

Cephalometric Review

Highlights of Tracing,
ABO Ceph Analysis, Regional Anatomy,
Superimposition Techniques &
Interpretation



The highest commitment to excellence.

Disclaimer

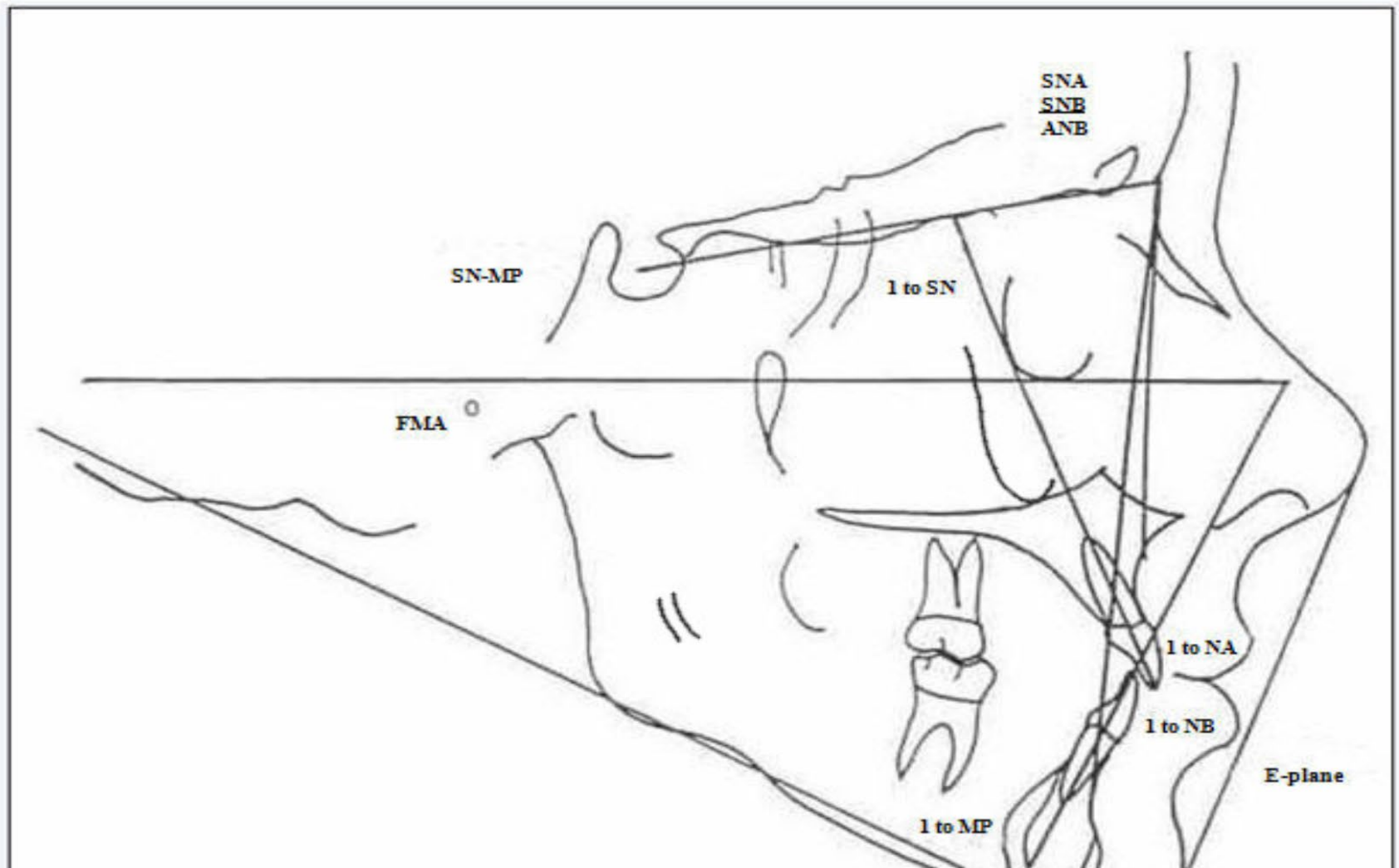
The following is not a substitute for a thorough understanding of cranial anatomy, growth and development, treatment affects or skeletal and dental diagnosis.

ABO Cephalometric Guidelines

EXAMPLE 1 CEPHALOMETRIC TRACING REFERENCE

Print

Tracing will be drawn in black, blue, or red, depending on the level of evaluation



- Original tracing is black
- Progress tracing is blue
- Final tracing is red

ABO Cephalometric Measurements

- SNA
- SNB
- ANB
- SN MP
- FMA
- U1 TO SN
- U1 TO NA
- L1 TO MP
- L1 TO NB
- E-PLANE

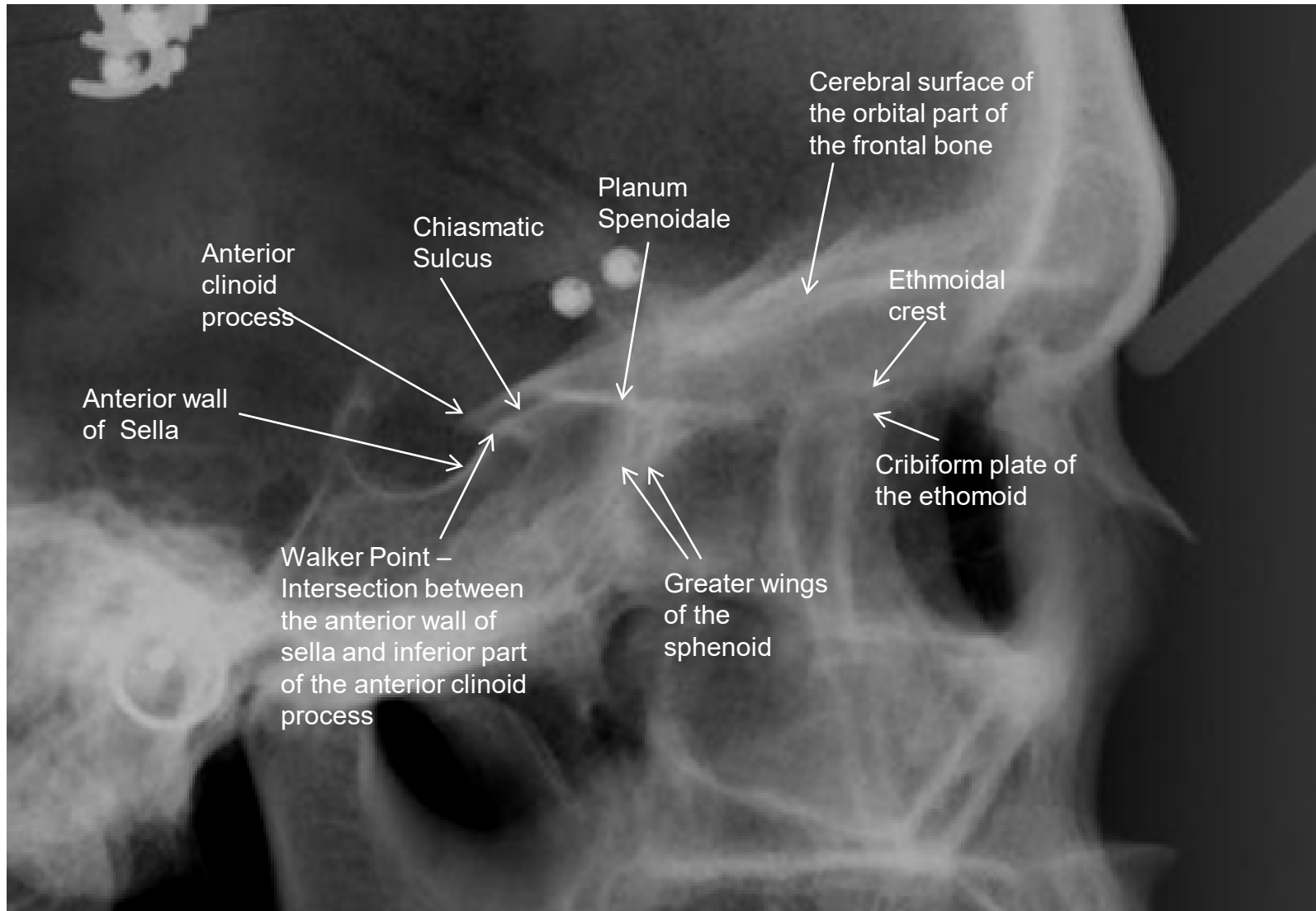
Cephalometric Landmark Definitions:

Sella S	midpoint of the sella turcica (hypophysial or pituitary fossa)
Nasion N	most anterior point of nasofrontal suture in the median plane
Porion Po	the upper- and outer-most point on the external auditory meatus
Orbitale Or	the most inferior and anterior point of the orbital margin
Point A	-subspinale, the deepest point on the curved profile of the anterior portion of the maxilla, between the anterior nasal spine and alveolar crest
Pogonion Pg	most anterior point of the bony chin, in the median plane
Menton Me	lowest point of the mandibular symphysis in the midline
Gnathion Gn	most anterior and inferior point of the bony chin (midpoint between pogonion and menton)
Point B	-supramentale, the deepest point on the curved profile of the mandible, between the chin and the alveolar crest
Condylion Cd	most posterior and superior point on the head of the condyle
Articulare Ar	the point of intersection of the posterior margin of the ascending mandibular ramus and the outer margin of the posterior cranial base
Gonion Go	the most posterior and inferior point on the angle of the mandible
Upper incisor apex	the root apex of the most anterior maxillary central incisor
Upper incisor tip	the tip of the crown of the most anterior maxillary central incisor
Lower incisor tip	the tip of the crown of the most anterior mandibular central incisor
Lower incisor apex	the root apex of the most anterior mandibular central incisor
ANS	anterior nasal spine, the tip of the bony anterior nasal spine in the midline
PNS	posterior nasal spine, the tip of the posterior nasal spine in the midline

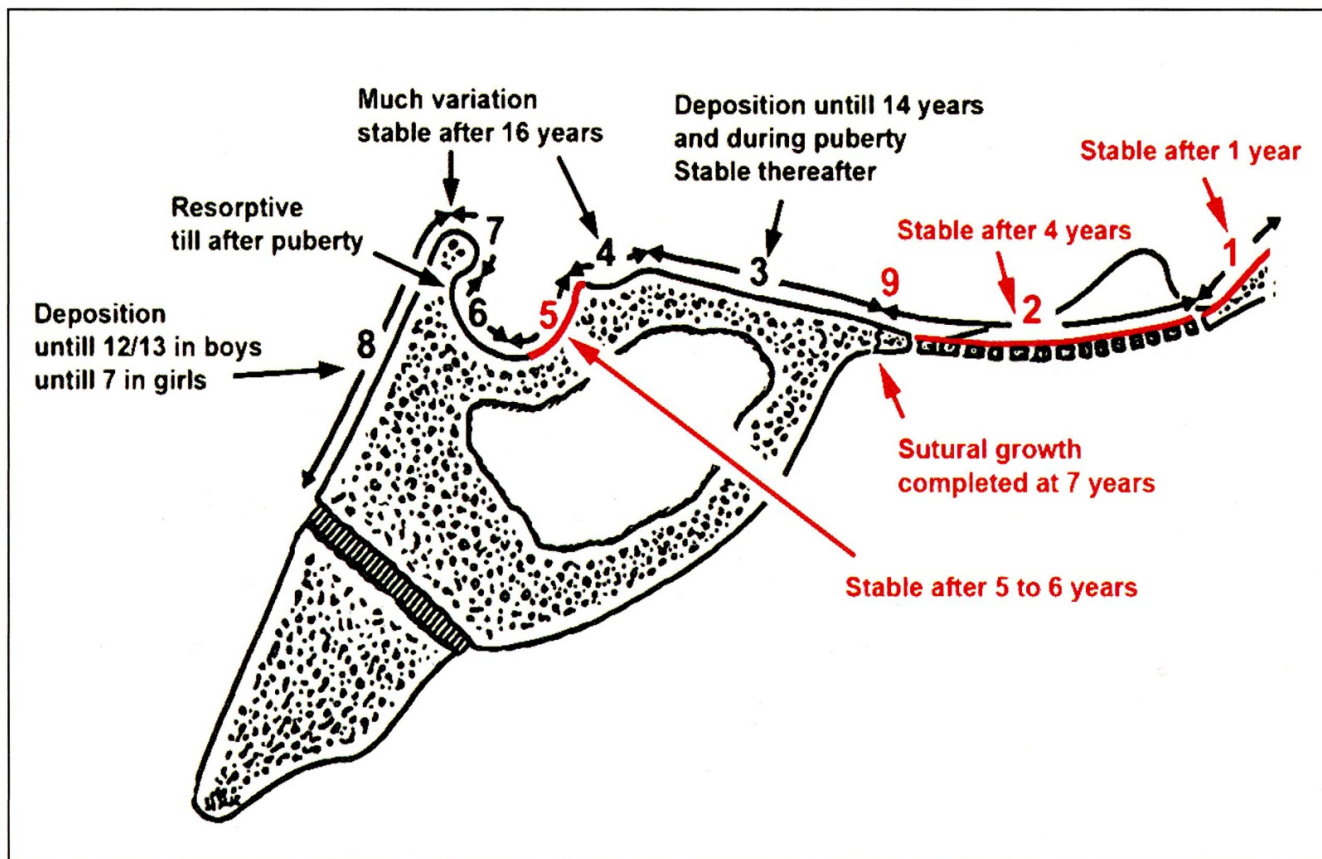
- Constructed Gonion is used for mandibular plane.
- Measurements given in an exam are specific to the scenario patient.
- Examinees should be familiar with cephalometric measurement norms, standard deviations and ethnic variations.

Superimposition Review

Cranial Base Anatomy



Evidence for Stability of these Anatomical Structures



Maxillary Regional Superimposition

Vertical changes:

- Maxillary growth in height occurs at its processes.
- Apposition of bone at the floor of the orbits.
- Resorption of bone at the nasal floor and apposition on the palatal surfaces.

Sagittal changes:

- Anterior surface of the zygomatic processes was relatively stable.

Maxillary Regional Superimposition

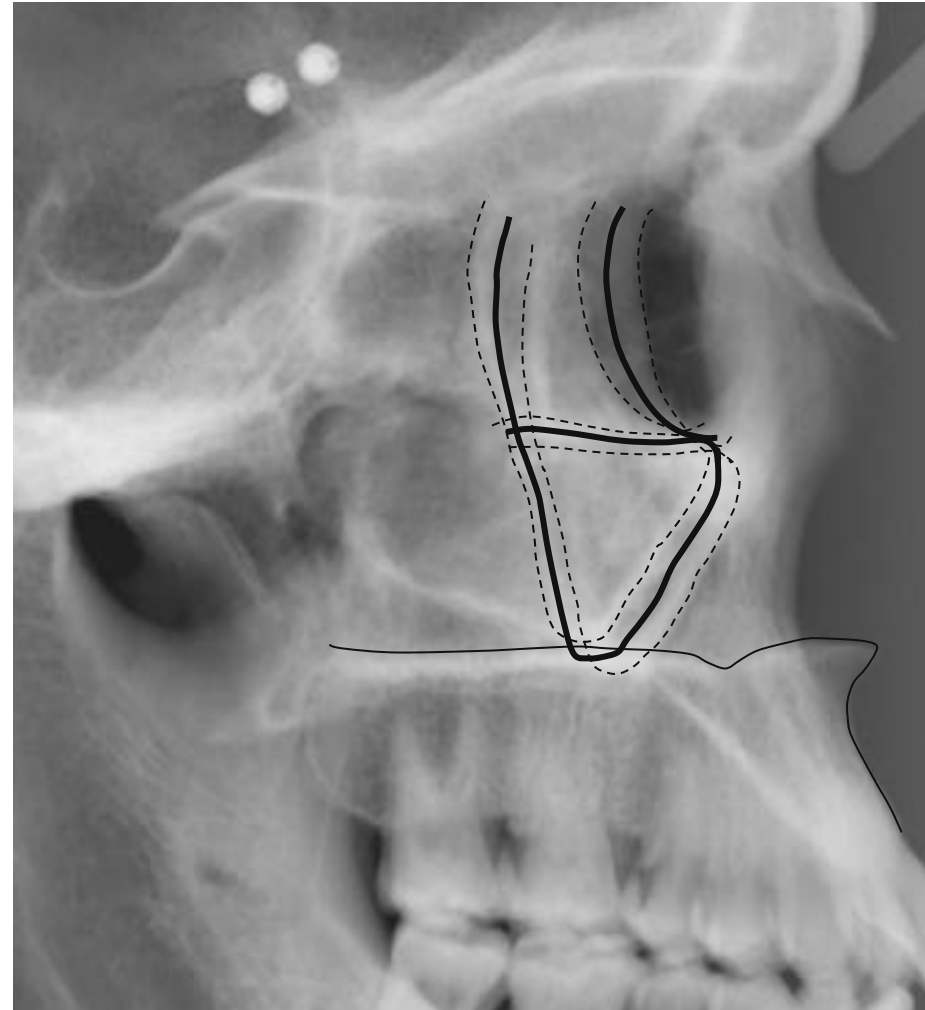
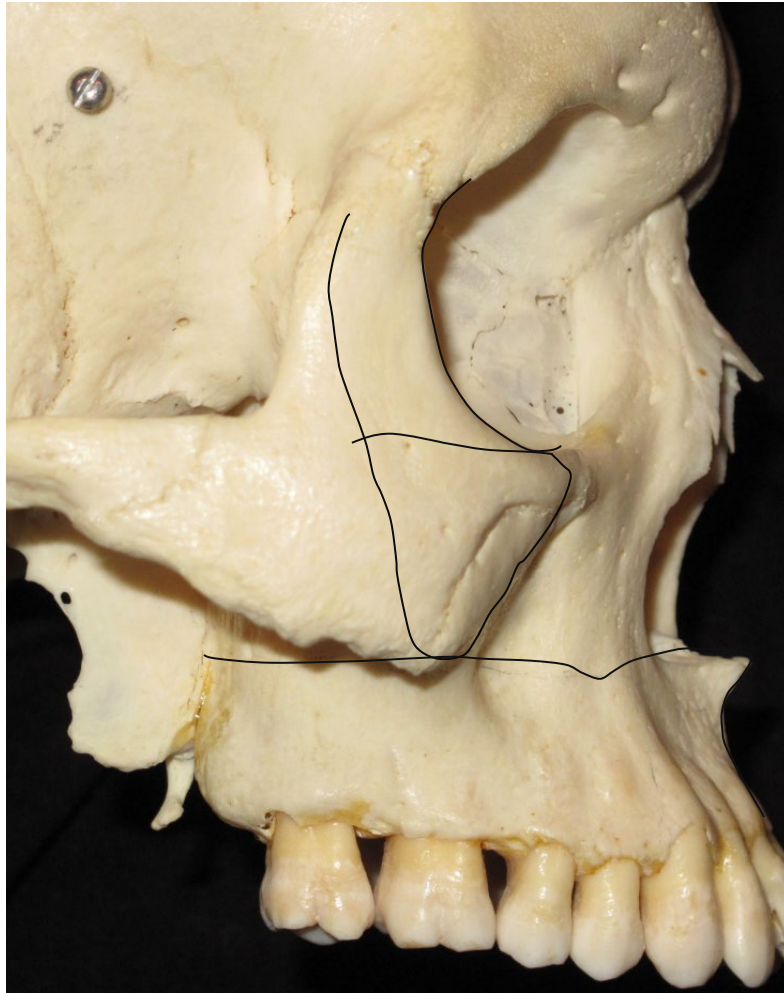
The ABO has used the literature to arrive at the suggested technique with the use of the appropriate anatomical structures.

