CEPHALOMETRICS

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CHAPTER 27

1. What is cephalometrics?

Cephalometrics is the science of measurement of the skull, which began in the early eighteenth century. After the introduction of X radiation, measurements were made on standardized radiographs. The technique of radiographic cephalometrics was introduced by Hofrath in Germany and Brodbent in the United States in 1934. The initial purpose was to research the growth and development of skeletal structures and to establish a quantitative method for obtaining descriptive information about dentofacial patterns.

2. How is cephalometric analysis performed?

It is performed by acquiring a standardized lateral view of the skull (Figs. 27-1, 27-2, and 27-3). A tracing is made of the skull film, and measurement is taken between points and planes constructed from anatomic landmarks.

3. How is a standard cephalogram obtained?

There are two specific requirements for obtaining a true standardized lateral head film. The distance from the x-ray source to the object should be 60 inches. The distance from the object to the film should be 6 inches. The central beam is directed through the center of the ear rods to strike the x-ray film at right angles. To limit parallax distortion due to shifting, the head should be stabilized with a head holder called a *cephalostat*. When these constants are maintained, a standardized lateral cephalogram is obtained with 10% magnification of the head. The lateral cephalogram must be made with the mandible in a centric position and lips relaxed (see Fig. 27-1).

4. Why is a cephalostat used?

The cephalostat provides a means to standardize image and magnification distortions of the cephalograph with standard positioning of the x-ray source from the subject.

5. How do you trace a cephalogram?

Tracing is done on a 0.003-inch acetate paper with a 0.05-mm lead pencil. The side closest to the film is traced. In tracing the mandibular structures, the superior part of the body and distal part of the ramus should be traced (the side closest to the film). Whenever there is a double image, the contours of the image can be traced by bisecting the two images. Figure 27-4 shows the representative landmarks that need to be traced.

6. What are the requirements for a landmark?

- The landmarks should be easily seen on a radiograph, uniform in outline, and easily reproducible.
- Lines and planes should have significant relationship to the vectors of growth of specific areas.
- Landmarks should permit valid quantitative measurements of lines and angle projected from them.
- Measure points and measurements should have significant relationship to the information sought.
- Measurements should be amendable to statistical analysis.

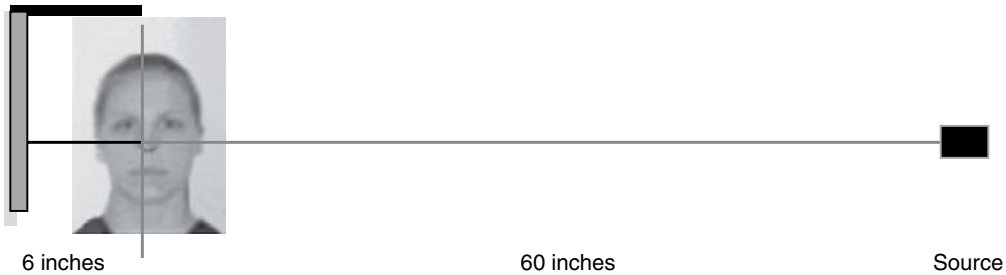

Figure 27-1. Technique of cephalometrics.
- Distance from source to midsagittal plane of object = 60 inches
- Distance from object to film = 6 inches
- Magnification ratio = 1:10
- Central ray should pass through external auditory meatus perpendicular to the film cassette

