thatmore and more patients are listing esthetics as a major reason to go for surgical treatment. So, the esthetic parameters would be the major factor in satisfying the patient in surgical treatment cases.

Holdaway thought "we should determine beforehand that the proposed orthodontic treatment will not result in adverse facial change", so soft tissue analysis is more important. The orthodontic treatment planning using video cephalometry will have better visualization of the facial response to the dental/soft tissue manipulation. So, the clinician can test different treatment plan before deciding the final one. Video cephalometry can quantify the osseous or dental movements of the treatment plan more accurately to reduce the guess. But it needs a lot of research and understanding for the application of this technology. In adolescent patient the complexity of growth prediction of both hard and soft tissues greatly complicates the predictability of VCD outcome. Hence judicious use of this technology in this type of cases will be helpful. But in adult cases, video cephalometric planning will be more predictable because of the completion of the growth of the tissues.

Three-Dimensional Imaging:

History:

- Van Loon in 1915 proposed the necessity of a 3 D system to define the relationship of dentition to the face and for treatment planning. So, he made a plaster cast of the face and the labial surface of maxillary incisors to orient the plaster cast of the dentition thereby creating the "face dentition".

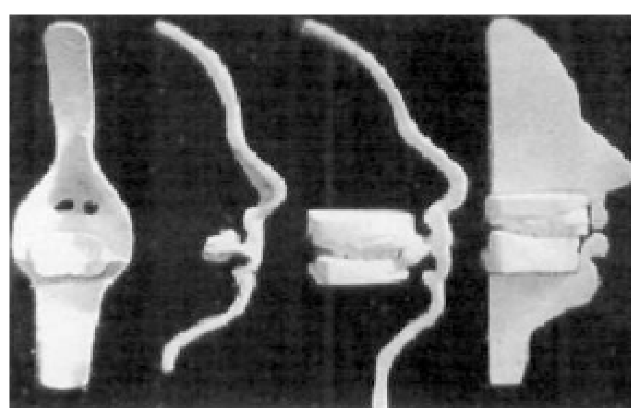

Figure 4. Face dentition

- Simons [1922] introduced gnathostatic models
- Baumrind and Moffitt proposed "coplanar cephalometry". Two images taken with the x-ray source in the same plane but in different location, but patient in same position.9,10
- Cutting et al proposed "biplanarcephalometry".