Let's review those anatomical structures.

Maxillary Regional Superimposition

- Both the right and left (or carefully split the two) zygomatic processes (ant. & post. Legs).
- Superior surface of both orbital floors (or carefully split).
- Superior surface of the palatal floor.

Maxillary Superimposition

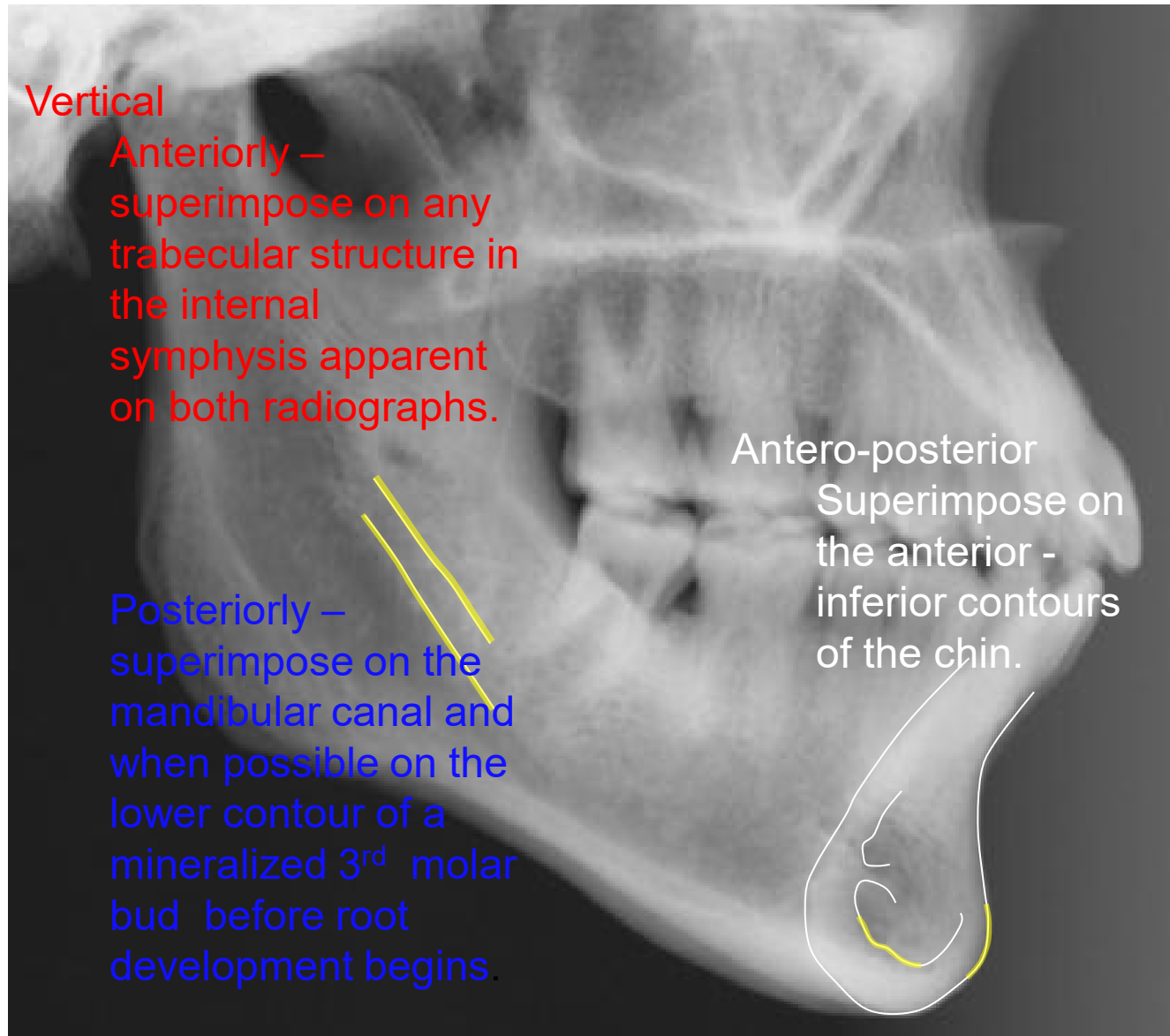


Mandibular Regional Superimposition

Anatomical Structures used for the Superimposition

1. The most anterior (inferior) portion of the symphysis.
2. The inferior, internal cortical plate of the symphyseal cross-section.
3. The inferior alveolar nerve canal.
4. When present, the inferior aspect of the 3rd molar tooth bud before root development.

Mandibular Superimposition Reference



Vertical

Anteriorly –
superimpose on any
trabecular structure in
the internal
symphysis apparent
on both radiographs.

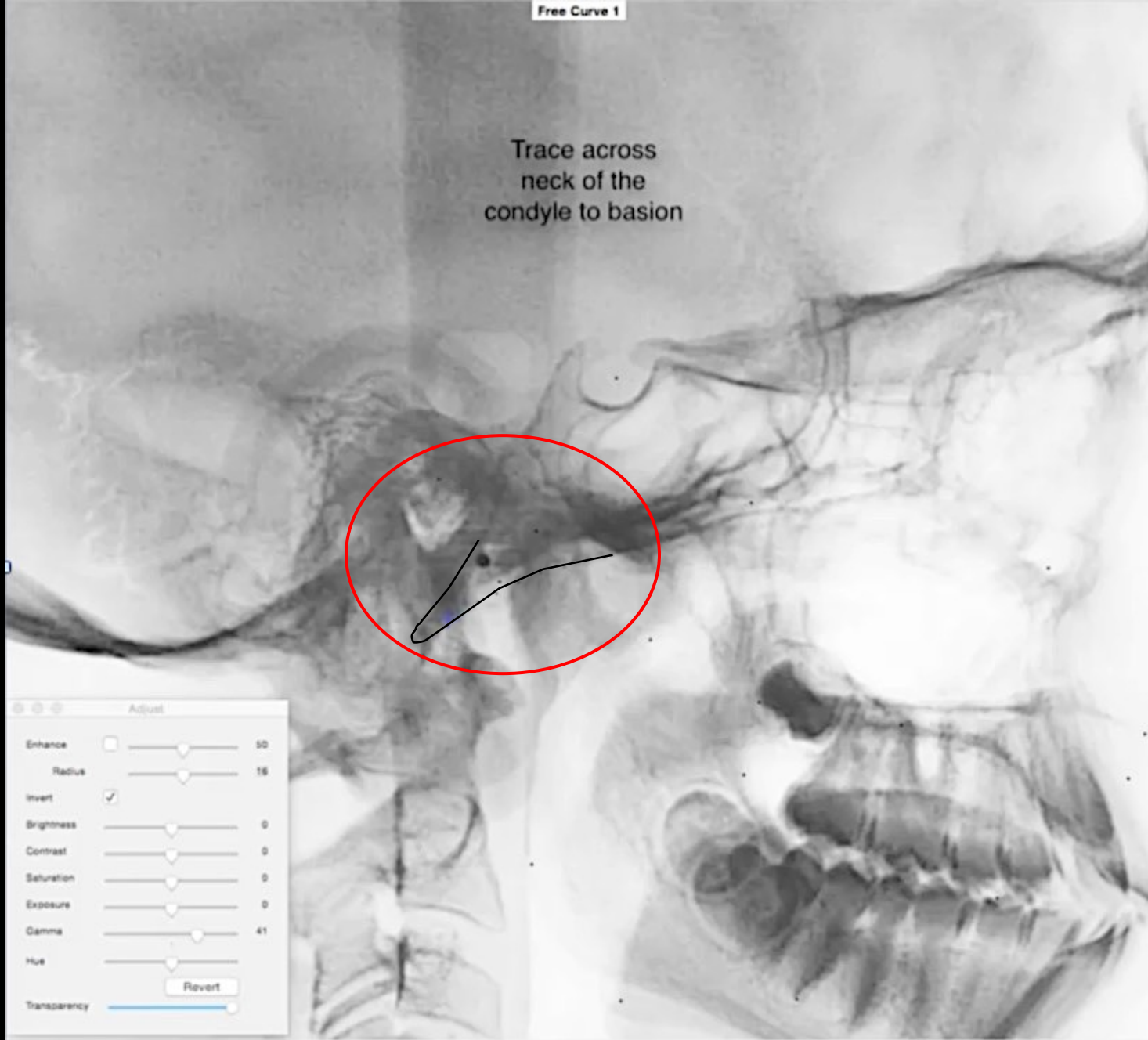
Posteriorly –
superimpose on the
mandibular canal and
when possible on the
lower contour of a
mineralized 3rd molar
bud before root
development begins.

Antero-posterior

Superimpose on
the anterior -
inferior contours
of the chin.

Tracing the Cranial Base

Trace across
neck of the
condyle to basion



Adjust

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Saturation		<input type="range" value="0"/>	0
Exposure		<input type="range" value="0"/>	0
Gamma		<input type="range" value="41"/>	41
Hue		<input type="range" value="0"/>	
Revert			
Transparency		<input type="range" value="100"/>	

Then up the
clivus to...
the dorsum
sellae



Adjust

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Gamma		<input type="range" value="41"/>	41
Hue		<input type="range" value="0"/>	
Revert			
Transparency		<input type="range" value="100"/>	

posterior clinoid to
posterior, inferior &
anterior sella to...



Adjust

Enhance 50

Radius 16

Invert

Brightness 0

Contrast 0

Saturation 0

Exposure 0

Gamma 41

Hue

Revert

Transparency

jugum
sphenoidale
to...

Adjust

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Invert	<input checked="" type="checkbox"/>		
Brightness			0
Contrast			0
Saturation			0
Exposure			0
Gamma			41
Hue			
Revert			
Transparency			

jugum
sphenoidale
to...

the sphenoidal plane

Adjust

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Gamma		<input type="range" value="41"/>	41
Hue		<input type="range" value="0"/>	
Revert			
Transparency		<input type="range" value="100"/>	

Cribiform plate of the ethmoid to...

Adjust

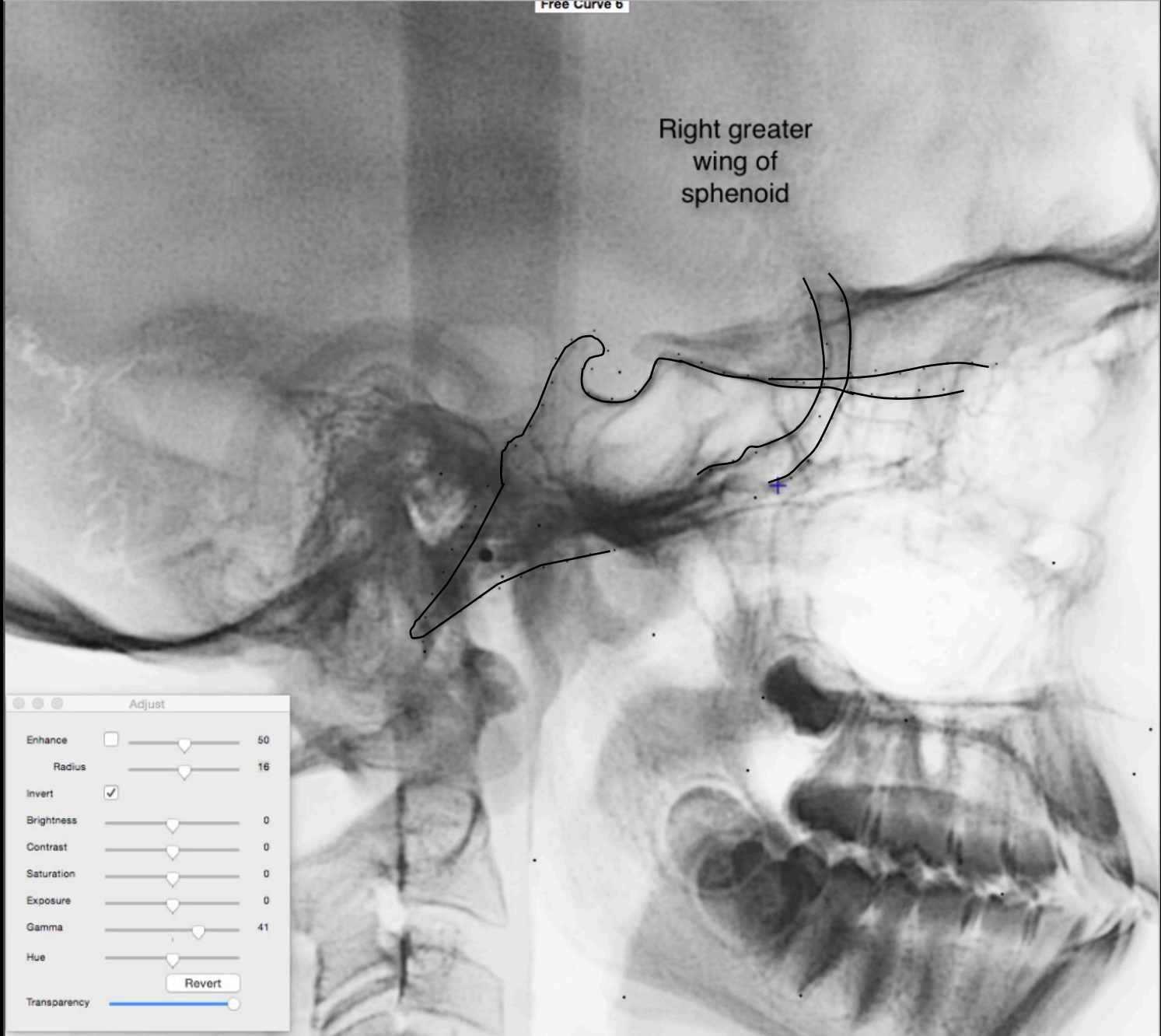
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Saturation			0
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Gamma			41
Hue			
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Transparency			

Left greater
wing of
sphenoid

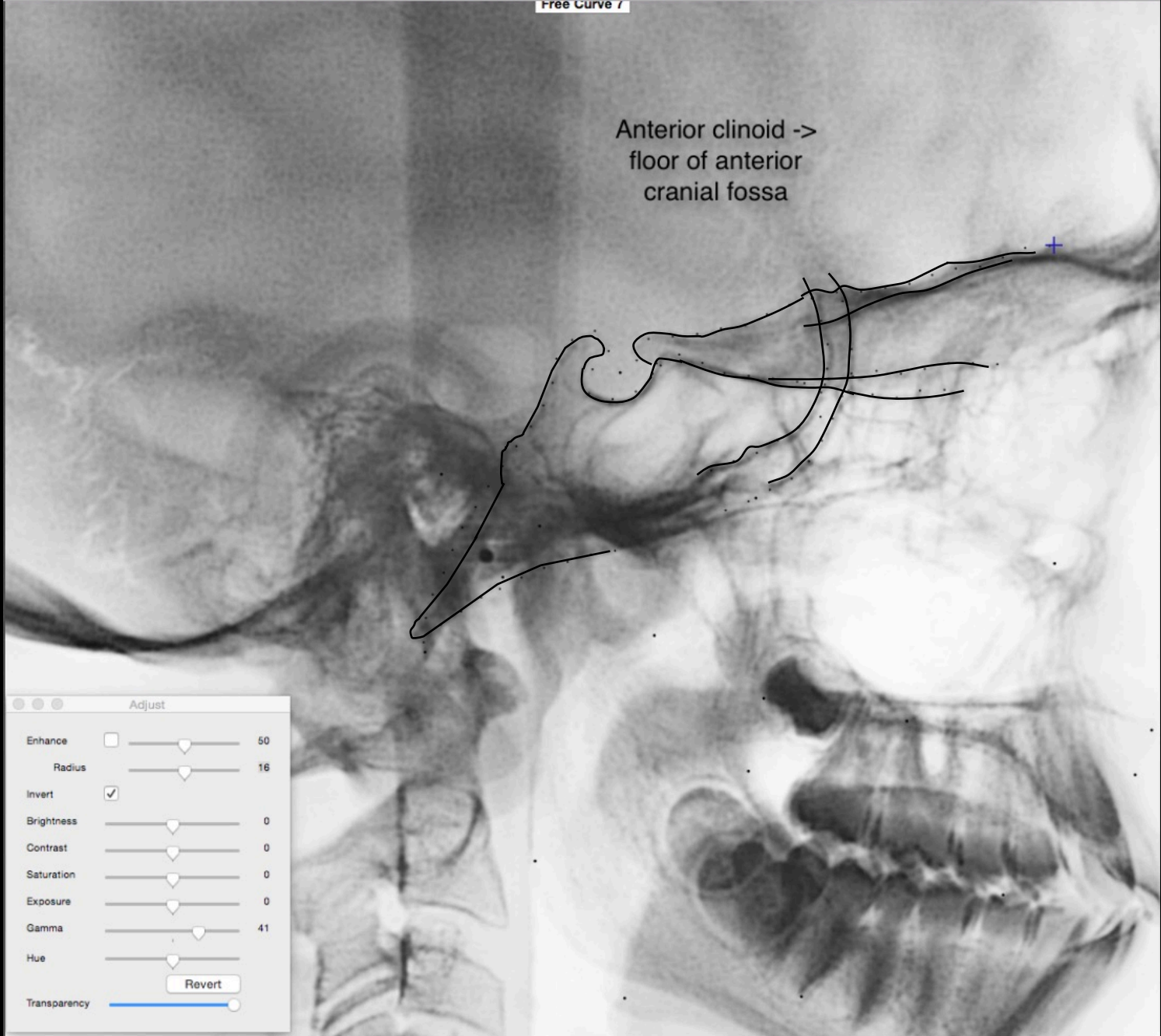
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Hue			
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Transparency			