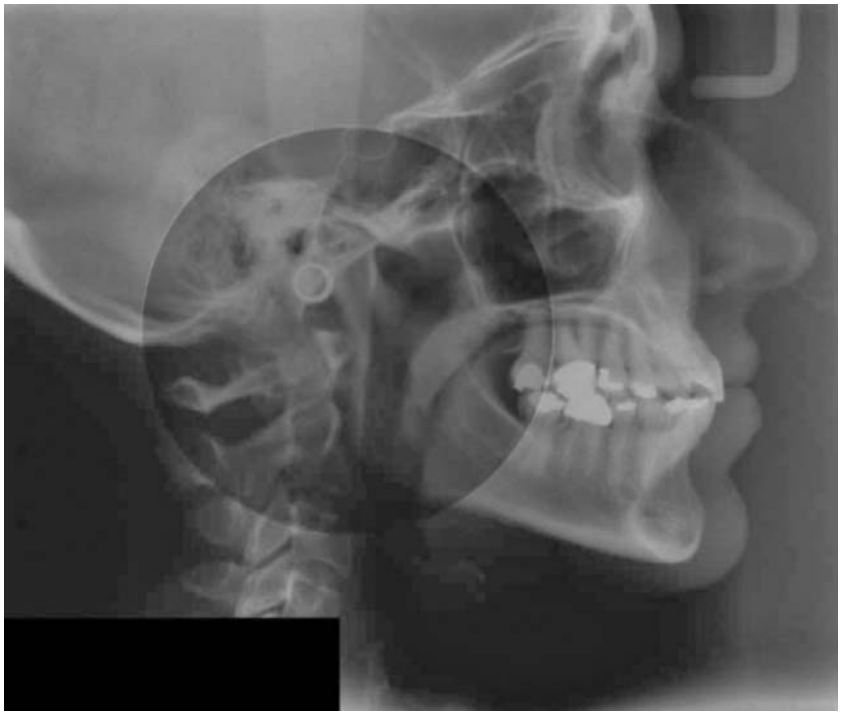

Figure 27-2. Lateral cephalogram.

Figure 27-3. Posteroanterior cephalogram.

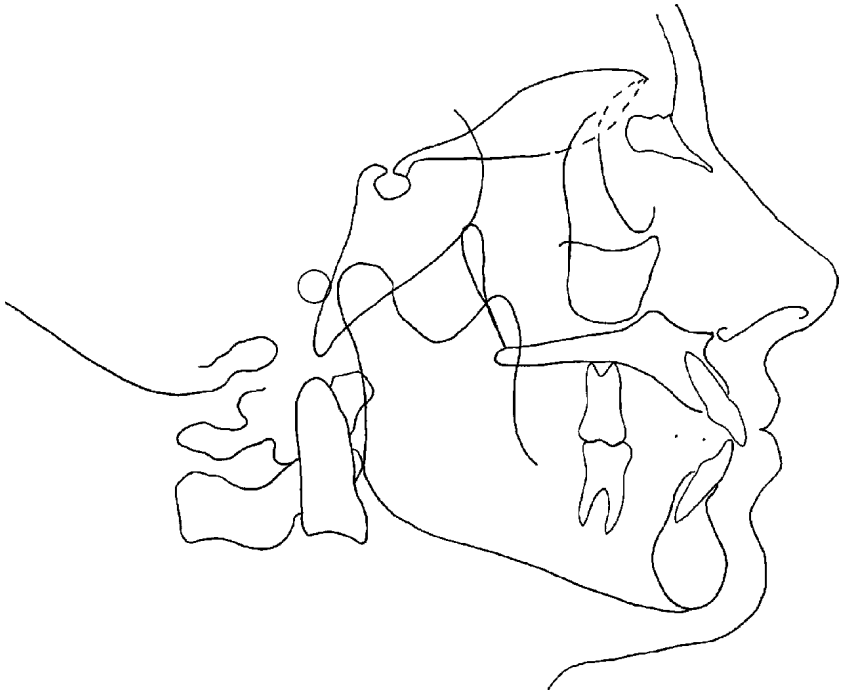

Figure 27-4. Cephalogram tracing.

7. What are the most commonly used landmarks?

The most commonly used landmarks are shown in Figure 27-5:

1. Nasion (N): Anteriormost point on the frontonasal suture
2. Basion (Ba): Lowermost point on the anterior point of the foramen magnum
3. Articulare (Ar): Point of the cranial base and the posterior border of the mandibular ramus
4. Porion (Po): Midpoint of the upper contour of the external auditory canal
5. Sella (S): Center of the sella turcica
6. Pterygomaxillary fissure (PTM): Point on the base of the fissure where the anterior and posterior walls meet
7. Orbitale (Or): Lowest point on the inferior margin of the bony orbit
8. Anterior nasal spine (ANS): Tip of the anterior nasal spine (sometimes modified as the point on the upper or lower contour of the spine where it is 3 mm thick)

