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RESEARCH ARTICLE

ERRORS IN CEPHALOMETRY

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ABSTRACT

Cephalometric measurements on radiographic images are subject to errors that may be caused by:

- Radiographic projection errors- magnification, distortion.
- Errors within the measuring system – digitized,,, identification, scaling errors and linearity
- Errors in landmark identification - The quality of the radiographic image sharpness, contrast, blur , noice.

The precision of landmark definition and the reproducibility of landmark location.The operator and the registration procedure.

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INTRODUCTION

During the recording procedure, the object as imaged on a conventional radiographic film is subjected to magnification and distortion.

Magnification

Magnification occurs because the X-ray beams are not parallel with all the points in the object to be examined. The magnitude of enlargement is related to the distance between the focus, the object, and the film. The use of long focus - object and short object - film distance has been recommended in order to minimize such projection errors. However, although relatively long focus –film distances are favourable, a focus film distance of more than 280 cm does not significantly alter the magnitude of the projection error The use of angular rather than linear measurements is a consistent way to eliminate the impact of magnification (Adams, 1940), since angular measures remain constant regardless of the enlargement factor.

Distortion: Distortion occurs because of different magnifications between different planes. Both linear and angular measurements will be affected.

- Linear distances will be foreshortened, an effect that can be compensated for if the relative lateral displacement of the landmarks and their distance from the midsagittal plane are known. A combination of information from lateral and frontal films has been proposed
- Landmarks and structures not situated in the midsagittal plane are usually bilateral, thus giving a dual image on the radiograph. The problem of locating bilateral structures subjected to distortion can to some extent be compensated for by recording the midpoints between these structures. Bilateral structures in the symmetric head do not superimpose in a lateral cephalogram.The fan of X-Ray beam expands as it passes through the head, causing a divergence between the images of all bilateral structures except those along the central beam.
- It is convenient, therefore, to average and trace as a single image those structures whose images are doubled and exhibit an apparent asymmetry (e.g., the mandibular ramus and corpus, the pterygoid space, and the orbits).
- In order to control errors during radiographic projection, the relationship among X-Ray target, head holder and the film must be fixed. Misalignment or tilting of the cephalometric components (e.g. the focal spot), the cephalostat, and the film with respect to each other, as well as rotations of the patient's head in any plane of space, will introduce another factor of distortion.

As angle distortion never exceeded ±0.5° for rotations of the head up to ± 5° .The resulting projection error seemed in no instance to be a major concern. Larger rotations of the head are unlikely, as they would be obvious to the examiner.

ERRORS WITHIN THE MEASURING SYSTEM

In conventional cephalometry, the development of computerized equipment for electronic sampling of landmarks has greatly speeded up data collection and processing and has reduced the potential for human measuring errors.

The errors related to recording procedure has two components

- The precision with which a marked point on the film or tracing can be identified by the cross hair of recording device.
- Errrors of the digitizing system like scaling errors and fields of non – linearity.

An accuracy of 0.1 mm is desirable without any distortion over the surface of the digitizer. Errors of scaling can be corrected by setting switches in the control unit of the digitizer or by scaling the incoming x-y co ordinates by a software programme. Non linearities can be corrected by including the Dxji and Dyji matrices in the digitizing programme.

Advantages of digitizer

- Reduces intra and inter observer variability.
- Eliminate need for tracing procedure.
- Improve superimposition.
- Accuracy in treatment evaluation.
- Growth analysis

ERRORS IN LANDMARK IDENTIFICATION

Landmark identification errors are considered the major source of cephalometric error. Factors involved are:

- The quality of the radiographic image
- The precision of landmark definition and the reproducibility of landmark location
- The operator and the registration procedure.

Quality of the radiographic image: In principle, the quality of a radiographic is expressed in terms of

Sharpness - Blur and Contrast - and **Noise**

Sharpness is the subjective perception of the distinctness of the boundaries of a structure; it is related to blur and contrast.

Blur is the distance of the optical density change between the boundaries of a structure and its surroundings. It results from three factors, namely geometric unsharpness, receptor unsharpness, and motion unsharpness.

- Geometric unsharpness is directly related to the size of the focal spot and to the focus film distance.
- Receptor unsharpness depends on the physical properties of the film and the intensifying screen. Combinations of fast films and rare earth intensifying screens are used to reduce the radiation exposure, but produce images with poorer definition.
- Motion unsharpnessMovement of the object, the tube, or the film during exposure results in image blur. By increasing the current, it is possible to reduce the exposure time, thus reducing the effect of movement. Blur from scattered radiation can be reduced using a grid at the image receptor end**.** In clinical orthodontic practice, however, the major parameters that influence the sharpness of cephalograms are the focus to film distance (geometric unsharpness) and the voltage capacity (kV) of the cephalometric equipment (motion unsharpness).

Contrast is the magnitude of the optical density difference between a structure and its surroundings. It plays an important role in radiographic image quality. Increased contrast enhances the subjective perception of sharpness, but excessive contrast leads to loss of details, owing to blackening of regions of low absorption and reverbering of regions of high absorption.