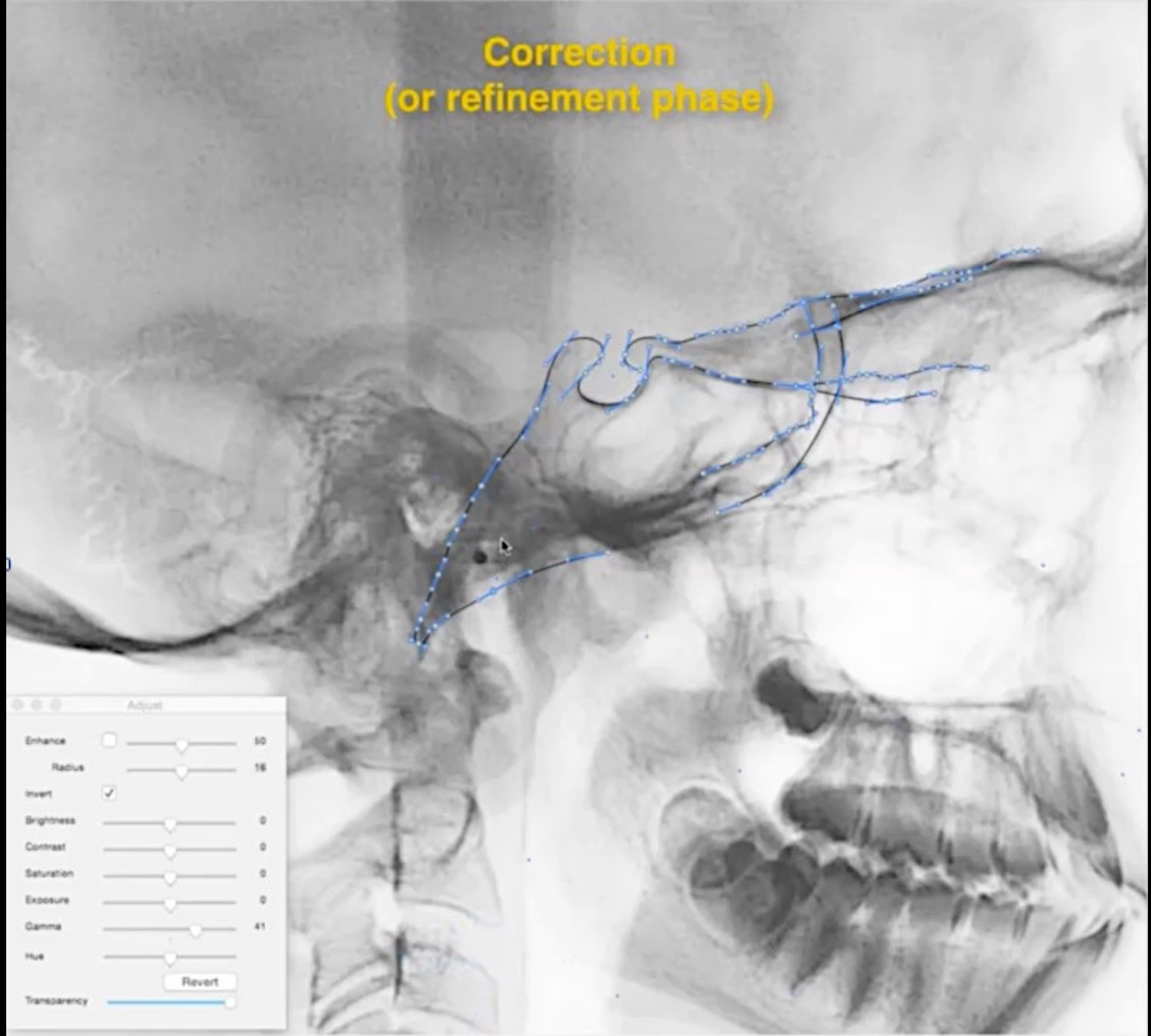
Right greater wing of sphenoid



Anterior clinoid ->
floor of anterior
cranial fossa



Correction (or refinement phase)



Adjust

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Hue		<input type="range" value="0"/>	
Revert			
Transparency		<input type="range" value="100"/>	

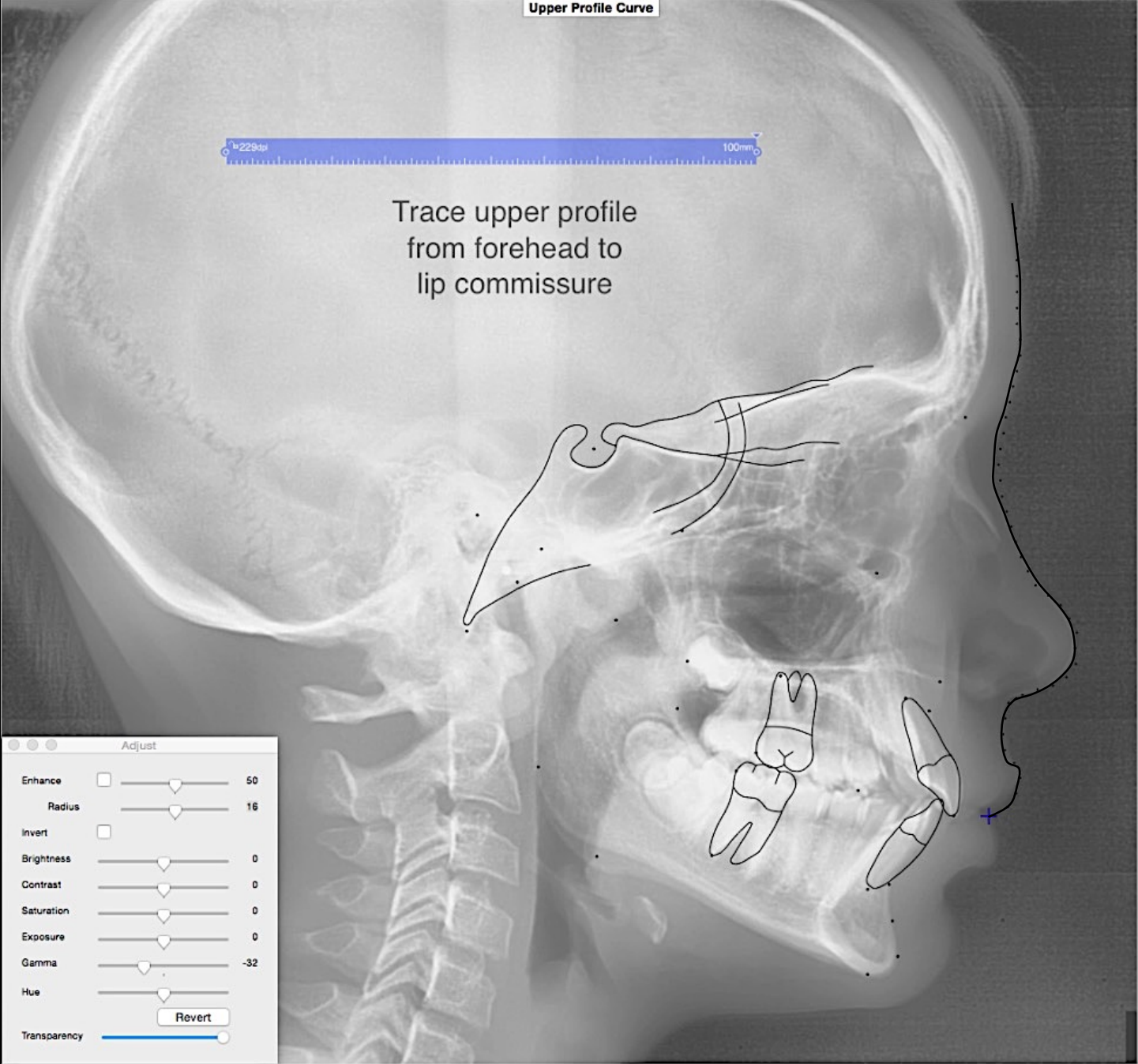


Tracing the:

- Upper Profile
- Lower Profile
- Mandible
- Maxilla
- Key Ridges



Trace upper profile
from forehead to
lip commissure



Adjust

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Invert	<input type="checkbox"/>		
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Contrast			0
Saturation			0
Exposure			0
Gamma			-32
Hue			
<input type="button" value="Revert"/>			
Transparency			



Trace lower profile
from lip
commissure to
throat

Adjust

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Radius			16
Invert	<input type="checkbox"/>		
Brightness			0
Contrast			0
Saturation			0
Exposure			0
Gamma			-32
Hue			
<input type="button" value="Revert"/>			
Transparency			



Trace mandible
from lower incisor
to distal of terminal
lower molar

Adjust

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Radius			16
Invert	<input type="checkbox"/>		
Brightness			0
Contrast			0
Saturation			0
Exposure			0
Gamma			-32
Hue			
<input type="button" value="Revert"/>			
Transparency			



Trace maxilla from
labial to lingual of
upper incisor

Adjust

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Radius			16
Invert	<input type="checkbox"/>		
Brightness			0
Contrast			0
Saturation			0
Exposure			0
Gamma			-32
Hue			

Revert

Transparency



Trace outer
symphysis

Adjust

Enhance	<input type="checkbox"/>		50
Radius			16
Invert	<input type="checkbox"/>		
Brightness			0
Contrast			0
Saturation			0
Exposure			0
Gamma			-32
Hue			
<input type="button" value="Revert"/>			
Transparency			



Trace inner
symphysis

Adjust

Enhance	<input type="checkbox"/>		50
Radius			16
Invert	<input type="checkbox"/>		
Brightness			0
Contrast			0
Saturation			0
Exposure			0
Gamma			-32
Hue			
<input type="button" value="Revert"/>			
Transparency			



Trace upper
and lower
nerve canals

Adjust

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Radius			16
Invert	<input type="checkbox"/>		
Brightness			0
Contrast			0
Saturation			0
Exposure			0
Gamma			-32
Hue			

Revert

Transparency



Trace right & left key ridges

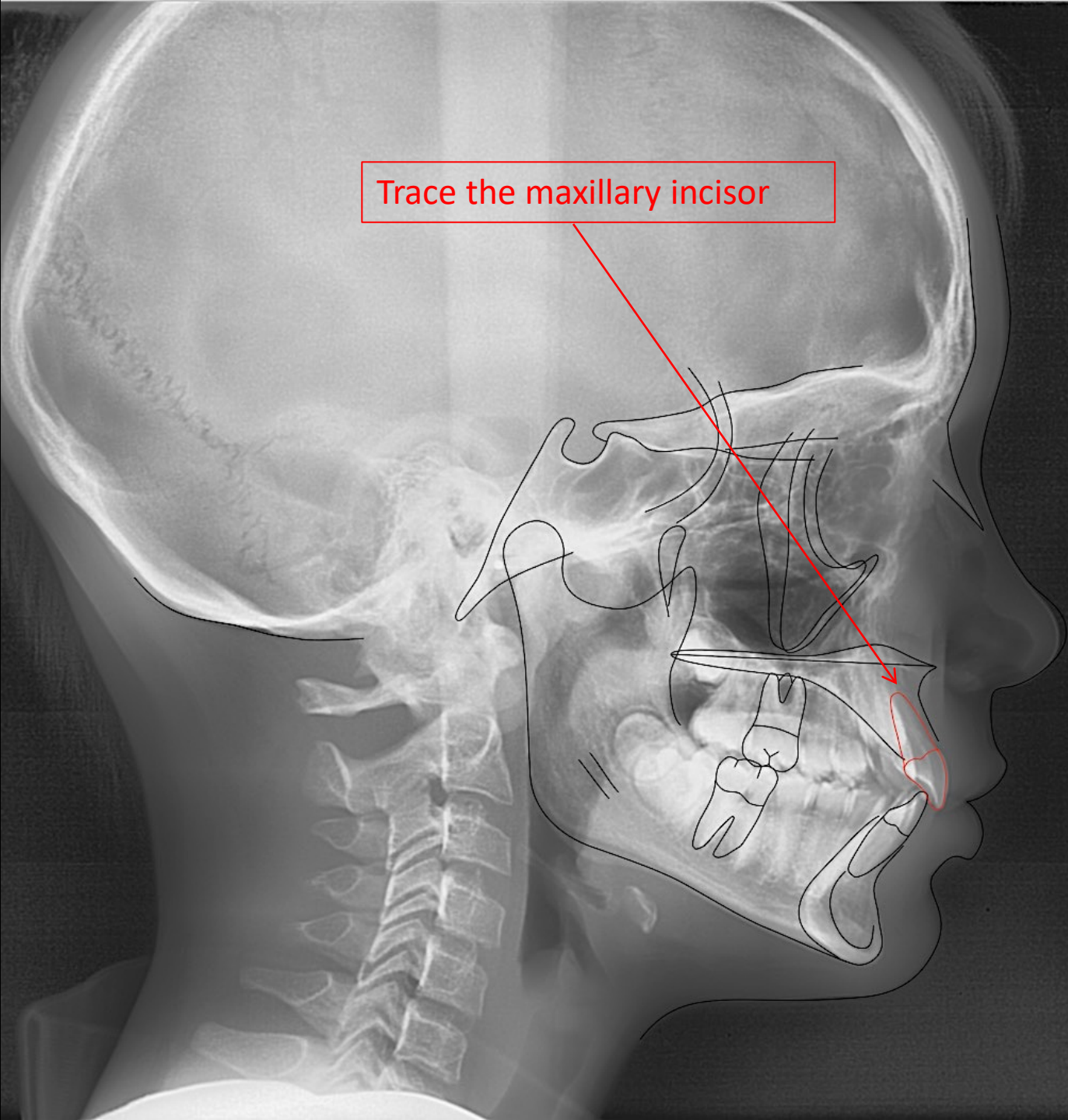
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Transparency			

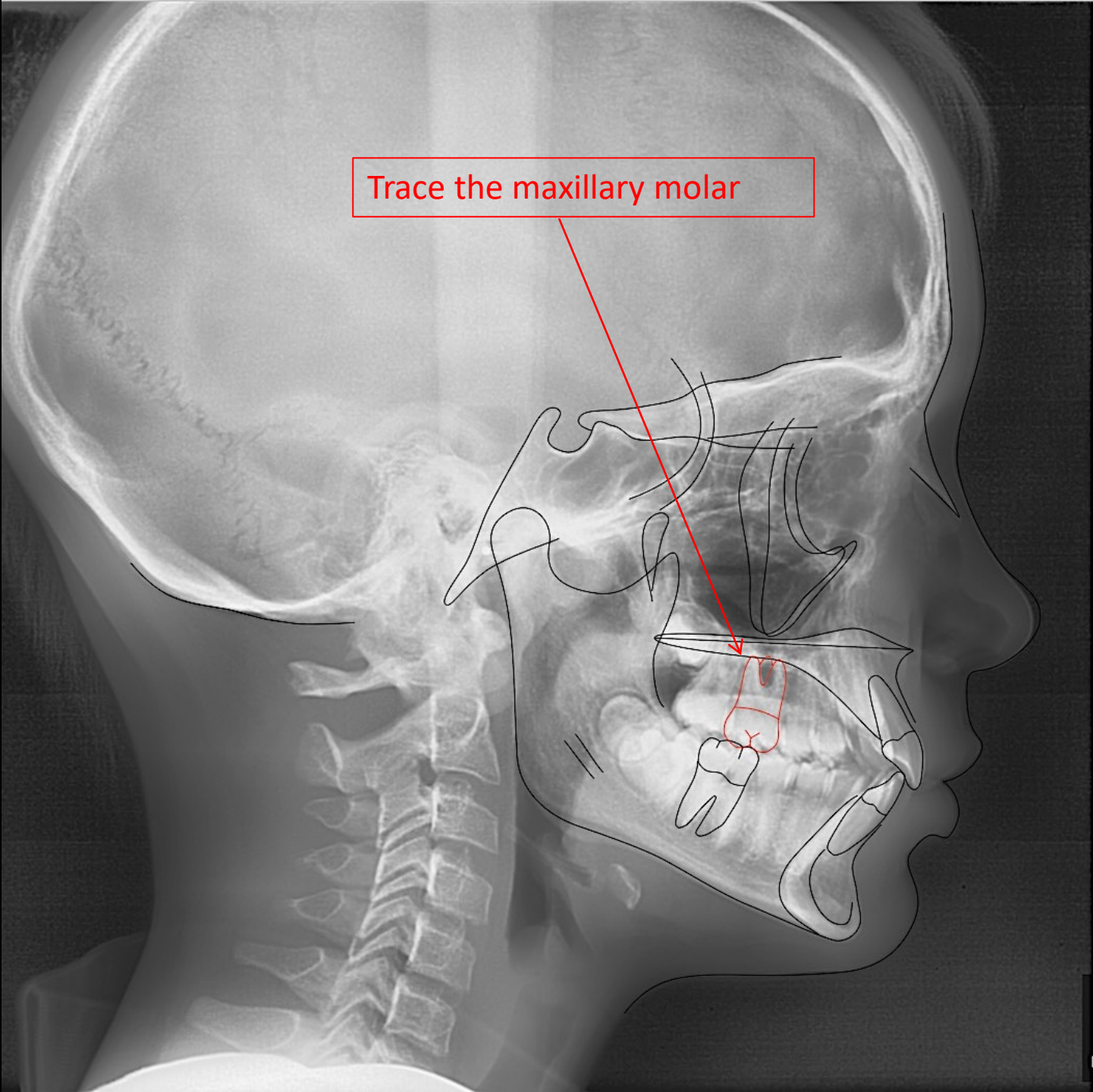


Tracing the:

