ORIGINAL ARTICLE

Radiographic localization of unerupted mandibular anterior teeth

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The parallax method and the use of 2 radiographs taken at right angles to each other are the 2 methods generally used to accurately localize teeth. For the parallax method, the combination of a rotational panoramic radiograph with an occlusal radiograph is recommended. This combination involves a vertical x-ray tube shift. Three case reports are presented that illustrate: (1) how this combination can accurately localize unerupted mandibular anterior teeth, (2) how a deceptive appearance of the labiolingual position of the unerupted tooth can be produced in an occlusal radiograph, (3) how increasing the vertical angle of the tube for the occlusal radiograph makes the tube shift easier to discern, (4) why occlusal radiographs are preferable to periapical radiographs for tube shifts, and (5) how localization can also be carried out with 2 radiographs at right angles to each other, one of which is an occlusal radiograph taken with the x-ray tube directed along the long axis of the reference tooth. (Am J Orthod Dentofacial Orthop 2000;118:432-8)

The use of a rotational panoramic radiograph with an occlusal radiograph has been advocated to localize unerupted maxillary anterior teeth.[1,2] This radiographic localization technique is based on a shift of the x-ray tube in the vertical plane. The aims of this article are to demonstrate the combined use of panoramic and occlusal radiographs to localize mandibular anterior teeth, and to discuss mandibular occlusal radiographs in some detail.

RADIOGRAPHIC LOCALIZATION

The 2 accurate means of radiographic localization generally used are the parallax method (image/tube shift method, Clark's rule, buccal object rule) and the right angle technique.[3,4] Computed tomography (CT) is the most precise method of radiographic localization. However, its relatively high radiation dose limits the indications for its use.[4]

Principle of Parallax

In radiologic terms, parallax is the apparent displacement of the image of an object to be localized, relative to the image of a reference object, caused by changing the angulation of the x-ray beam. The change in angulation of the beam is caused by a change in the x-ray tube position. Normally, the reference object is the tooth closest to the object to be localized. The image of the object closer to the x-ray tube moves in the opposite direction to the tube, while the image of the object that is farther away moves in the same direction as the tube. The acronym SLOB can assist in recalling the principle of tube shift: Same-Lingual; Opposite-Buccal (if the image of the impacted object moves in the same direction the tube moves, then the object is lingual; if it moves in the opposite direction, then the object is buccal).[5]

Fig 1 illustrates in diagrammatic fashion the principle of parallax. The lateral incisor (the reference object), when viewed from the anterior tube position, is hidden by the canine. However, when viewed from the posterior tube position, the canine is farther from the tube than the lateral incisor, ie, the labial canine has moved in the opposite direction to the shift of the tube. The anterior-to-posterior shift of the tube is a shift in the horizontal plane. This technique was introduced by Clark.[6] Later, Richards[7] introduced the concept of a vertical shift of the tube, which is also demonstrated in Fig 1, with inferior substituted for anterior and superior for posterior.

Clark[6] and Richards[7] both used periapical radiographs in their discussion of the parallax method. Keur[8,9] introduced 2 major improvements in the technique: the use of occlusal radiographs and the combined use of panoramic and occlusal radiographs.

Occlusal and Panoramic Radiographs

Keur used occlusal radiographs rather than periapical radiographs for a tube shift because occlusal radiographs cover a larger area. This has 2 advantages: (1) the tube can be moved much more between exposures, resulting in the shift of the image of the impacted tooth being greater and therefore easier to determine (as discussed below); and (2) the impacted tooth is shown in its entirety, which is usually not the case with 1 periapical radiograph.

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Keur also introduced the combined use of panoramic and occlusal radiographs for a vertical tube shift. Because a panoramic radiograph is often taken as an initial radiograph, this combination requires only one additional exposure, the occlusal radiograph.