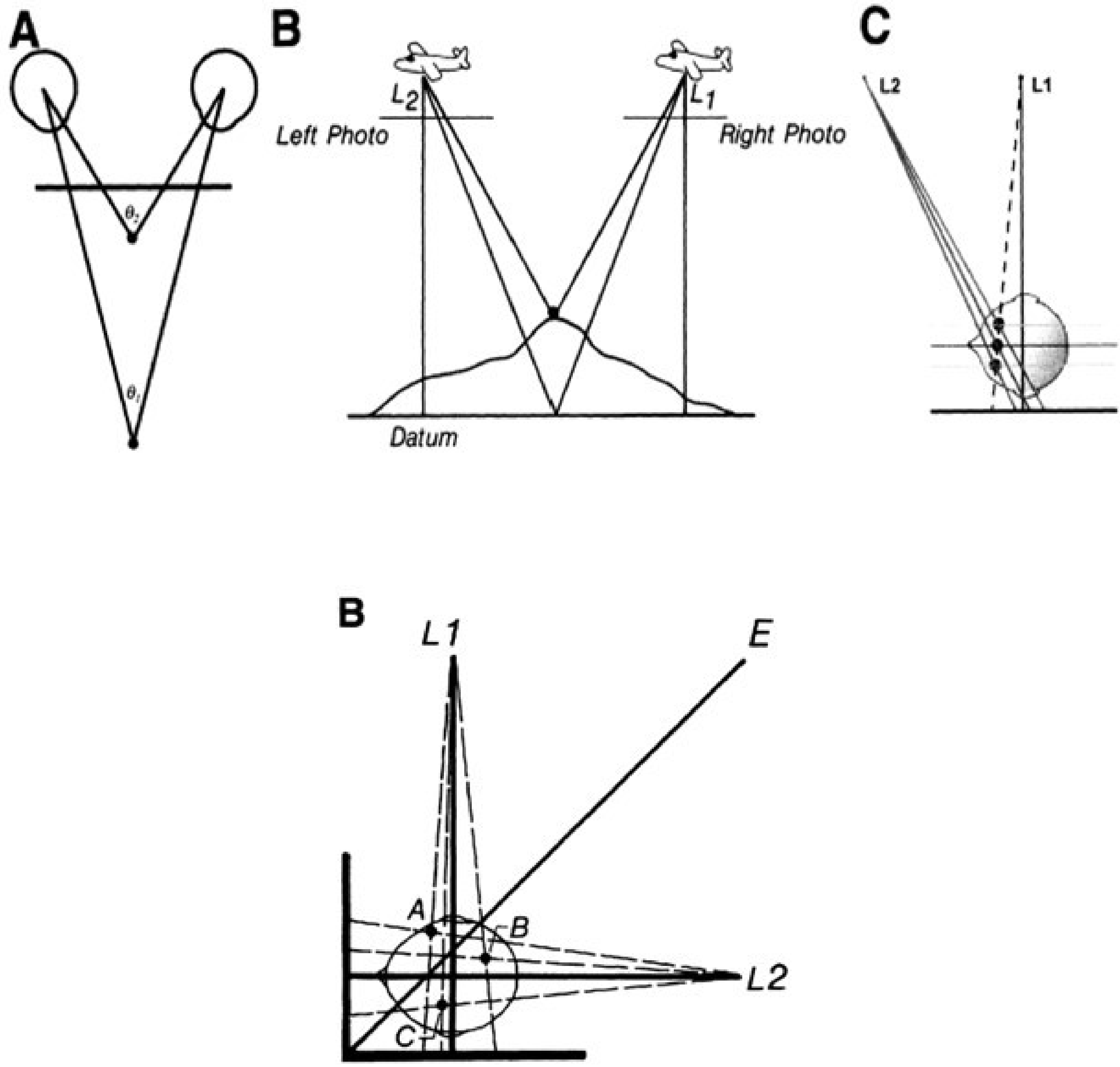

Figure 5. Biplanarcephalometry; Biplanarcephalometry

Two images taken with the x-ray source right angled to each other. Film cassettes right angled to each other but the patient in the same position.

Cephalometrics is a three-dimensional entity. Broadbent and Bolton,since their introduction of the cephalostat, had described about the role of coordinating the lateral and frontal (PA) cephalogramsto get a distortion free craniofacial image. By placing the films in position with respect to the head, if we draw lines from the x-ray source to individual landmark of either film as threads in space, thenit will look like a pair of pyramid of thread, intersecting at right angle throughout the inner space of the patient's head (Fig. A). If both the films are joined with the corner, they meet each other and flattened into one plane, then each thread will flatten to the side of other film with certain distance (Fig. B). The Orientator is the diagram of the flattened threads. On superimposition over the abutted pair of films, the points in each film that correspond to any particular locus in the other can be visualized.