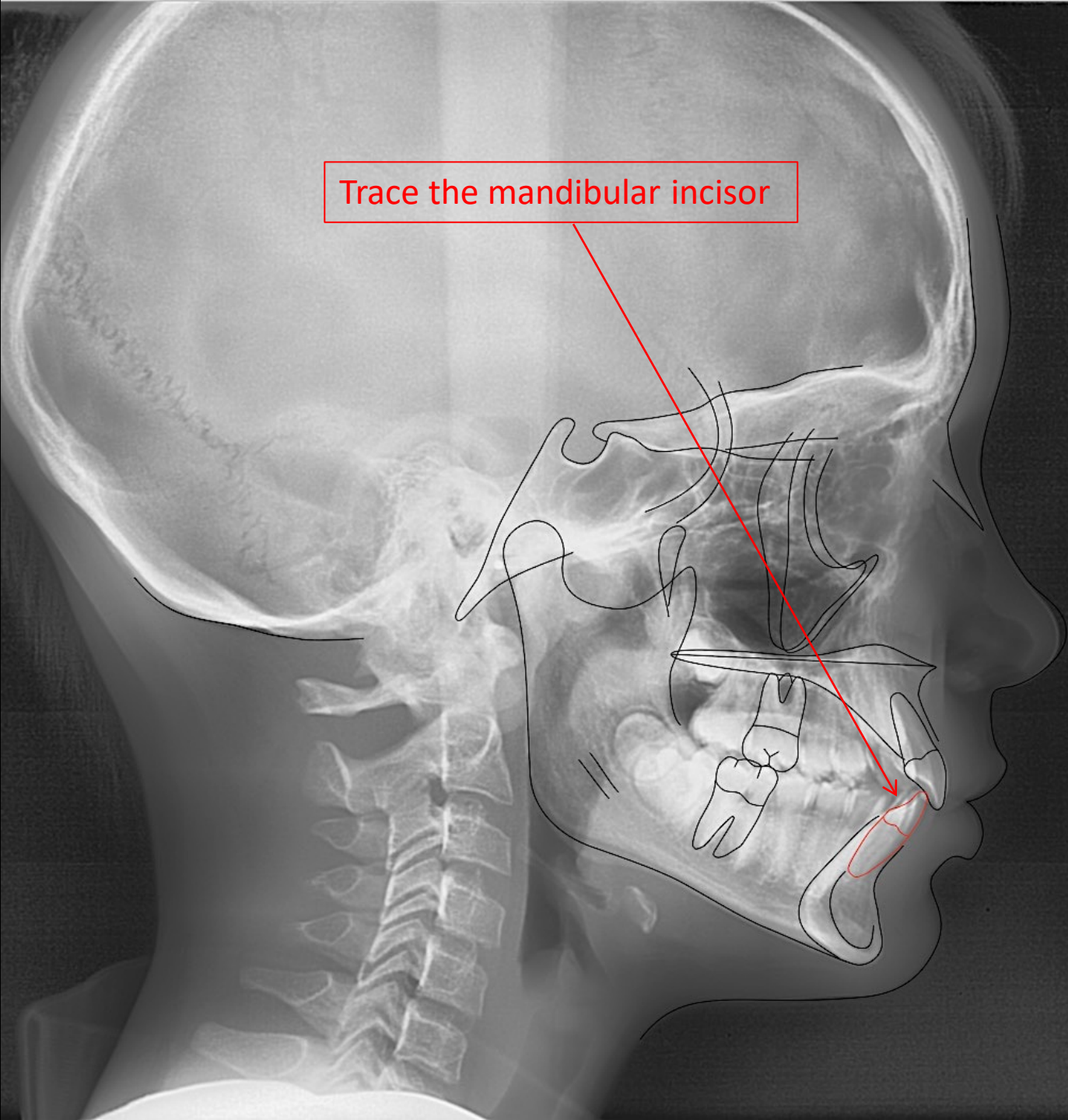
- Maxillary and Mandibular Incisors
- Maxillary and Mandibular Molars
- Frontal Bone
- Nasal Bone
- Occipital Bone



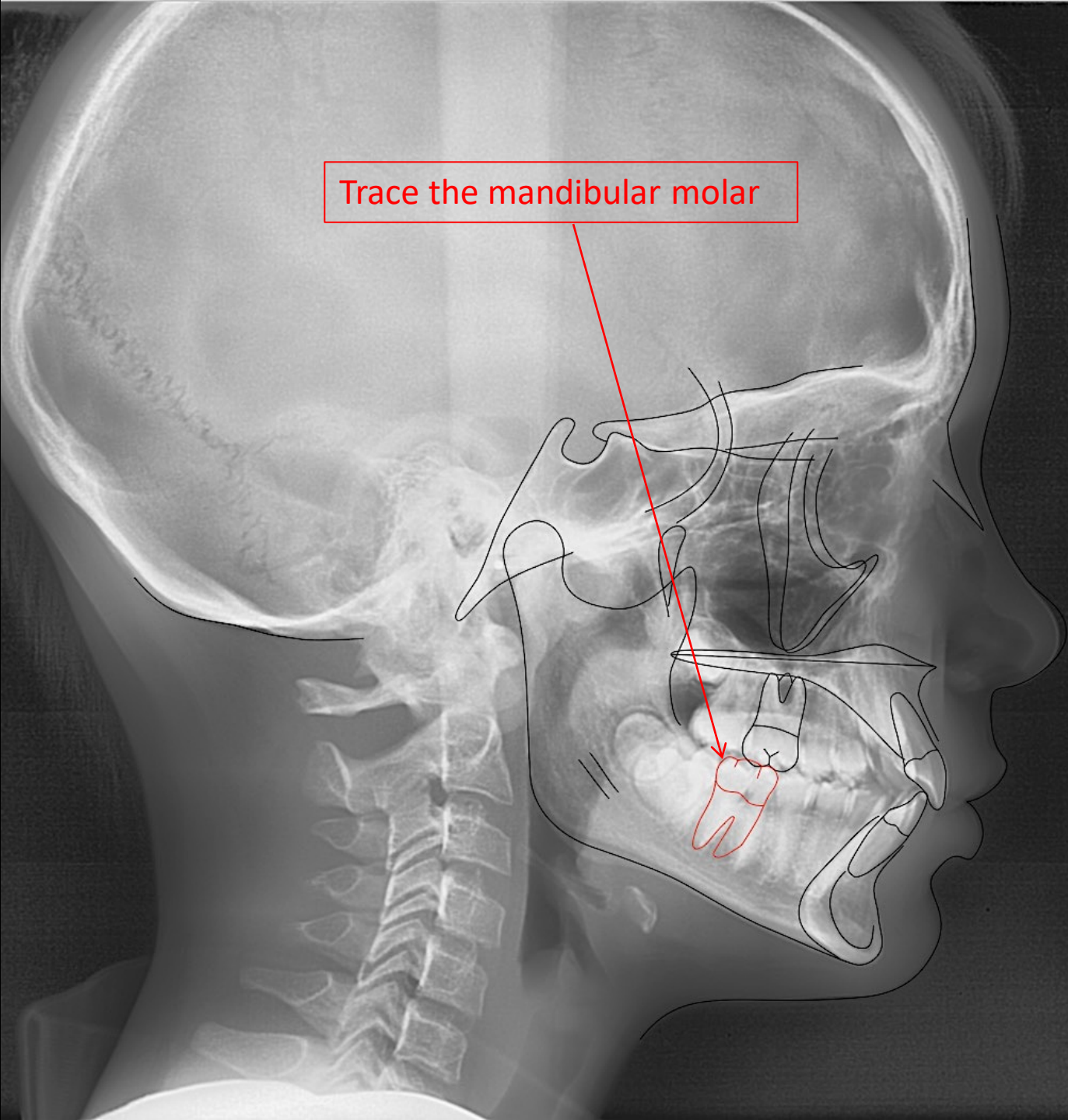
Trace the maxillary incisor



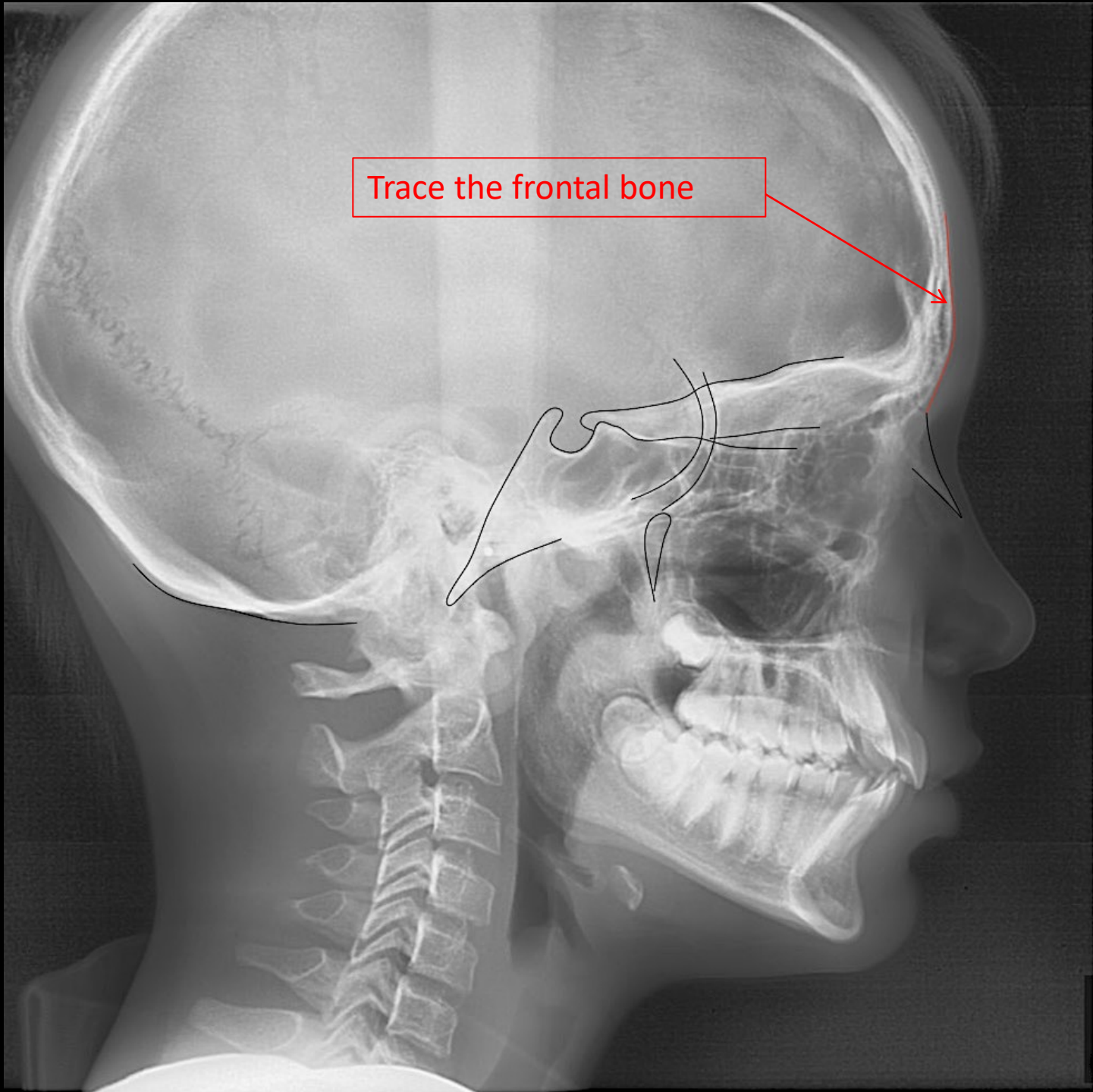
Trace the maxillary molar



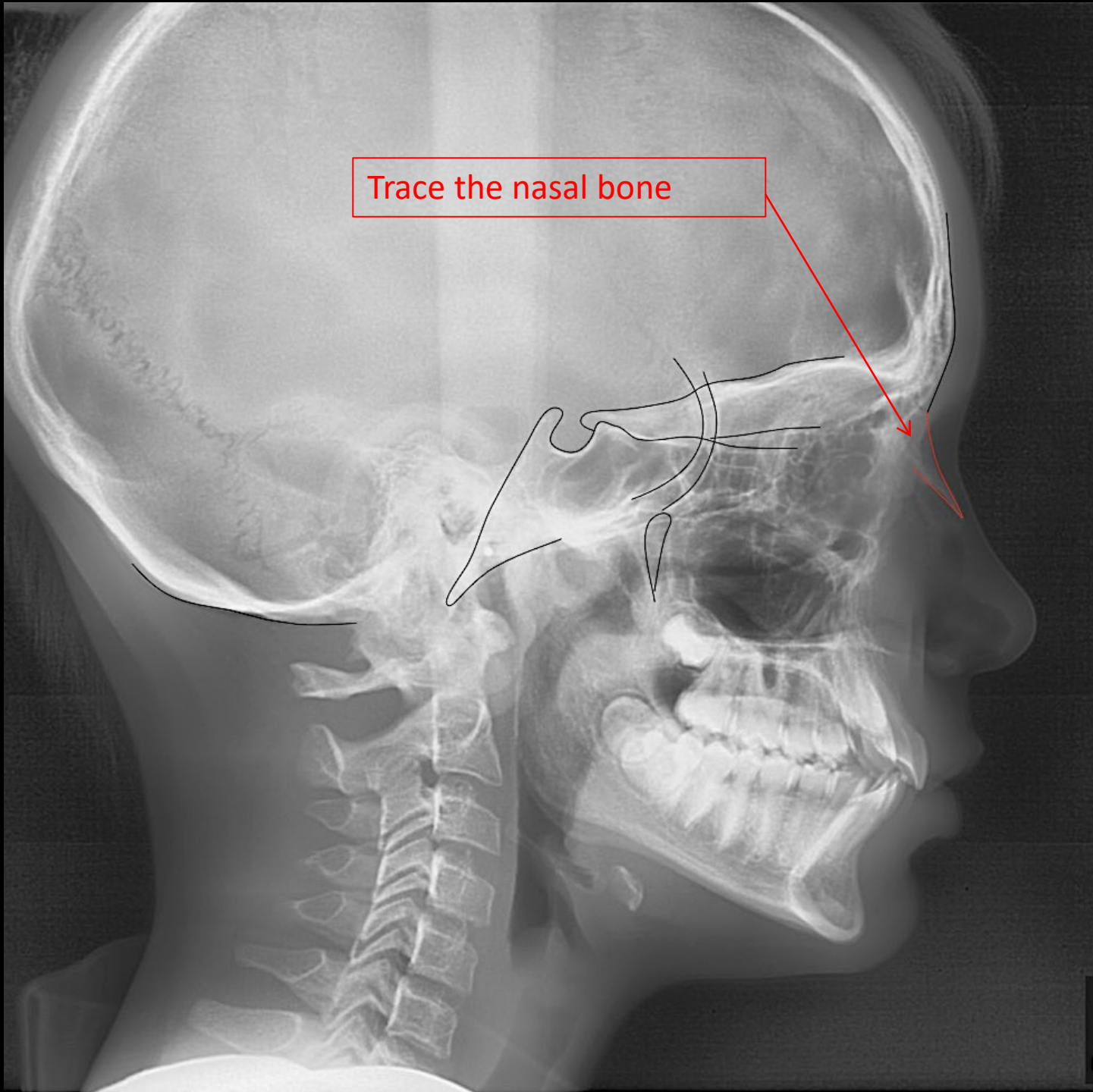
Trace the mandibular incisor



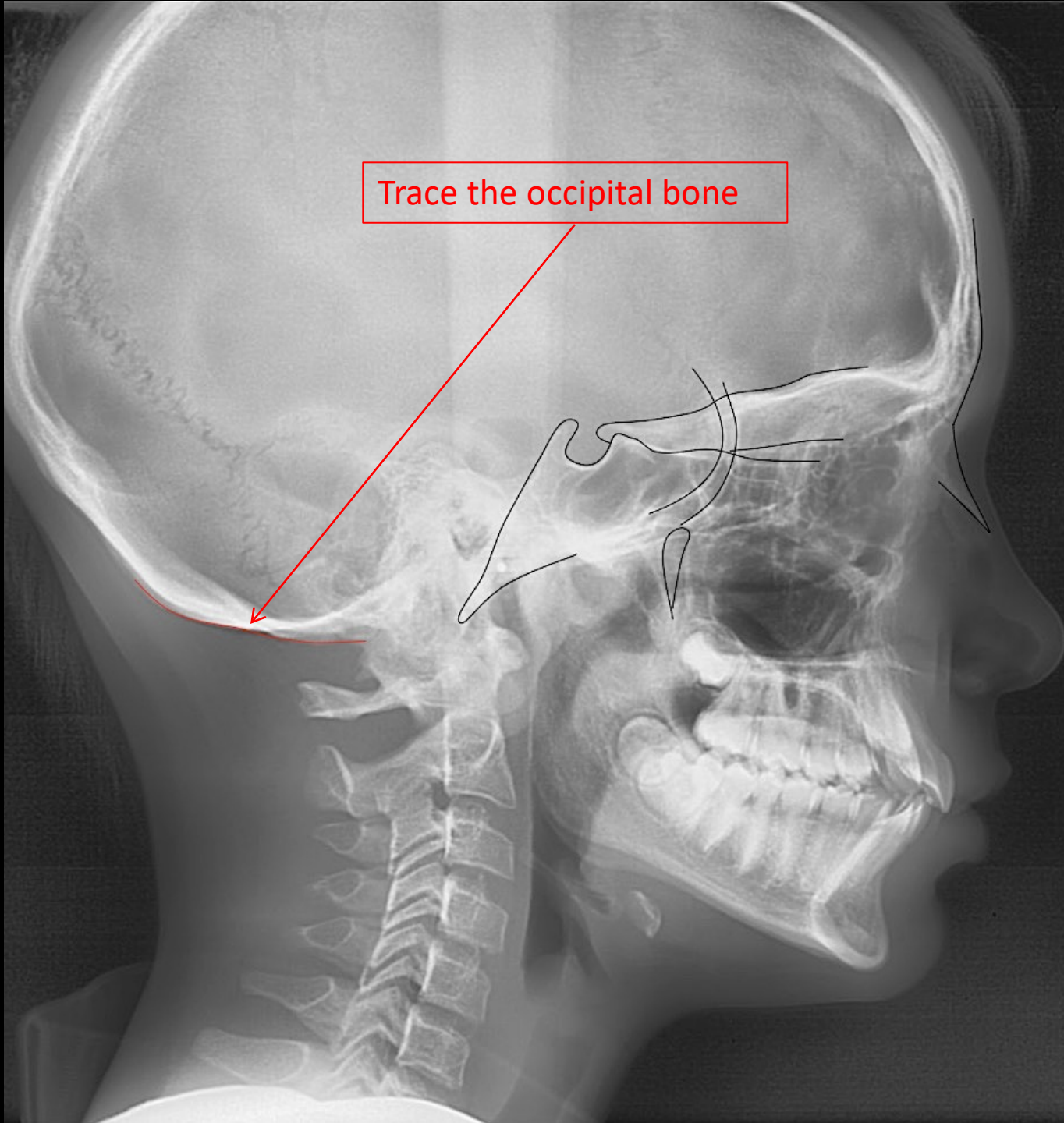
Trace the mandibular molar



Trace the frontal bone



Trace the nasal bone



Trace the occipital bone



Tips & Tricks When Tracing with a Computer Program

- Adjust the line width of the computer generated lines to 0.1mm (or 0.2mm at most).
- Trace the image line with greatest contrast.
- Best to trace the superior surfaces of sella.
- Best to trace the superior surfaces of:
 - Jugum sphenoidale
 - Cribriform plate of the ethmoid bone
 - Ethmoidal crest

Tips & Tricks When Tracing with a Computer Program

- Be consistent in what and where you trace between cephs.
- Use gamma control for more accurate location of bone margins & profile.
- Have the 2nd or 3rd cephs available to help visualize each anatomical structure.