In Fig 2, for the purpose of illustration, the path of x-rays from the panoramic radiograph machine tube and the occlusal radiograph machine tube is depicted as a single straight line. The panoramic radiograph tube is actually positioned behind the patient's head (ie, lingual to the arches) at an angle of –7° to the occlusal plane, and the film is in front of the head. However, to aid interpretation of the vertical tube shift, the tube must be considered to be in front of the head (ie, facial to the arches) at an effective angle of +7° (Fig 2*A*) because the relationship of the image of the canine to the image of the lateral incisor is unaltered.[1] The anterior occlusal radiograph in Fig 2*B* is taken at an angle of –55° to the occlusal plane,[5] ie, there is an effective difference of 62° between the 2 radiographs. In the panoramic radiograph, the image of the cusp tip of the canine is superimposed on the apex of the lateral incisor, whereas in the anterior occlusal radiograph the image of the cusp tip of the canine is superimposed much more coronally, ie, the image of the labially positioned canine, which is closer to the x-ray tube, moves in the opposite direction to the shift of the tube.

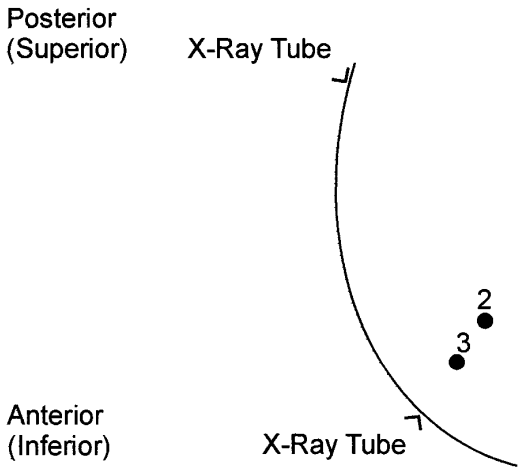

Fig 1. Canine, when viewed from anterior (inferior) position of tube, obscures lateral incisor. When viewed from more posterior (superior) position, canine is farther from the tube than is lateral incisor, ie, labial canine has moved in opposite direction to tube.

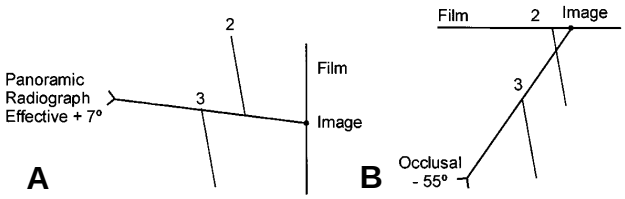

Fig 2. A, Panoramic radiograph tube effectively at +7° to occlusal plane. Image of cusp tip of labial canine is projected, on film, at apex of lateral incisor. **B**, Tube for mandibular occlusal is at –55°. Image of cusp tip of labial canine is projected on lateral incisor three quarters of its length above apex, ie, tooth closer to tube has moved in opposite direction to tube.

Significance of Distances

The 2 distances that are important in localization are the distance between the impacted tooth and its reference tooth and the distance the x-ray tube is moved.[1,2] The greater the distance between the impacted tooth and the reference tooth, the greater will be the shift of the image of the impacted tooth with a given x-ray tube movement, resulting in an easier determination of its position.

With a given distance between the impacted tooth and its reference tooth, a greater movement of the tube resulting from a greater change in the angulation of the tube will result in a greater shift of the image. Therefore, by moving the tube over as great a distance as possible, the clinician can facilitate interpretation of the position of an impacted tooth located close to the dental arch. This second distance is discussed further in case 3.

True and Cross-sectional Occlusals

The right angle technique uses 2 radiographs taken at right angles to each other.