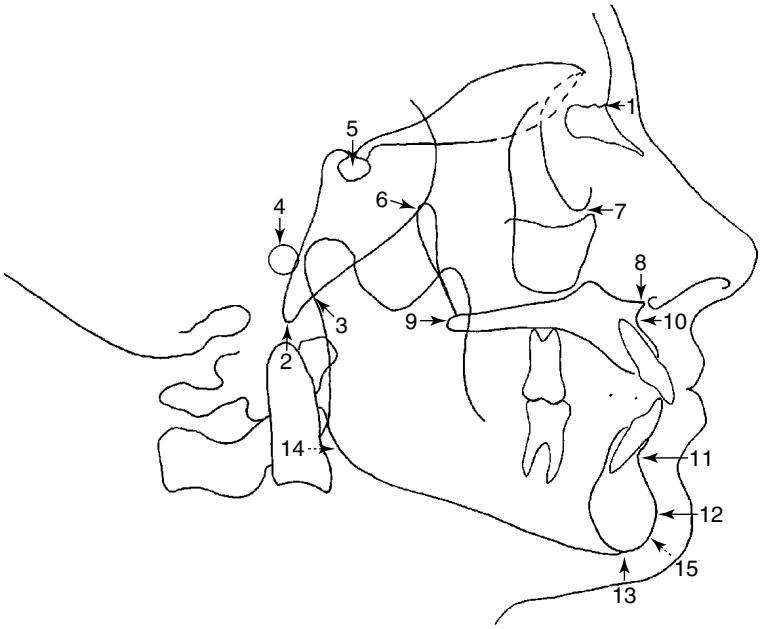

Figure 27-5. Commonly used landmarks.

9. Posterior nasal spine (PNS)
10. Point A (A): Innermost point on the contour of the premaxilla between the anterior nasal spine and incisor tooth
11. Point B (B): Innermost point on the contour of the mandible between the incisor and the bony chin
12. Pogonion (Pog): Anteriormost point on the contour of the bony chin
13. Menton (Me): Most inferior point on the mandibular symphysis
14. Gonion (Go): Point on the angle of the mandible obtained by bisecting the angle formed by intersection of a tangent drawn to the lower and posterior borders of the ramus
15. Gnathion (Gn): Constructed point located between the pogonion and menton

8. What is a cephalometric plane?

A plane by definition connects three or more points. A line by definition connects two or more points. These two terms are often used synonymously. The commonly used planes are as follows (Fig. 27-6):

Cranial Base Planes

1. Basion-nasion (Ba-N)
2. Sella-nasion (S-N)
3. Frankfort horizontal plane (Po-Or)

Maxillary Planes

1. Palatal plane: Constructed by joining the anterior nasal spine to the posterior nasal spine
2. Occlusal plane: Plane extending between the mesial cusp of the maxillary molar through the point that bisects the overbite
3. Nasion–point A
4. Long axis of mandibular incisor

Mandibular Planes

1. Mandibular plane: Line drawn tangent to the lower border of the mandible and passing through the menton
2. Nasion–point B
3. Nasion–pogonion facial axis plane
4. Long axis of mandibular incisor

9. What are the components of cephalometric analysis?

- Skeletal analysis
- Soft-tissue profile analysis
- Dental analysis

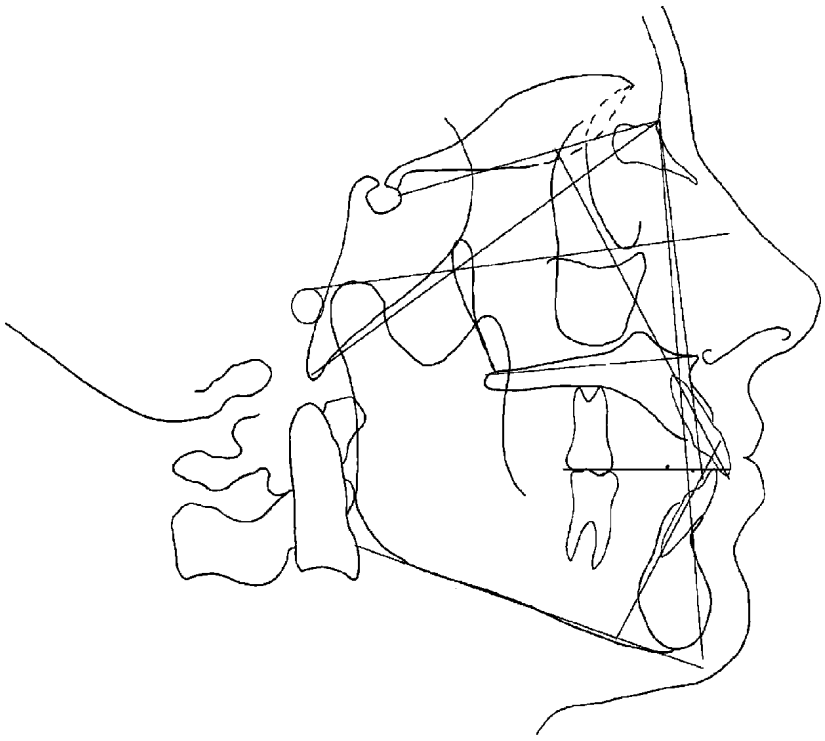

Figure 27-6. Cephalometric planes.