Tips & Tricks When Tracing with a Computer Program

- Make sure the tooth templates are all the same size **within an individual tracing** and also **between different tracings**, i.e.:
 - Don't have a small incisor and/or molar template for pre-treatment and large ones for post-treatment or vice-versa.
 - Don't have a very small incisor and very large molar or vice-versa within the same tracing.
 - If you can choose a tooth template size, use images from the best ceph for each template.

Tips & Tricks When Tracing with a Computer Program

- Learn the quickest way to make the tracing lines show or be hidden; toggle between the two frequently when correcting (“refining”).
- Learn the quickest way to zoom in and out, and use it frequently.
- Use the point of the cursor to place on an anatomical area, and then hide or show your tracing to see if it is accurately placed.
- Have 1st tracing on the ceph and in view when tracing the 2nd ceph.
- **DO NOT ACCEPT PRE-TRACED, PROGRAM GENERATED ANATOMICAL LINES AS ACCURATE; REFINE THESE AS NEEDED TO MEET THE ACCURACY REQUIREMENT.**

Superimpositions

Superimposition Videos
are on the ABO Website



The highest commitment to excellence.



Superimpositions are Done in the Following Order

1. Overall craniofacial superimposition
2. Maxillary regional superimposition
3. Mandibular regional superimposition

How do you Superimpose Tracings?

For the cranial base superimposition, you need structures that do not change or grow over time. This allows you to assess the total changes, both tooth movements in the maxilla and mandible and the displacement of teeth due to jaw growth.

To determine the effect of growth, the orthodontist must subtract the tooth movements found in the maxillary and mandibular superimpositions from the total change found in the cranial base superimposition.

Cranial Base Superimposition

1. Anterior wall of sella turcica below the anterior clinoid processes
2. Planum sphenoidal
3. Greater wings of the sphenoid
4. Cribriform plate
5. Ethmoidal crests
6. Cerebral surfaces of the orbital part of the frontal bone



Maxillary Regional Superimposition

- Reposition the Composite tracing so the Initial Maxillary Regional tracing is over the Maxillary area of the Final tracing.
- For the A-P orientation, place the anterior surface of the Zygomatic Arch tracings over one another.

Maxillary Regional Superimposition

- Reposition the Composite tracing so the Initial Maxillary Regional tracing is over the Maxillary area of the Final tracing.
- For the A-P orientation, place the anterior surface of the Zygomatic Arch tracings over one another.
- In the vertical plane, move the Initial tracing up & down so the inferior border of the orbit or orbital floor is below that of the Final tracing.

Maxillary Regional Superimposition

- The Final tracing of the floor of the nose/ palatal plane should be slightly inferior to the tracing of the initial floor of the nose/ palatal plane.

Maxillary Regional Superimposition

- The Final tracing of the floor of the nose/palatal plane should be slightly inferior to the tracing of the initial floor of the nose/palatal plane.
- The orbital floor of the Final tracing should show vertical apposition in the ratio of $3/5$ compared to $2/5$ for resorption at the floor of the nose.

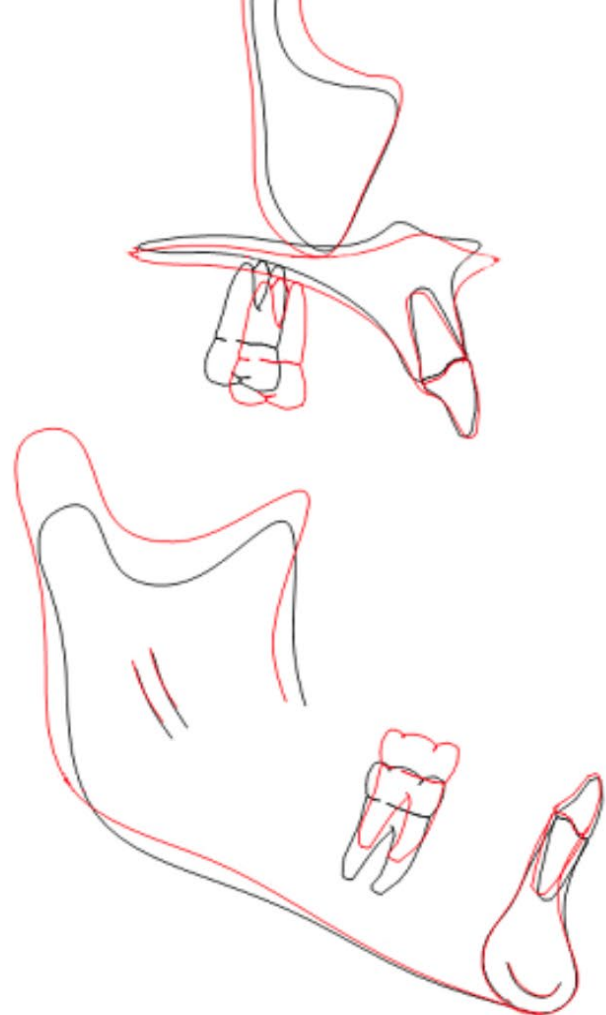
Mandibular Regional Superimposition

- Reposition the Composite tracing so the Initial Mandibular Regional tracing is over the mandibular area of the Final tracing.



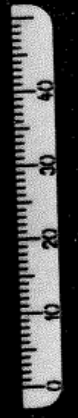
Mandibular Regional Superimposition

- Reposition the Composite tracing so the Initial Mandibular Regional tracing is over the mandibular area of the Final tracing.
- Use the internal x-sectional features of the symphysis and the inferior alveolar nerve canal tracing. Go back and forth between the 2 areas until the best superimposition of each is obtained.



Common Cephalometric Errors

- Image quality
- Accuracy of tracing
- Not following ABO guidelines
- Head positioning
- Software constraints







A-2 Head Position





A-2 Head Position

- Significant error occurs in the position of landmarks lateral to the sagittal plane by varying the head position.
- Damon DH. A Clinical Study of Extraoral High pull Traction to the Maxilla Utilizing a Heavy Force: A Cephalometric Analysis of Dentofacial Changes. (Thesis.) Seattle: University of Washington, 1970.
- Masumoto GT. An Analysis of the Use of the Metallic Implant Method in Superimpositioning of the Maxilla. (Thesis.) Seattle: University of Washington, 1970.

A-2 Head Position

- Patients can rotate their heads as much as 3° and tip their heads 5° even though positioned firmly in the cephalostat.
- Julius RB. A Serial Cephalometric Study of the Metallic Implant Technique and Methods of Maxillary and Mandibular Superimposition. (Thesis.) Seattle: University of Washington. 1971.

A-2 Head Position

- Patients can rotate their heads as much as 3° and tip their heads 5° even though positioned firmly in the cephalostat.
- Julius RB. A serial cephalometric study of the metallic implant technique and methods of maxillary and mandibular superimposition. (Thesis.) Seattle: University of Washington. 1971.
- These head position problems introduce the potential for error in the superimposition tracings.



A-2 Head Position

- Therefore, make sure your patients are positioned consistently in the cephalostat. (Train assistants well).

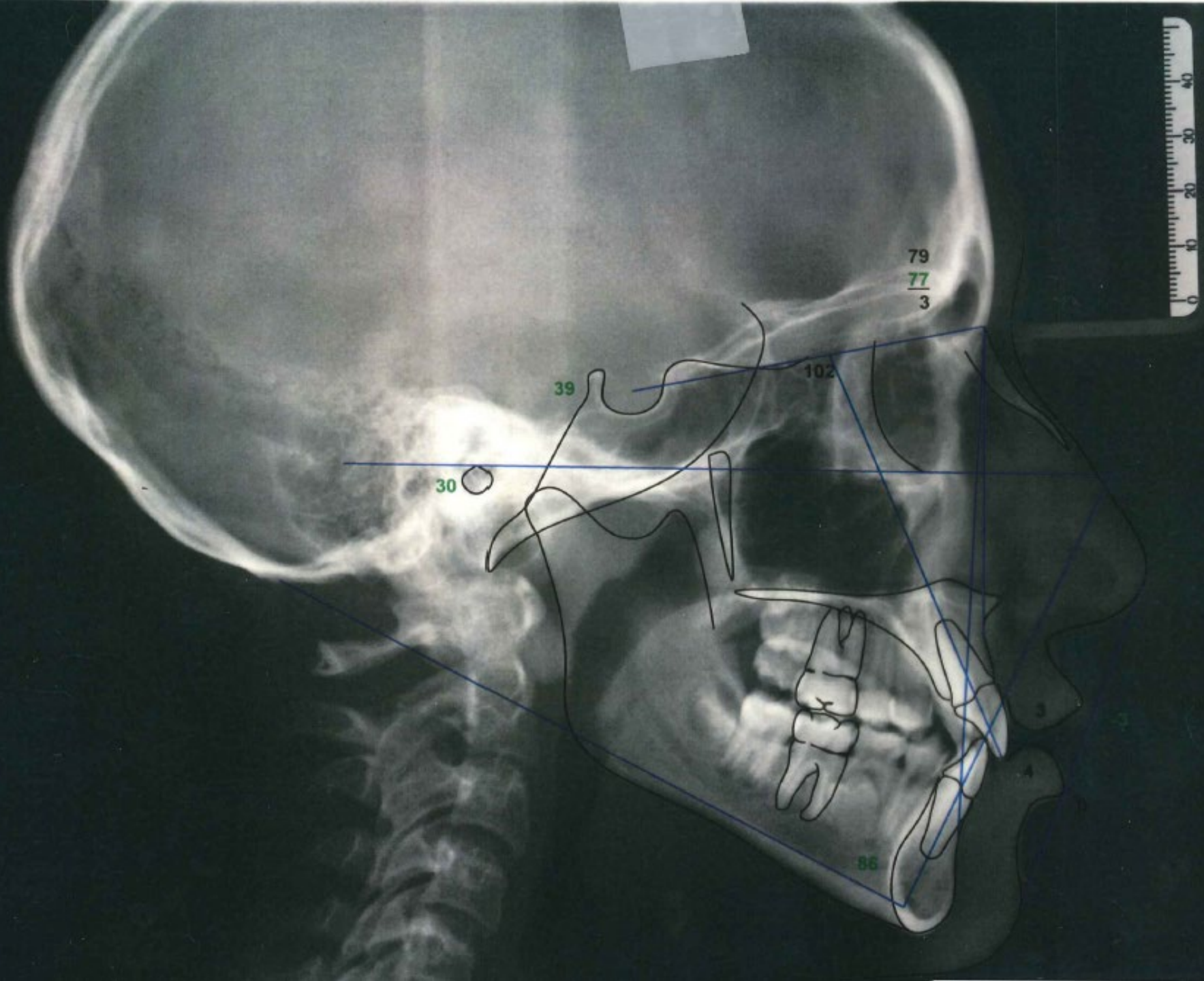


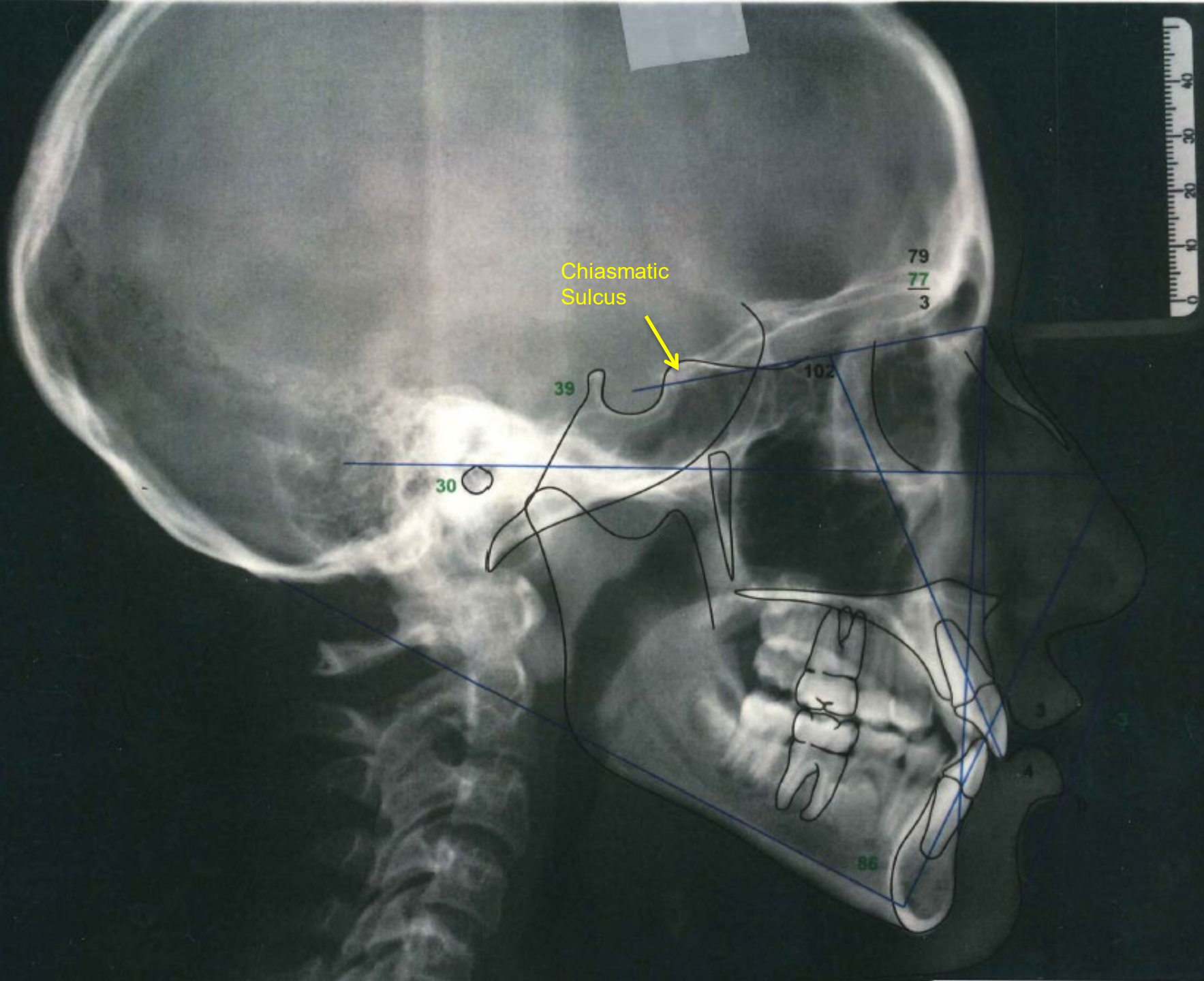
A-2 Head Position

- Therefore, make sure your patients are positioned consistently in the cephalostat. (Train assistants well).
- With CBCT originated 2D lateral cephalograms, make sure that you attempt to position the head on the screen and obtain the best sagittal cut as you can. You have to exercise good judgment in the orientation of the image.

Typical Tracing Errors and Omissions

How many can you identify
on the following tracing?