In clinical practice, the most important parameters influencing the contrast of cephalometric films are the film cassette system and the kV level used. High kV values tend to level out any differences in radation absorption, thus reducing the difference in grey level between various tissues.

Noise refers to all factors that disturb the signal in a radiograph. It may be related to:

- The radiographic complexity of the region (i.e., the radiographic superimposition of anatomical structures situated in different depth planes) – this is known as noise of pattern, structure, or anatomy; or
- Receptor mottle – this is known as quantum noise. It depends on the sensibility and the number of radiosensitive grains present in the film.

These types of errors can be minimized by films of high quality and filter.

Digital technology has changed the parameters of image quality by

- Main advantage of digital processing may be a reduction in radiation does due to lower exposure time
- Enhancing sharpness and contrast
- Reduction jn noise.
- The contrast and density of a single underexposed image can be adjusted for several diagnostic tasks, thus reducing the number of examinations.

Precision of landmark definition and reproducibility of landmark location refer karbanda A clear, unambiguous definition of the landmarks chosen is of the utmost importance for cephalometric reliability.If the conditions required to record some landmarks – eg. Lips in repose, centric occlusion or head posture are neglected an invalidation of the measurement occur . Miethke (1989) found that the landmarks that can be localized most exactly are incision superior incisal and incision inferior incisal, with a value of the mean x and y standard deviations as polar coordinates of 0.26 mm and 0.28 mm respectively. A value of uptp 2 mm is observed in majority of 33 landmarks, which were on the basis consider to be acceptable reproductibility.

Anatomical porion and cephalometric landmarks on the condyle cannot be located accurately and consistently on lateral cephalograms taken in the closed mouth position.

Baumrind and Frantz pointed out that the impact that errors in landmark location have on angular and linear cephalometric measurements is a function of three variables.

- The absolute magnitude of the error in landmark location
- The relative magnitude or the linear distance between the landmarks considered for that angular or linear measurement.
- The direction from which the line connecting the landmarks intercepts their envelope of error.

The envelop is the pattern of total error distribution. Since cephalometric landmarks have non circular envelop of error. Error in landmark identification can be reduced if measurements are replicated and their values are averaged. Consecutive evaluation of one cephalogram at random shows,the localization of landmark is more exact the second time than at the first judgement. The more the replication, the less is the error. For specific landmarks, the application of alternative techniques of radiological registrations can minimize errors in landmark identification. For example, if the mandibular condyle is to be used as an important landmark in cephalometric studies, an open mouth cephalogram should be taken. Subsequent superimposition on the respective cephologram in the centric occlusion position can provide the most accurate and reliably measurement Also, if porion is defined as a machine point rather than an anatomical point, higher reliability should be anticipated

The operator and the registration procedures

Several studies have pointed out that operators alertness and training and his or her working conditions affect the magnitude of the cephalometric error. The most important contributions to improvement in landmark identification are experience and calibration. Bias in operators variability, which involves both inter observer variability (the disagreement among observers for the identification of a particular landmark) and intra observer variability (the disagreement within the same observer over a period of time owing to changes in his or her identification procedure). A good method to reduce this error consists of calibration and periodical recalibration tests to establish specific confidence limits of reproducibility for each observer. Since serial tracing must maintain precise common landmarks in regions without change during treatment or growth, landmark location in such regions can be identified in one of the cephalograms and transferred to the other cephalograms of the patient by use of templates of the corresponding structure (e.g. incisal edges of maxillary and mandibular incisors)

OTHER VIEWS

45 DEGREE LATERAL PROJECTION

since lateral cephalogram does not present a true picture of the contact relationship of the posterior teeth and intra oral radiographs of molar teeth often distort second and third molar images too.
The 45 degree lateral head plate or lateral jaw projection buccal gives a more accurate recording of actual tooth position in either left or right segment

USES

- Following the cases of serial extraction cases
- Third molar eruption.

OPEN MOUTH POSTEROANTERIOR CEPHALOGRAM: In cases of suspected significant mandibular displacement, the posteroanterior cephalogram must be taken with the mouth of the patient slightly opened.
In this way a differential diagnosis between functional mandibular displacement and dento skeleton facial asssymetry can be made.

SUBMENTOVERTEX PROJECTION

Identification of transverse and skeleton asymmetries from frontal radiograph can be integrated with submentalvertex view. Used to demonstrate base of skull,position and orientation of condyle, sphenoid sinus, curvature of mandible, lateral wall of maxillary sinus and displacement of fractured zygomatic arch.

CONCLUSION

Today more adult patients are being treated than ever before. Identification of tranverse and skeleton asymmetries from PA cephalogrm can be integrated with lateral cephalogram and submento vertex to plan multiple discrepancy approach to adult treatment. Knowledge and recognization of landmarks being the most sensible approach for judicious interpretation of cephalometric data.

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