Table 27-1. Normal Values for Commonly Used Measurements

MEASUREMENT	MEAN VALUE (CAUCASIAN)	MEAN VALUE (AFRICAN-AMERICAN)
SNA	82	85
SNB	80	81
ANB	2	4
U1-NA	22	23
	4 mm	7 mm
L1-NB	25	34
	4 mm	10 mm
U1-L1	131	111
L1-MP	90	—
FMA	25	25
Facial axis	0–2	—

FMA, Frankfort-mandibular plane angle; *L1-MP,* mandibular incisor-mandibular plane; *L1-NB,* mandibular incisor-nasion to A-point plane; *U1-NA,* maxillary incisor-nasion to B-point plane.

10. What is the purpose of skeletal analysis?

The main purpose is to classify facial types and to establish the relative anteroposterior relation of the basal arches to the cranial base and to themselves (Table 27-1). Angle SNA indicates the anteroposterior positioning of the maxilla in reference to the cranial base. The normal angle for a Caucasian is 82°. An angle that exceeds 82° indicates maxillary protrusion, and an angle less than 82° indicates maxillary retrusion. Angle SNB indicates the anteroposterior relation of the mandible in reference to the cranial base. The mean is 80°. Basal arch analysis indicates the relation between the maxilla and mandible (ANB angle). The normal value is 2°.

Another method involves first correcting the length of the cranial base sella-nasion. In adult females the length is 77 mm, and in adult males the length is 83 mm. From this corrected position of nasion, draw a perpendicular to the Frankfort plane. Maxillary reference point A should lie on the plane, and, chin projection (Holdaway ratio) being normal, pogonion should be on the plane in adult males and should be 2 mm behind the plane in adult females. If point A is ahead of the plane, it indicates horizontal maxillary excess. If point A is behind this plane, it indicates horizontal maxillary deficiency. Similarly, if pogonion is ahead of this plane, it indicates mandibular excess. If it is behind this plane in adult males and is more than 2 mm behind in adult females, it indicates mandibular deficiency. (Value for sella-nasion plane reconstructed to the correct length and angulation obtained from the University of Michigan Growth Center standards.)

An important factor in skeletal analysis is the vertical relation of the maxilla and mandible to the cranial base. The first measurement is to relate the anterior maxilla, done by evaluating tooth exposure on the lateral cephalogram (with lips relaxed) and frontal facial picture. Both should show tooth exposure of approximately 2 mm. The second group of measurements is the palatal plane. It should be parallel to the Frankfort plane. The occlusal plane angle should be 7°, and the mandibular plane angle should be 25° to the Frankfort plane.

The third measurement is the posterior facial height. The posterior cranial base (S–Ar) and ramus height (Ar–constructed gonion Go) should be a ratio of 3:4. If the ramus height ratio is less than 3:4, it indicates a short posterior face height. A ratio greater than 3:4 indicates an excessive posterior facial height. A short posterior face height should be evaluated in connection with the mandibular plane angle and is suggestive of a condylar problem and, therefore, a more difficult case to treat. An increased posterior face height usually suggests a distracted condyle due to a functional shift and indicates the need for a splint. The fourth of these measurements is the ratio of the total facial height (measured from nasion to menton). If this value is considered to be 100%, the upper part of the face (nasion to anterior nasal spine) should be 45% and the lower part (anterior nasal spine to menton) should be 55%, although men tend to be slightly longer in the lower third of the face.

11. What does the dental analysis indicate?

It indicates anteroposterior positioning of the teeth in relation to their basal bones. The long axis of the maxillary incisor should be angled at 104° to the cranial base. The long axis of the mandibular incisor should be angled at 90° to the mandibular plane.