Chiasmatic
Sulcus

79
77
3

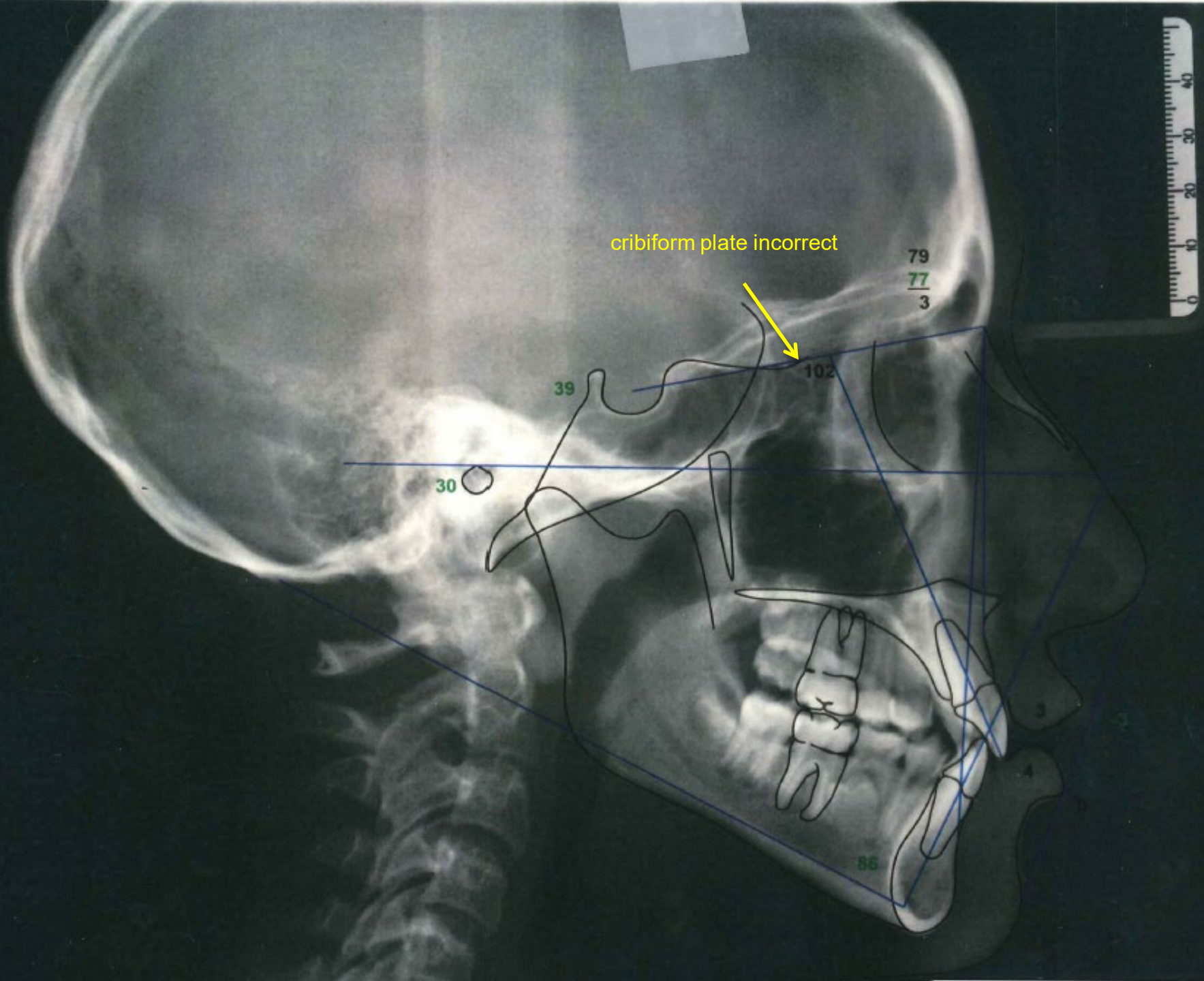
39

102

30

86





cribriform plate incorrect

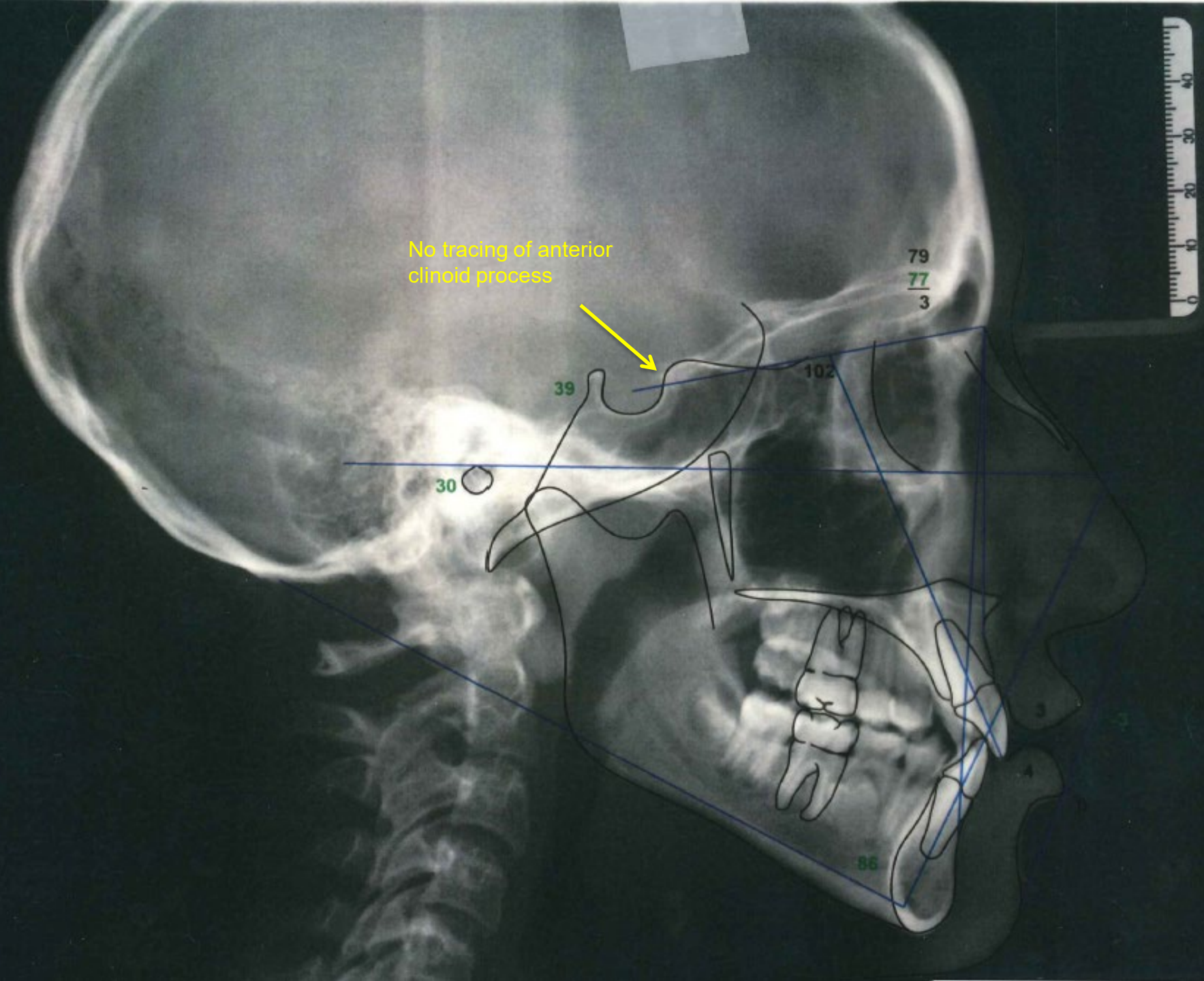
79
77
3

39

102

30

86



No tracing of anterior
clinoid process

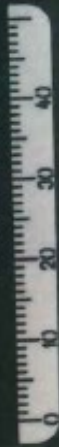
79
77
3

39

102

30

86





No tracing of floor of anterior cranial fossa



79
77
3

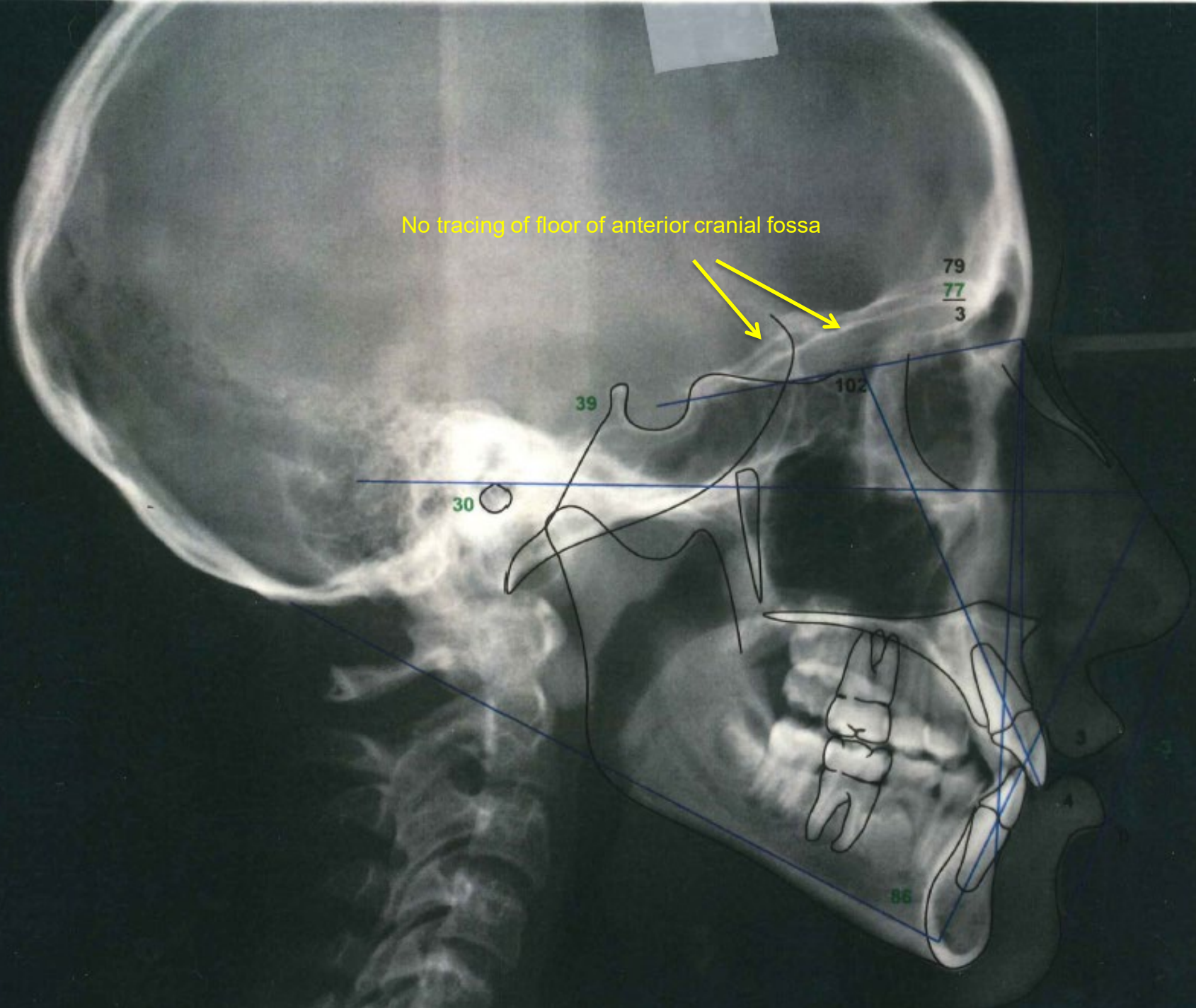


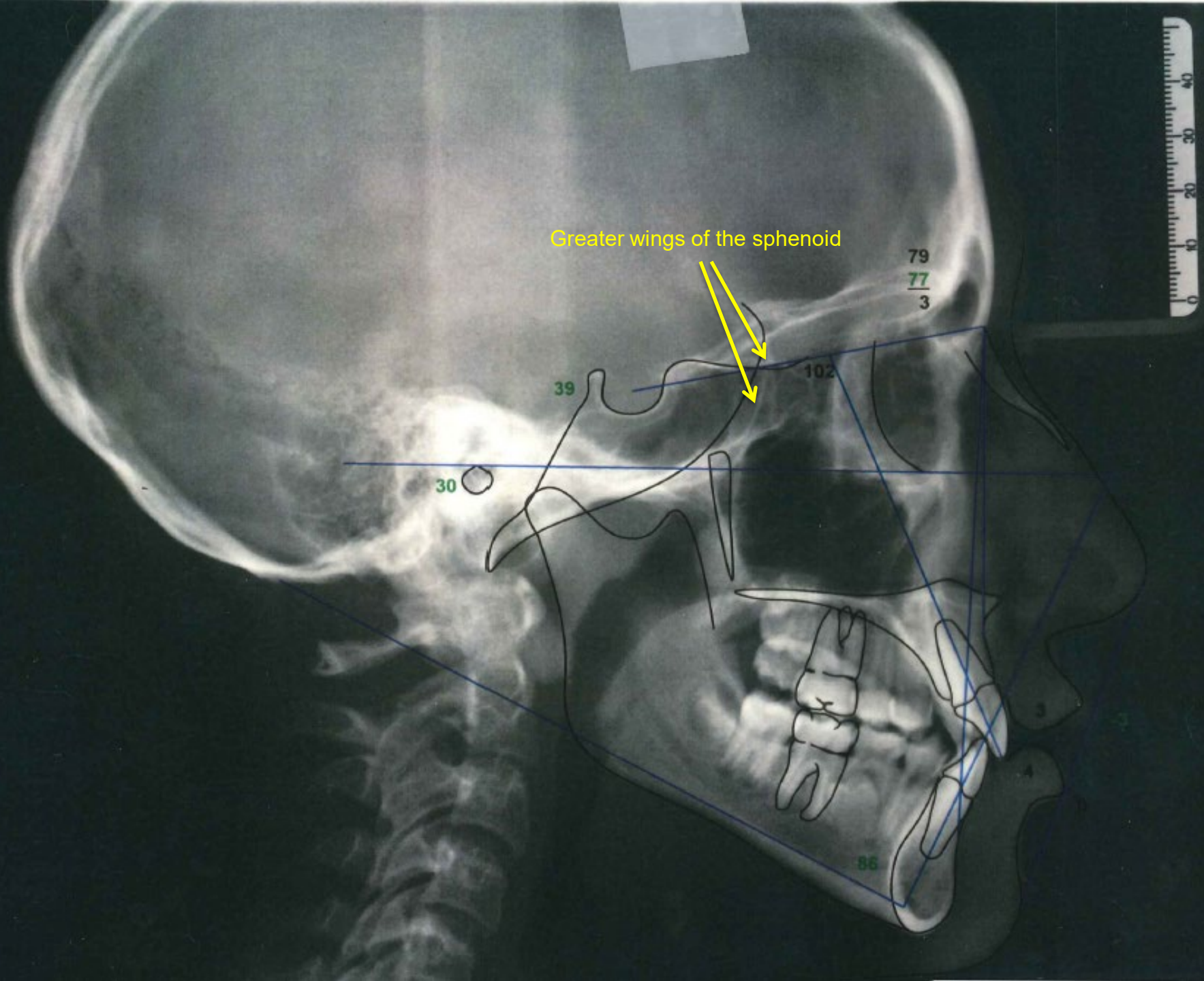
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102