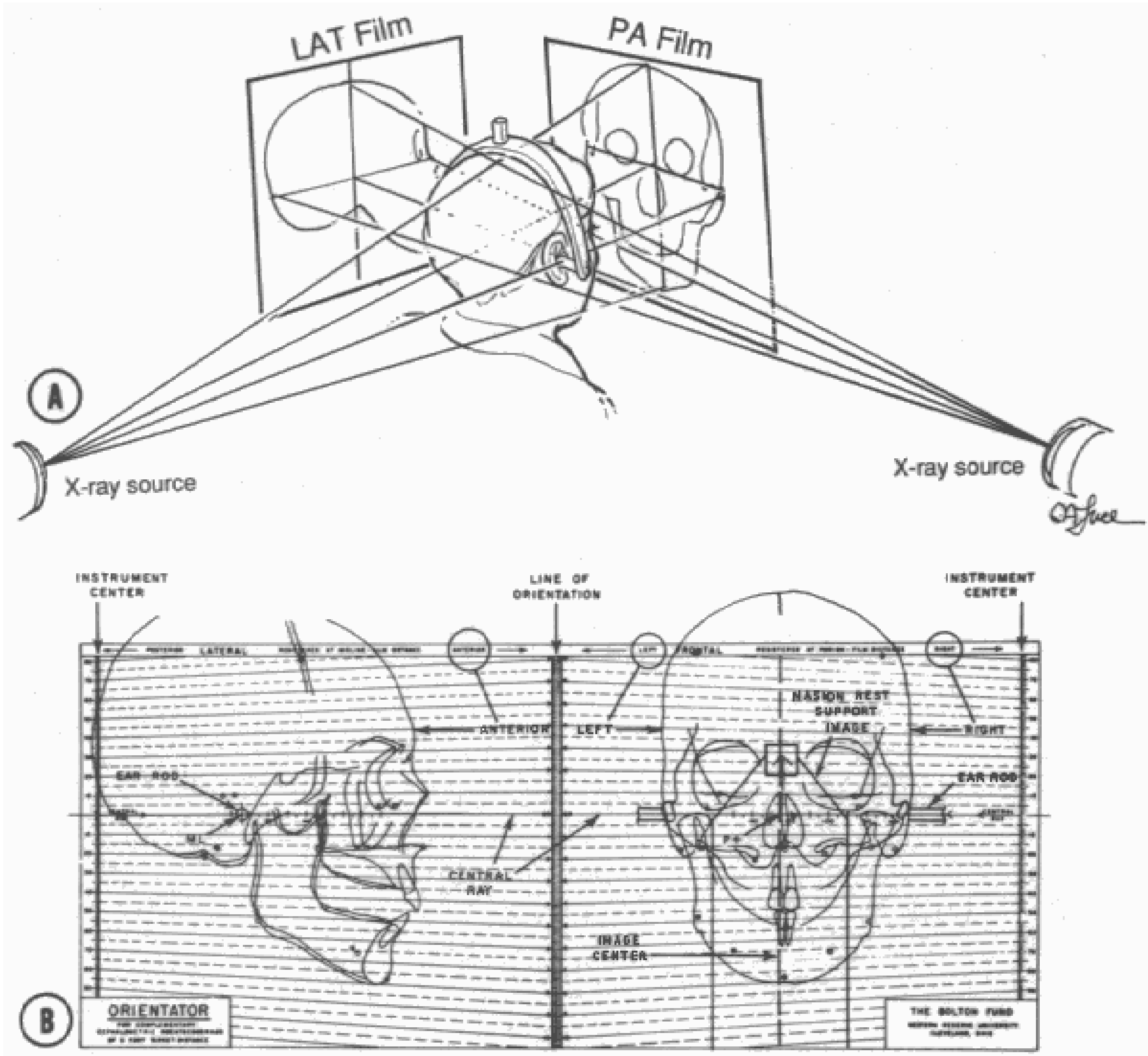

Figure 6. Orientator

Broadbent and Bolton used this to correct the distortion arises due to the spread x-ray beam. The principle of the Orientator then becomes identical with that of one standard photogrammetric tool for this purpose, the ray intersection method.

Cone Beam Computed Tomography (CBCT): CBCT was firstused indentistry in the United States between 2001 and 2004. The initial machines were providingonly a one-to-one, 3D view of the patient's head but the cost and radiation was more. But due to the evolution of a new technology,several CBCT manufacturers come with a combination of partial rotation around the patient's head and pulse technology. A CBCT scanner wasdeveloped which takes a 3D image with lesser radiation than a panoramic radiograph.[11]

Currently, the treatment planning has changed and giving more stress to soft tissues and the facial profile as we are moving from 2D to 3D imaging. This change is possible due to introduction of conebeam computed tomography (CBCT), which captures 3D images in short time and with a very less amount of radiation.[12,13] Images from conventional (fan-beam) CT and CBCT can be combined to create 3D models of the cranio-facial skeleton, the teeth and the soft-tissues.[14-16] By placing these models into the neutral head posture (NHP)[17-19], we can now convert them into "3D cephalograms" if taken at a fixed distance from the subject with the subject's head in a cephalostat.

CT-based 3D cephalograms have resulted the development of 3D cephalometric analyses.[19-25]

However, the problem of the unreliability of internal reference systems and the lack of tools to assess and measure symmetryin some 3D measurements needs to be addressed.

Conclusion

As we begin the millennium, it is time to look at the technologies that may help clinicians provide better patient care. As computer technology has become more sophisticated, it became possible to combine the benefits of the Cephalometry, patient's photographs, study models into one diagnostic practice as well as an effective way to improve patient-parent relationship, and practice management.

There is also potential to remove much of the human errors by using computerized treatment simulation in clinical practices having some imaging skills. For this reason, there have been developments to use computer vision and robots to assist in complex surgeries. Treatment effects could be monitored much more accurately in these vein clinical problems may be revisited to determine if our knowledge based on to dimensional records is accurate.

While there is room for growth in cephalometry, particularly in videoimaging, frontal imaging, 3-D imaging, database generation, quantified studies on accuracy of prediction and the integration of videoimaging & 3-D imaging into clinical practice, these diagnostic and treatment planning aid has clear utility. There is substantial evidence that these technologies offer the practicing orthodontist advantages in following areas:

- Provides the graphic method of communication with patients that can overcome the deficiencies inherent in verbal description of treatment goals and/or outcomes.
- All parties including doctors and patients can be involved in making treatment decisions.
- Improvement in quantification of treatment plans, particularly in the area of orthognathic surgery. With coordinated videocephalometric technology, the surgeon can visualize a plan and have the computer integrated records provide a quantified plan to take to the operating room.
- The use of images in communication with other professional enhances the communication of the problems present and development of potential solutions.

All these advantages due to the advancement in the cephalometry make this diagnostic tool still vital in the field of orthodontics.

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