12. What does the profile analysis assess?

Profile analysis permits appraisal of the soft tissue that covers the skeletal facial profile. Remember that the soft tissue profile is related to facial skeletal dimensions, tonicity of the soft tissue, and habitual posture of the face in the head in space. An easy way to evaluate the profile is to relate the face to Ricketts' aesthetic plane (the line extending from the soft tissue nose tip to the soft tissue chin). The upper lip should lie 2 mm behind the plane; the lower lip should lie on the plane.

The nasolabial angle is formed at the base of the nose by a line drawn parallel to the base of the nose and a tangent drawn to the upper lip. It is also an important factor in establishing the anteroposterior position of the maxilla. The nasolabial angle should be 102° in both men and women, with a standard deviation of 8°. An acute nasolabial angle may be a reflection of maxillary dentoalveolar protrusion. To rule out the influence of the nose on this angle, the upper lip should be evaluated in relation to the vertical orientation of the face. The tangent drawn to the upper lip should be 8° in men and 14° in women, with the nasion perpendicular. An obtuse nasolabial angle or a decreased cant of the upper lip is an indication of a retrusive maxilla.

13. What is the Holdaway ratio?

The Holdaway ratio, which is used to evaluate chin retrusion or prominence, is an orthodontic method that relates the prominence of the mandibular incisor to the NB and the pogonion to the NB line. For an ideal Holdaway ratio, the lower incisor and the pogonion should be the same distance from the NB line. The ratio is depicted as 1:1. Per cephalometric standards, the lower incisor should be 4 mm in front of the NB line; therefore the chin also should be 4 mm in front of the NB line. It is important that the surgeon not advance the chin beyond the confines of the mandibular incisor teeth.

14. What are the applications of cephalometrics?

- Diagnosis
- Growth prediction
- Visual treatment objective
- Surgical treatment objective (STO)

15. How is the STO carried out?

The STO is carried out on a lateral cephalogram taken in centric position with the lips relaxed. A frontal facial picture with the lips relaxed and a picture with a wide smile on are also helpful in deciding the vertical positioning of the maxilla.

16. How do you evaluate the effect of treatment?

It can be evaluated by the process called *superimposition*. There are three basic types:

- *Overall superimposition* is usually done by superimposing the anterior cranial base on the de Caster plane. After age 7 years, the sphenoethmoidal synchondrosis is fused, after which the anterior cranial basis is a stable structure that can be used for superimposition. This form of superimposition indicates the overall change in the maxilla and mandible in reference to the cranial base.
- *Maxillary superimposition* is done by superimposing the anterior nasal spine on the palatal plane (ANS–PNS). It reveals the dental changes in the maxilla.
- *Mandibular superimposition* is done by superimposing on the lingual aspect of the symphysis parallel to the lower border of the mandible or mandibular plane. It indicates the changes in the mandibular dentition due to the treatment.

17. Have there been any recent advancements in cephalometrics?

Yes. There are three major advancements:

- Digital imaging
- Computerized cephalometrics
- Cone beam computed tomographic (CT) scan

18. What is digital imaging?

In digital imaging, a static or dynamic sensor is used to capture the image instead of a silver halide film.

19. What are the advantages of digital imaging?

- Digital imaging allows the possibility of digital archiving.
- The image can be digitally enhanced for better landmark identification.

20. What are the disadvantages of digital imaging?

- Distortion, especially if a dynamic sensor is used for scanning.
- Standardization ruler must be used. If not, magnification/constriction cannot be accounted for.

21. What is computerized cephalometrics?

Computerized cephalometrics is a process of using a scanned lateral cephalometric radiograph or digital radiograph and a computer to make a tracing that, in turn, is used to make measurements and superimposition (Figs. 27-7 and 27-8). The image can also be used to create multiple simulated treatments (STO) without destroying the initial image.