30

86





Greater wings of the sphenoid

79
77
3

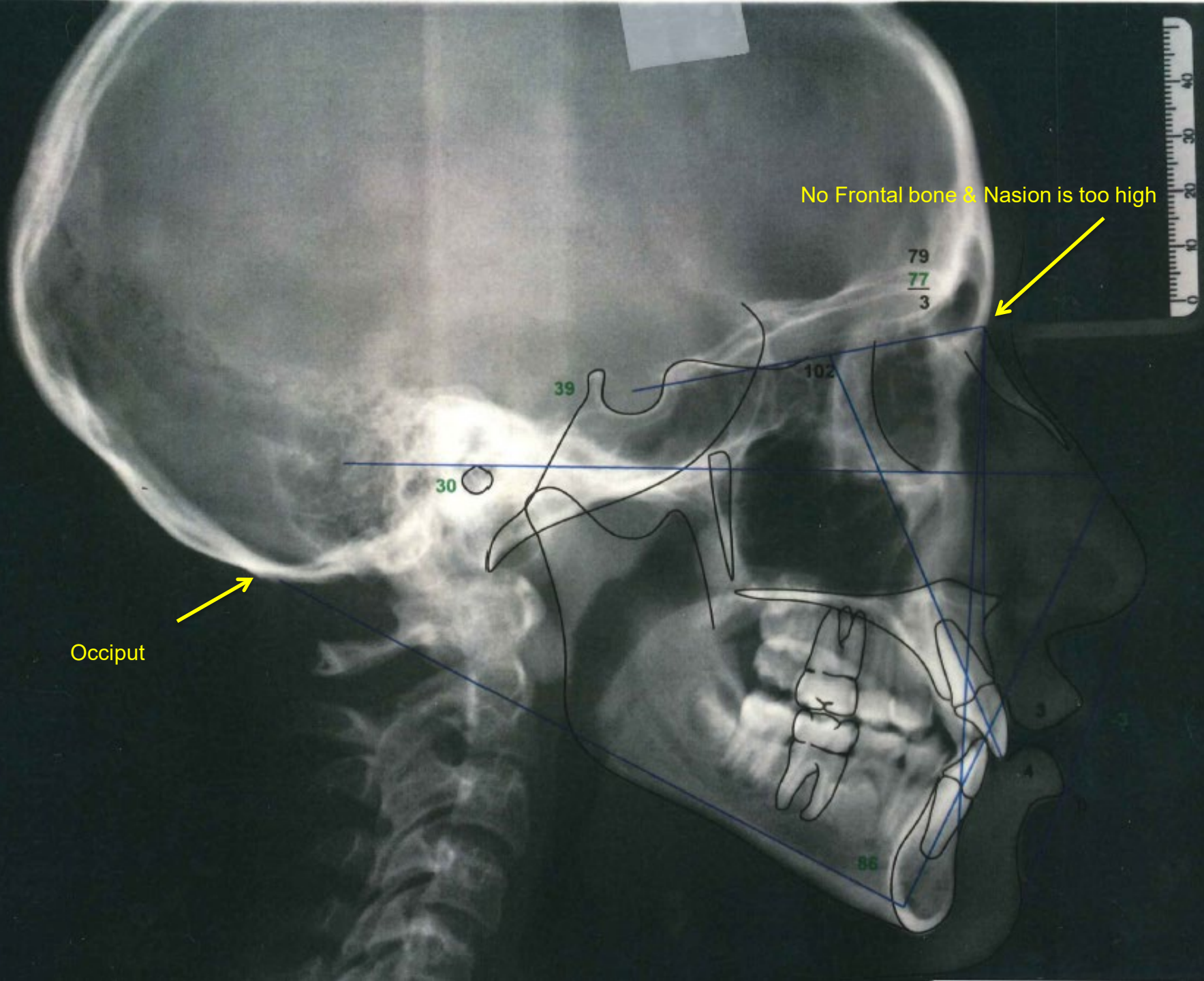
39

102

30

86





No Frontal bone & Nasion is too high

79
77
3

39

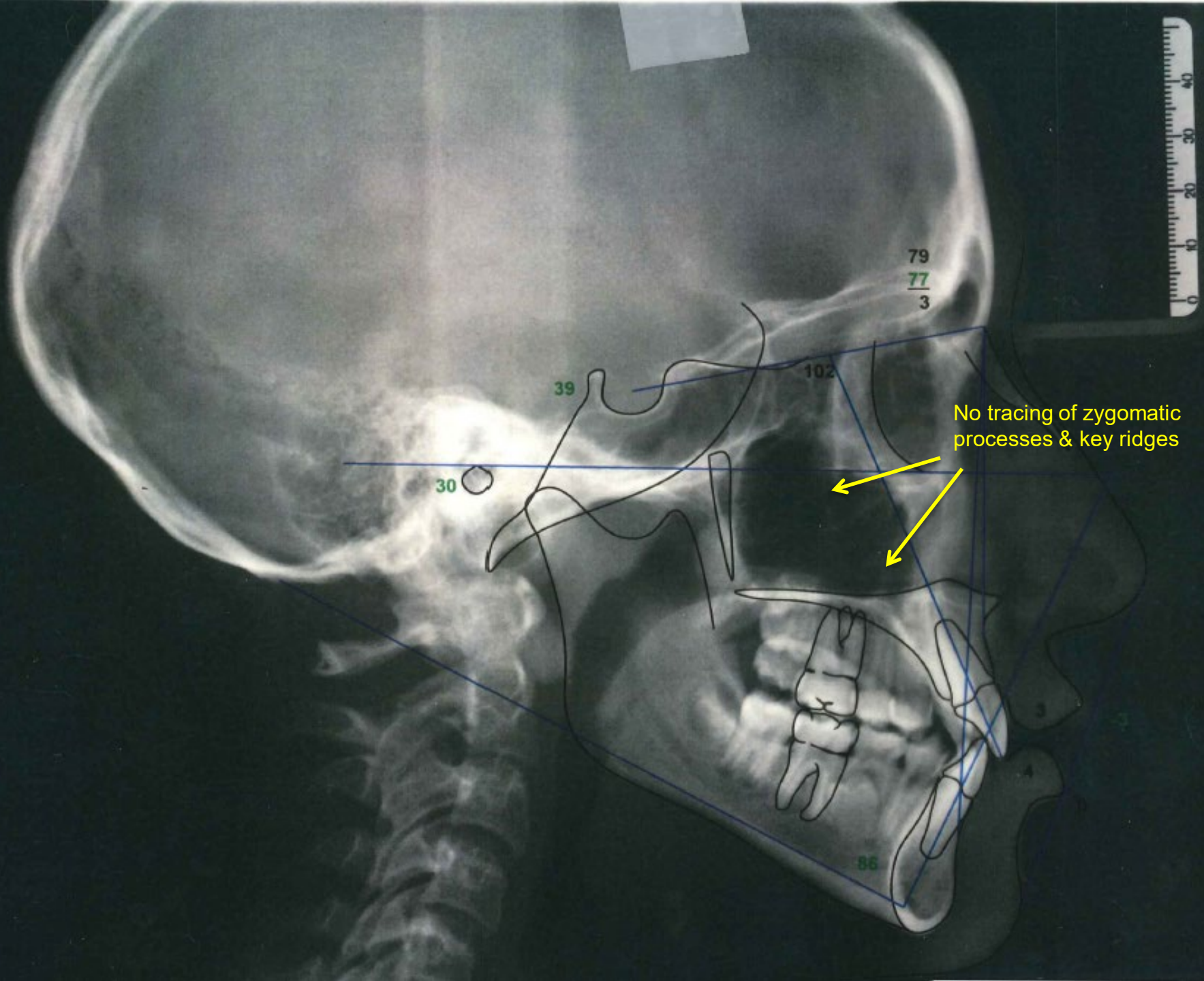
102

30

Occiput

86





79
77
3

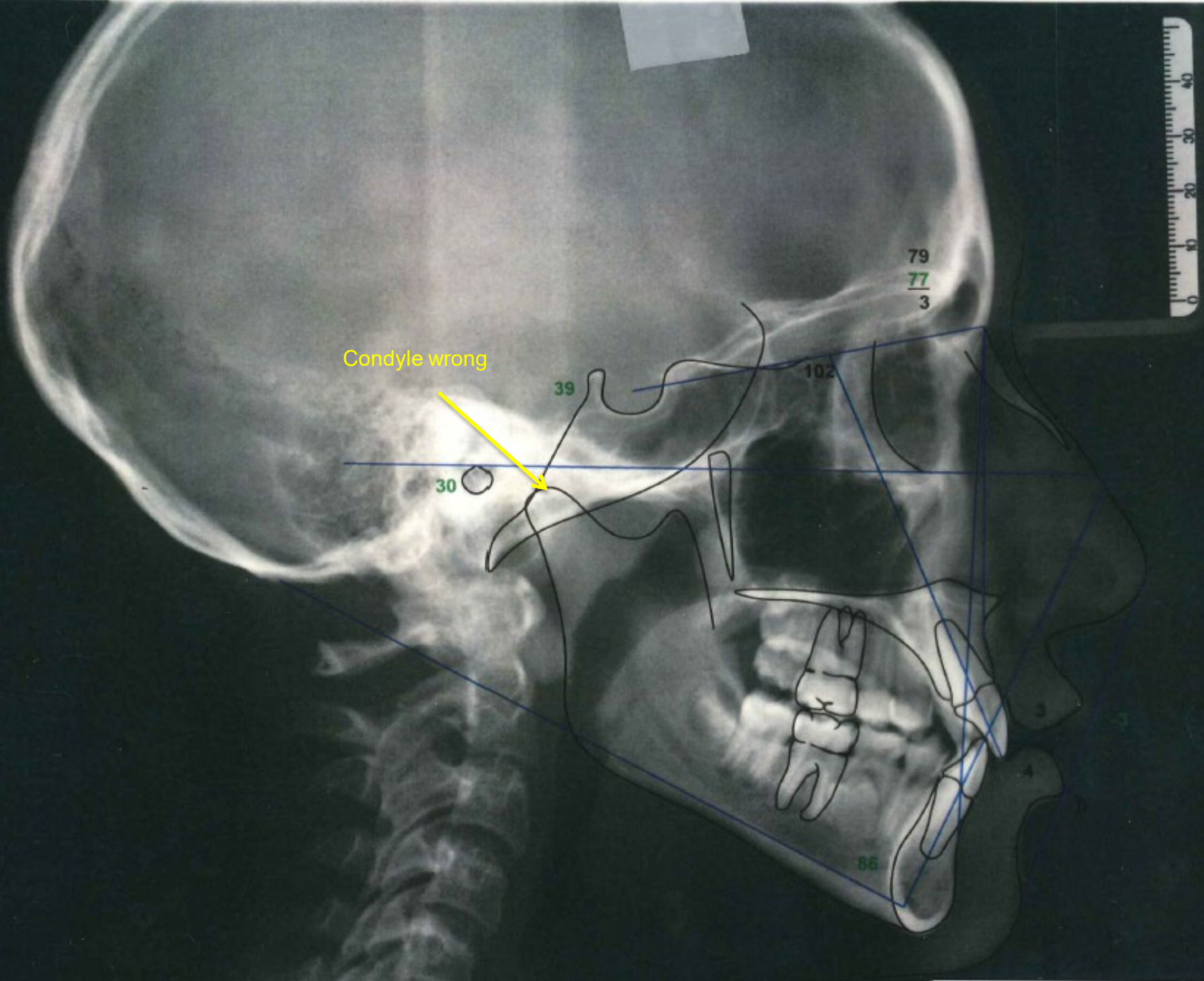
39

102

30

No tracing of zygomatic processes & key ridges

86



Condyle wrong

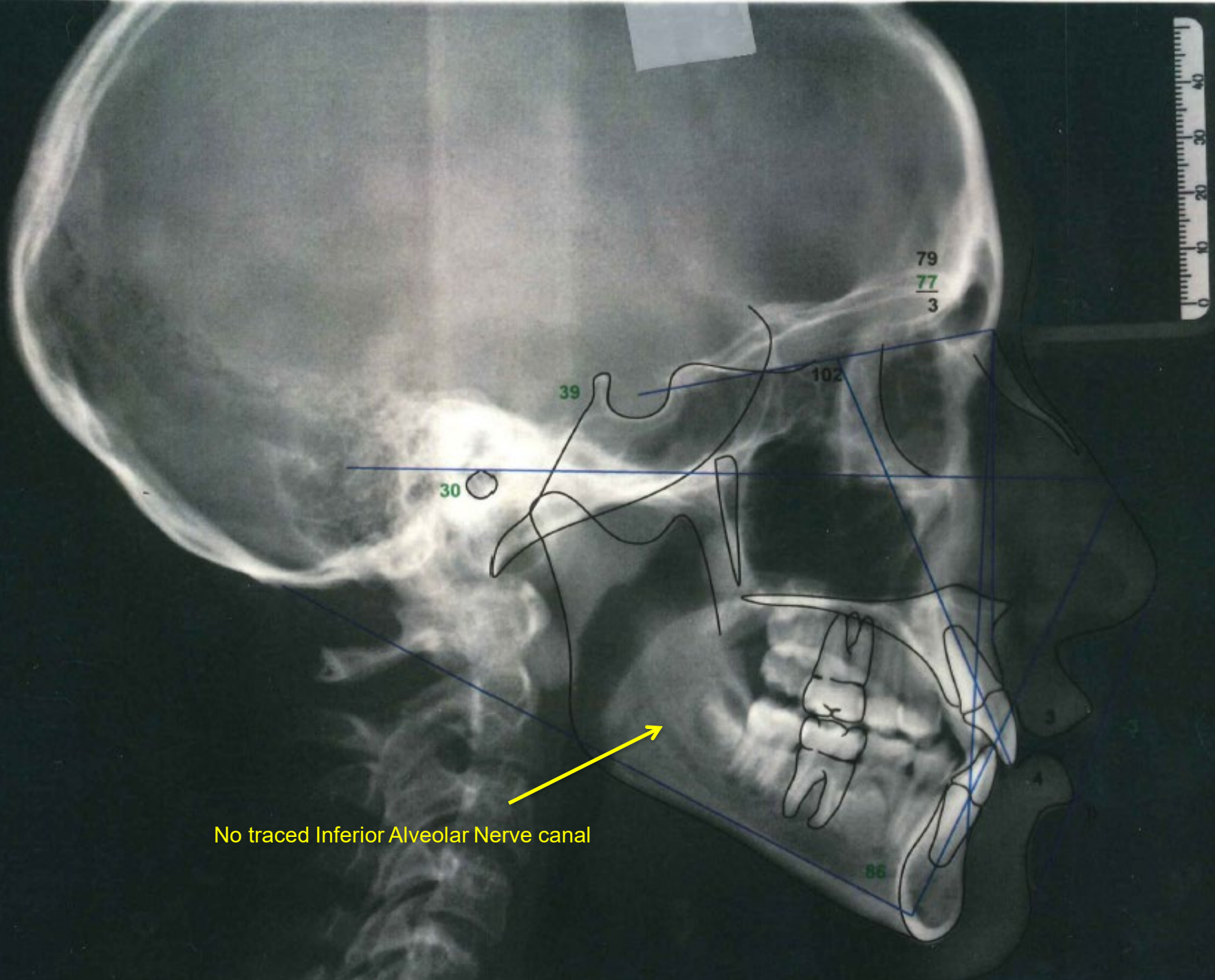
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77
3