The literature is somewhat confusing about the definition of true occlusal and cross-sectional occlusal radiographs, radiographs commonly used in the right angle technique. Mason[10] stated that the mandibular anterior true occlusal view is taken with the x-ray beam directed up the root canals of the incisors, usually at an anteroinferior angle to the occlusal plane and film of 100° to 110°. Andreasen[11] wrote that the axial view of the mandible, with a projection angle parallel to the apices of the incisors, gives information about the position of the crown of the impacted tooth in relation to the apices of the adjacent (reference) teeth. However, he warned that this projection should be a true axial projection in relation to the incisors, otherwise the radiograph will give false information about the position of the impacted tooth. Becker[12] differentiated between the angles of the tube to the occlusal plane required to produce the mandibular true occlusal radiograph for the canine/premolar region (–90°) and for the incisor region of the arch (approximately –110°).

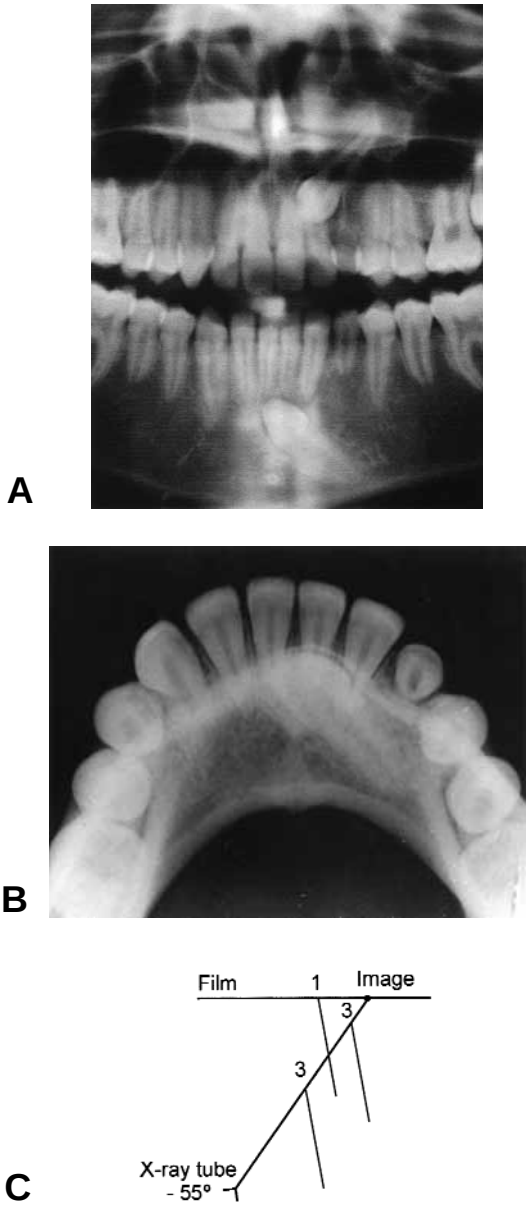

Fig 3. A, Cropped panoramic radiograph shows both left canines are unerupted. **B**, Mandibular anterior occlusal radiograph suggests left canine may be lingual. **C**, Possible positions of unerupted left canine *(3)* in relation to right central incisor *(1)*.

In contrast, Langland et al[13] illustrated a horizontally impacted, mesially migrated mandibular canine using a panoramic radiograph and 3 intraoral radiographs, one of which was an occlusal radiograph taken at –90° to the occlusal plane. They came to the wrong conclusion concerning the position of the canine using image magnification as the basis for their answer. They made no mention of the vertical tube shift available between the panoramic radiograph and any of the intraoral radiographs. Alling et al[14] also illustrated a horizontally impacted, mesially migrated mandibular canine with a panoramic radiograph and an occlusal radiograph. The x-ray beam was directed at –90° to the film for the occlusal radiograph, which was termed a cross-sectional occlusal radiograph. They did not mention the vertical tube shift available between the panoramic radiograph and the occlusal radiograph. Goaz and White[5] wrote that a mandibular cross-sectional occlusal radiograph is taken with the central ray at a right angle to the film. Surprisingly, they also stated that a maxillary cross-sectional occlusal radiograph is one taken with the central ray directed just below nasion at a vertical angulation of +65°. Brocklebank[15] did not adequately define a true occlusal radiograph. She stated that cross-sectional occlusal radiographs are those where the cental x-ray beam is directed along the long axis of the teeth, but then clouded the issue by saying that the term *true occlusal* is also appropriate for mandibular cross-sectional occlusal radiographs as the central ray is directed at 90°, or true, to the film.