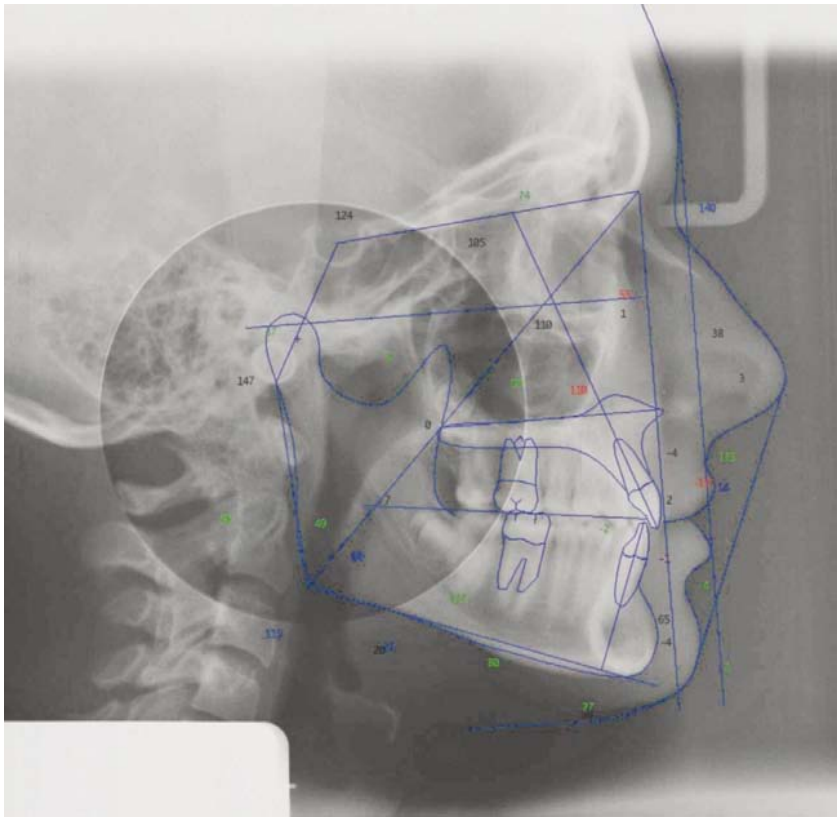

Figure 27-7. Radiograph with computer-generated tracing and measurements superimposed.

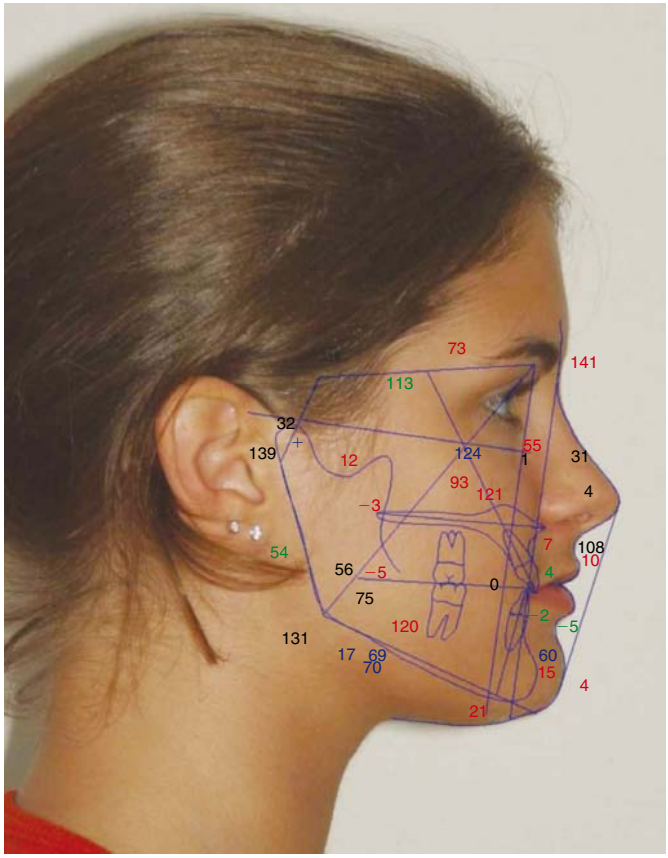

Figure 27-8. Tracing superimposed over lateral facial photograph.

Figure 27-9. Comparison of pretreatment morphing and actual postsurgical result.

22. What is the advantage of computerized cephalometrics?

One of the greatest advantages is the ability to superimpose the tracing over a picture and manipulate the facial picture to match the changes made on the radiographic tracing. This procedure is called *morphing* (Fig. 27-9).

23. What are the disadvantages of morphing a picture?

Morphing can be performed only on the lateral profile, and the accuracy of morphing still is questionable.

24. What is cone beam CT?

Cone beam CT is an in-office CT scan that provides a three-dimensional image of the facial complex. This is the future of imaging in the field of orthodontics.

Cephalometrics is a valuable tool in the diagnosis and treatment planning of orthodontic and surgical cases, but it must be used only as an adjunct to clinical diagnosis. After all, we treat patients and faces, not x-rays.

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