39

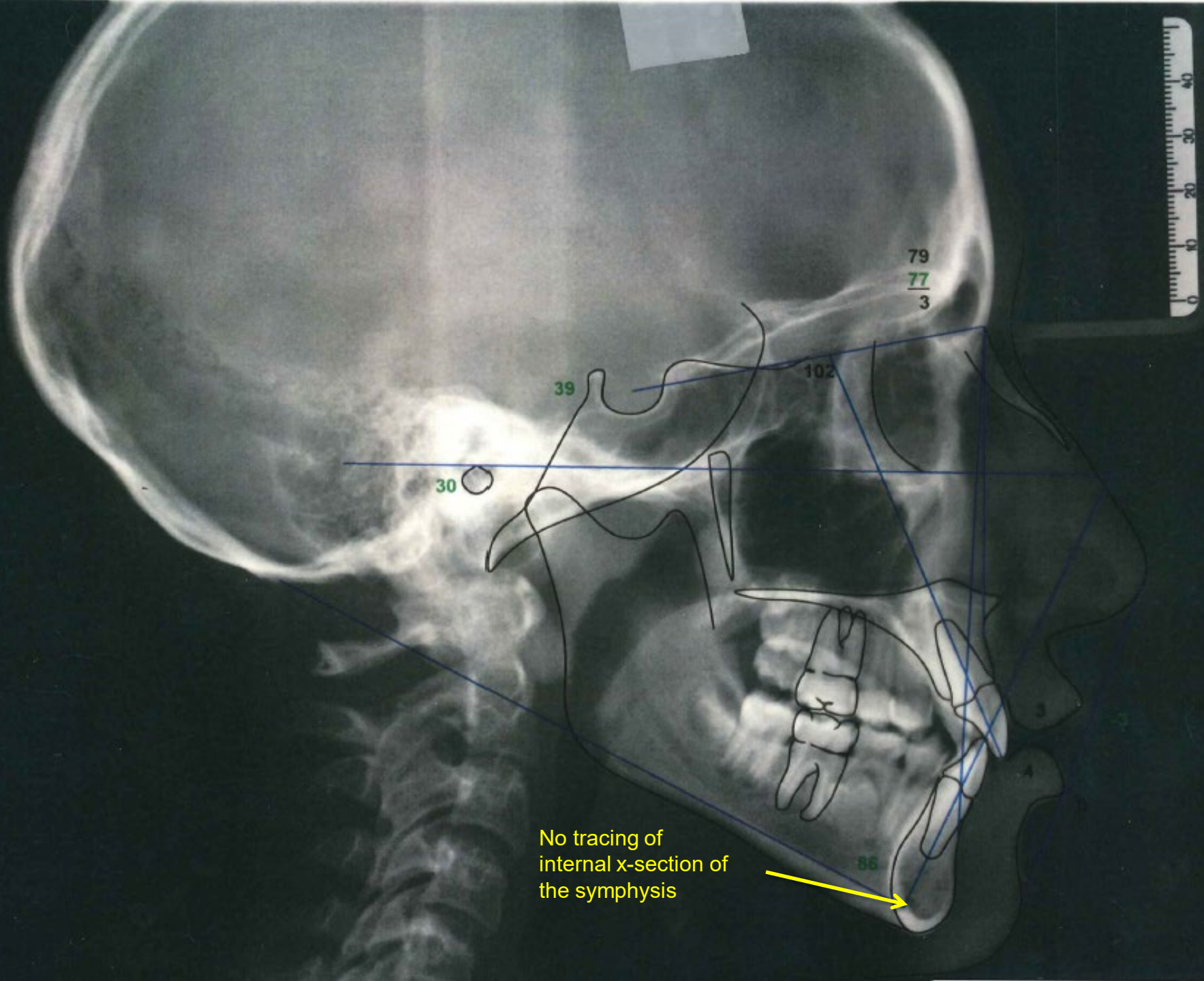
102

30

86



No traced Inferior Alveolar Nerve canal



79
77
3

39

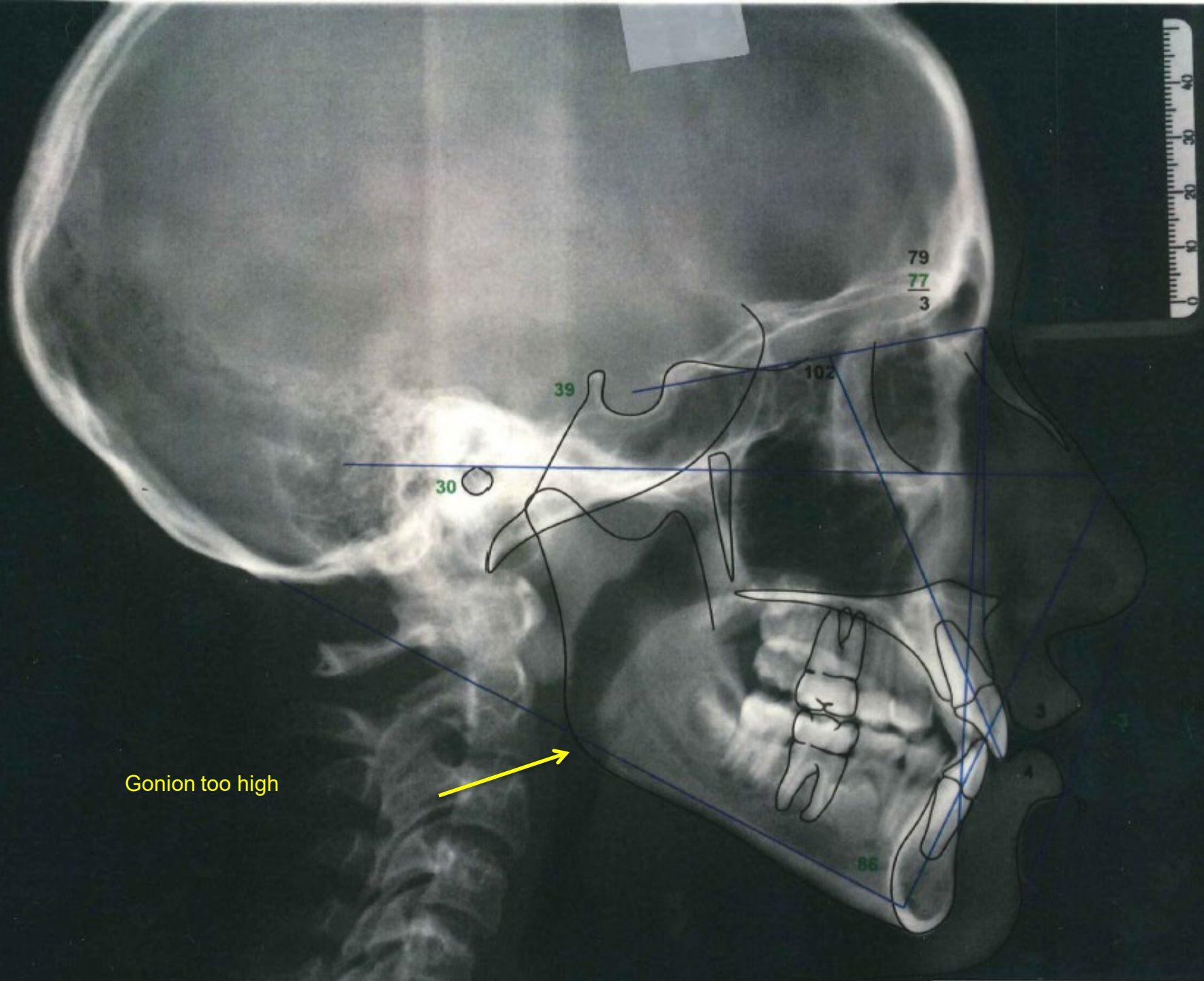
102

30

86

No tracing of
internal x-section of
the symphysis





Gonion too high



79
77
3

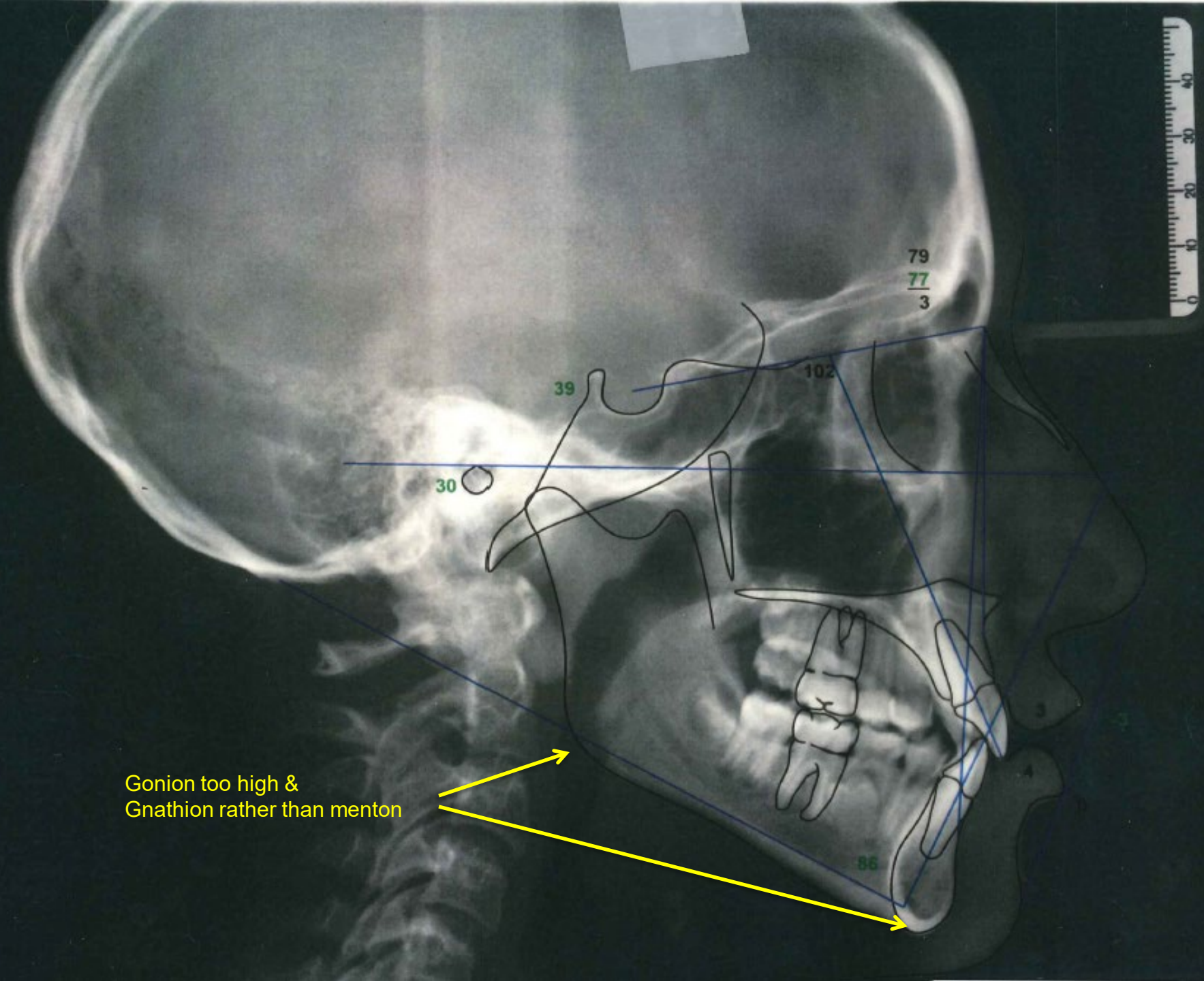
39

102

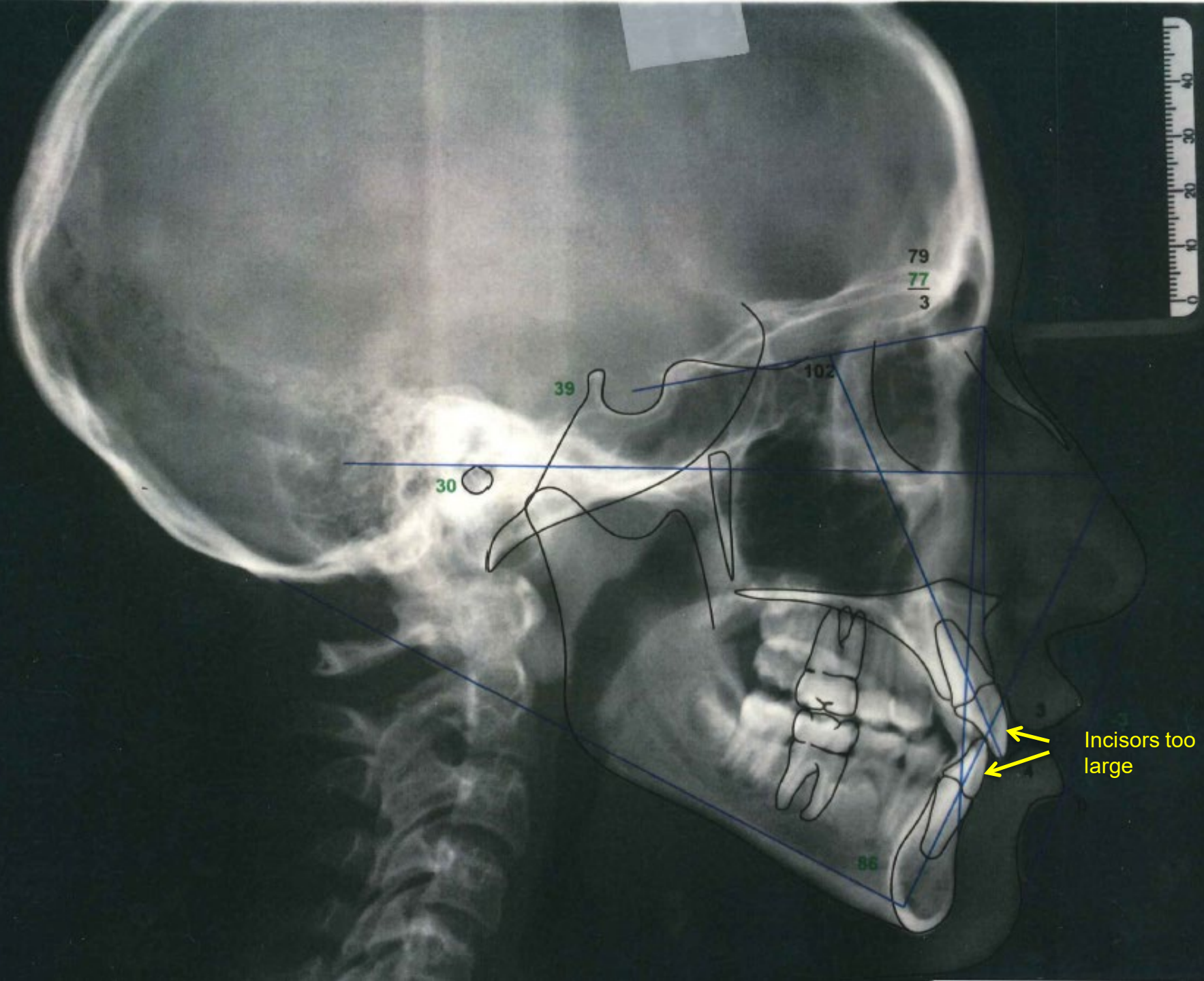
30

86





Gonion too high &
Gnathion rather than menton



79
77
3

39

102

30

86

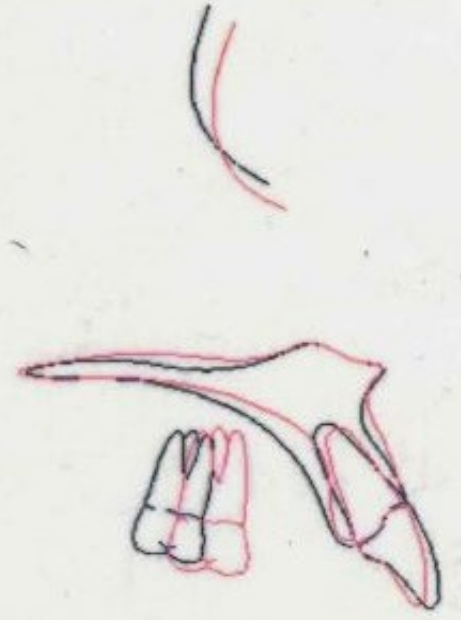
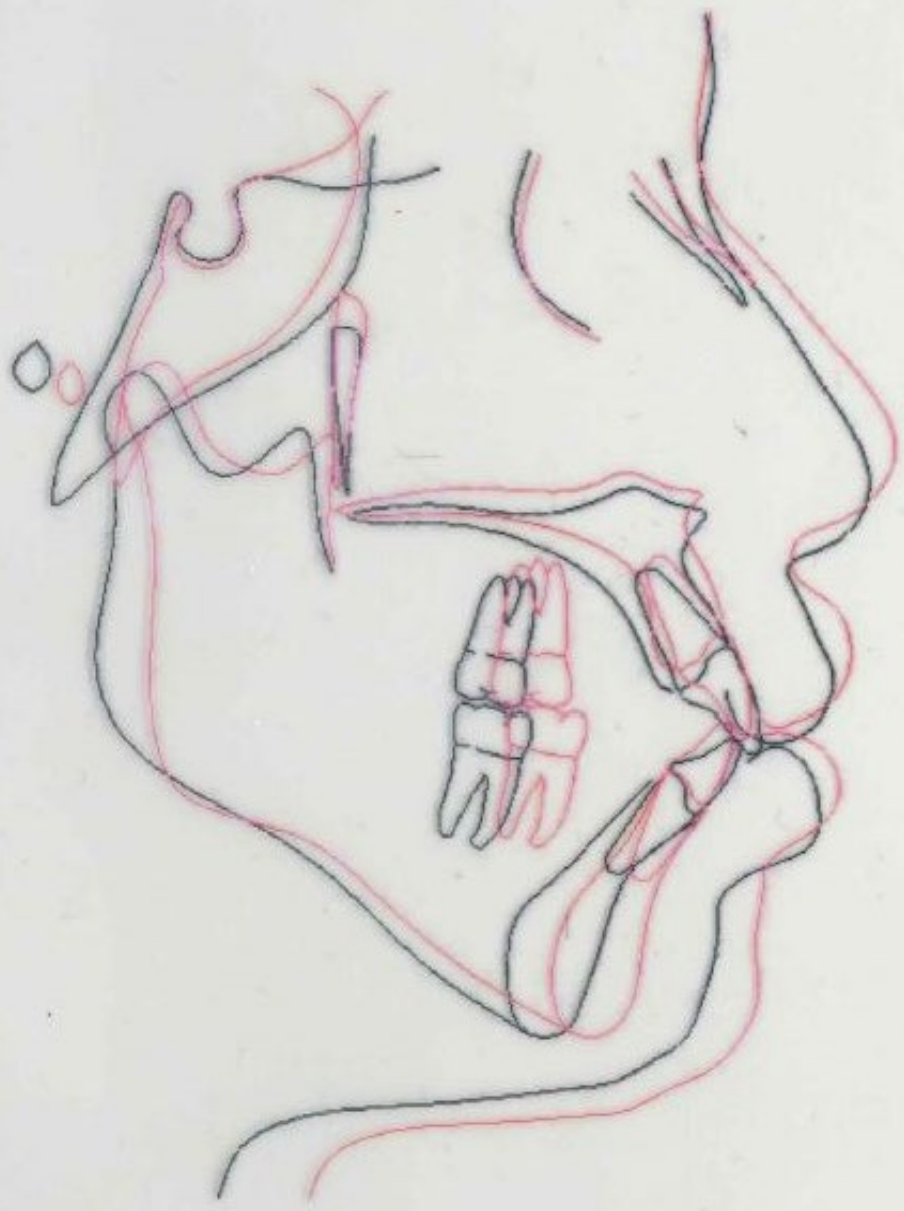
Incisors too large

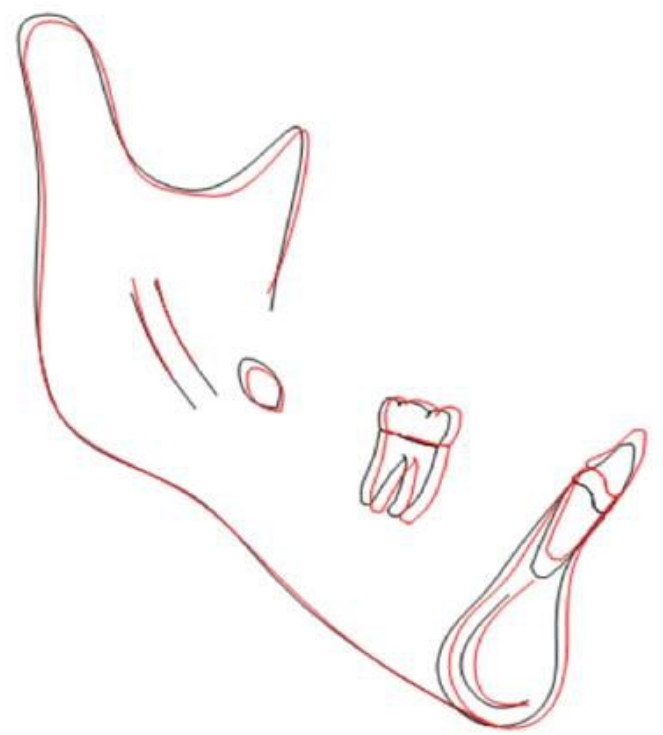
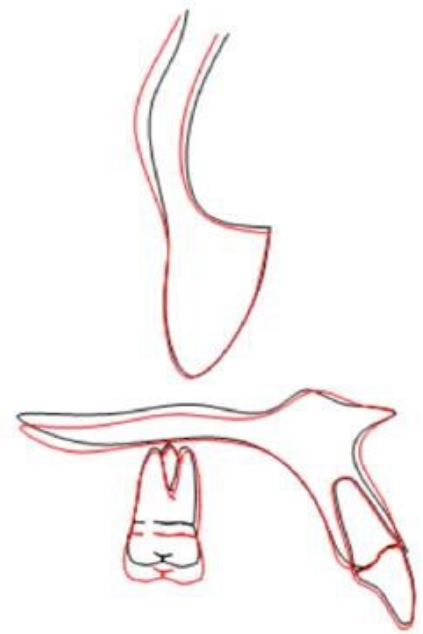
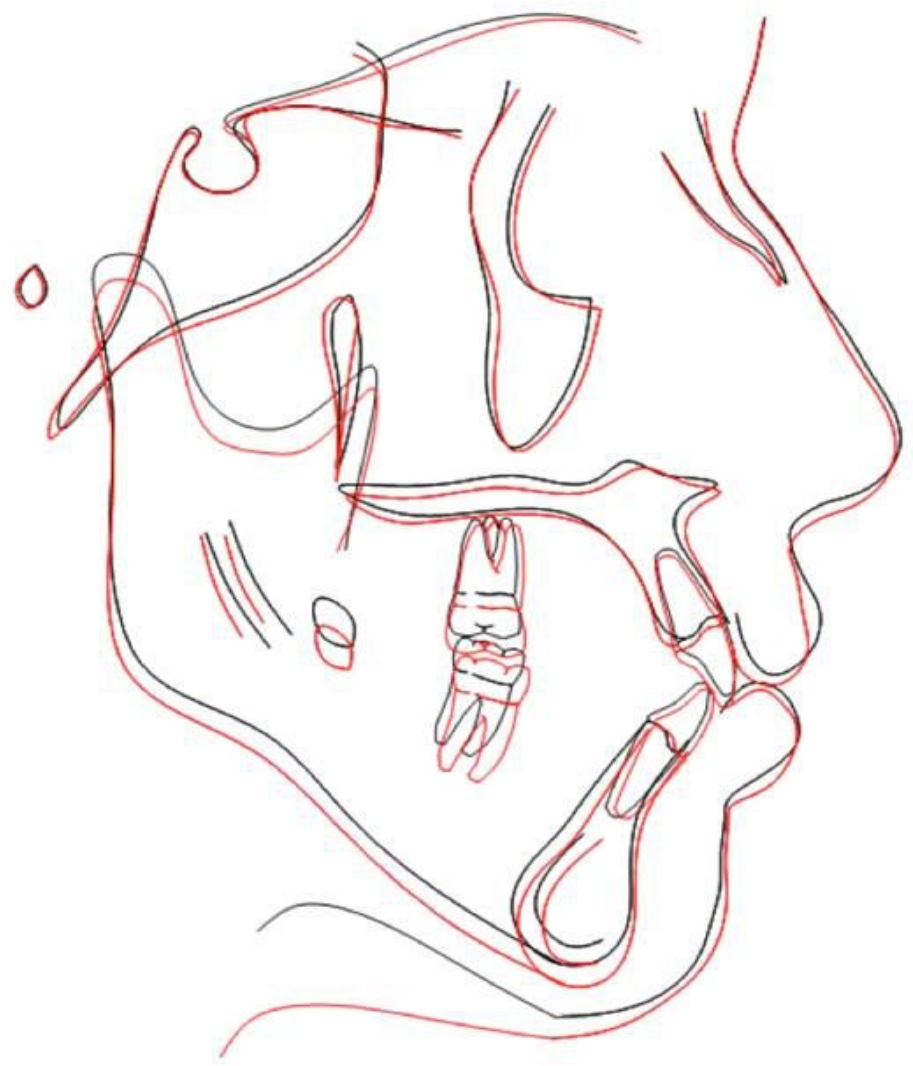


Causes of Inaccuracy of Tracings

- Incorrect Landmark identification and inaccurate tracing of the “true” anatomical structures.
- Not tracing the minimal needed anatomical structures.
- Virtual tracings from computer software may not accurately reflect the TRUE anatomy.
- Consistent tracing of the same anatomic surfaces between initial and final cephs.

Examples of Incorrect Superimpositions





A Systemic Method of Serial Cephalometric Assessment

- A system for evaluating treatment and growth is needed to assess affects of the skeletal, dental and facial changes facilitates precision and thoroughness.

- Serial cephalograms monitor growth and treatment change over time.
- Think in three planes of space:
 - Horizontal
 - Vertical
 - Transverse

Areas of evaluation:

- Skeletal
- Dental
- Facial
- Growth affects
- Treatment affects

Three views:

- Overall superimposition
- Maxillary superimposition
- Mandibular superimposition



Overall Superimposition

- Direction of growth: Maxilla and mandible
- Amount of growth : Maxilla and mandible
- Change in planes: Palatal, occlusal and mandibular
- Soft tissue change: Nose, lips, chin
- Incisors relative to facial plane



Maxillary Superimposition

- Incisal change: Vertical tip, torque, bodily change
- Molar change: Vertical, tip, torque, bodily change
- Occlusal plane change: Clockwise or counterclockwise rotation
- Morphology change



Mandibular Superimposition

- Incisor change: Vertical, tip, torque, bodily change
- Molar change: Vertical, tip, torque, bodily change
- Occlusal plane: Clockwise or counterclockwise rotation
- Morphology change: Hard tissue, profile
- Growth: Measured at Articulare

Acknowledgements

- Dr. Robert Little and Dr. Michael Fey:
Cephalometric Superimposition
- Buschang PH, Roldan SI, Tadlock LP:
Guidelines for Assessing the Growth and
Development of Orthodontic Patients.
Seminars in Orthodontics 23(4): 321-335,
December 2017.
- Dr. Allen Moffitt
- Dr. Ron Gallerano