The Shorter Oxford English Dictionary defines *true* as "exact, accurate, precise" and as "exact in position." In contemporary dental radiography, the term *cross-sectional mandibular* is used for tomograms taken at right angles to the long axis of the mandible, eg, for implant planning. In this article, the term *axial occlusal radiograph* is used rather than true or cross-sectional. The mandibular axial occlusal radiograph does not have the high radiation dose disadvantage of the maxillary (vertex, true) axial occlusal radiograph. The x-ray beam for the mandibular axial occlusal radiograph only has to penetrate the mandible and the floor of the mouth; the maxillary axial occlusal radiograph the beam must penetrate the skull and its contained tissues.

Case 1

The panoramic radiograph of a 14-year-old female (Fig 3*A*) shows that both left permanent canines are unerupted. The mandibular anterior occlusal radiograph (Fig 3*B*) suggests that the unerupted canine may be positioned lingually. However, a vertical tube shift between the panoramic radiograph (Fig 3*A*) taken at +7° to the occlusal plane and the occlusal radiograph (Fig 3*B*) taken at –55° shows that the image of the mandibular canine moves from below the images of the apices of the mandibular incisors (the reference teeth) up onto the roots of the incisors, ie, in a direction opposite to the shift of the tube. Therefore, it can be determined that the canine is positioned labially.

The diagram in Fig 3*C* illustrates how the deceptive appearance of the position of the left canine apparently

being positioned lingual to the incisors in the anterior occlusal radiograph (Fig 3*B*) arises. The image of the cusp tip of the canine in either position, labial or lingual to the incisor, would be projected on the identical part of the incisor. As has been shown above, the canine is actually labial to the incisor root.

Case 2

The panoramic radiograph of another 14-year-old female (Fig 4*A*) shows that the mandibular permanent left canine is unerupted and the superior margin of its crown is 8 mm below the apex of the right mandibular central incisor. In the anterior occlusal radiograph (Fig 4*B*), the superior margin of the canine crown is above the apex of the right central incisor. The vertical tube shift between the panoramic radiograph (Fig 4*A*) and the anterior occlusal radiograph (Fig 4*B*) shows that as the x-ray tube moved down from the position for taking the panoramic radiograph (Fig 4*A*) into the position for taking the occlusal radiograph (Fig 4*B*), the image of the unerupted canine moved up. Therefore, the canine is labial. The axial occlusal radiograph (Fig 4*C*) confirms this.

The axial occlusal (Fig 4*C*) and panoramic (Fig 4*A*) combination of radiographs can be used for the right angle technique of localization. This is the same combination of radiographs as for the parallax method, the only difference is between the angulation for taking the occlusal radiographs. The axial occlusal radiograph (Fig 4*C*) provides the labiolingual (antero posterior) position of the canine, whereas the panoramic radiograph (Fig 4*A*) supplies the vertical position of the tooth. Both radiographs show the mesiodistal (transverse) position of the canine. The mandibular axial occlusal radiograph has several limitations. It may present difficulties in positioning the x-ray tube precisely, and therefore it may display a misleading position of the unerupted tooth, as was noted by Andreasen above. It does not show the fine detail of the unerupted tooth or of the roots of the reference teeth and the alveolar bone, so a third radiograph, an anterior occlusal or a periapical radiograph, is necessary, resulting in greater radiation exposure and expense for the patient. Finally, it may not show structures that are markedly less radiopaque than the reference teeth, eg, an odontome or a supernumerary.

Other radiographs, if available, may assist in the confirmation of the position of the unerupted tooth, eg, a lateral cephalometric radiograph may supply the vertical and labiolingual positions of the unerupted mandibular anterior tooth.

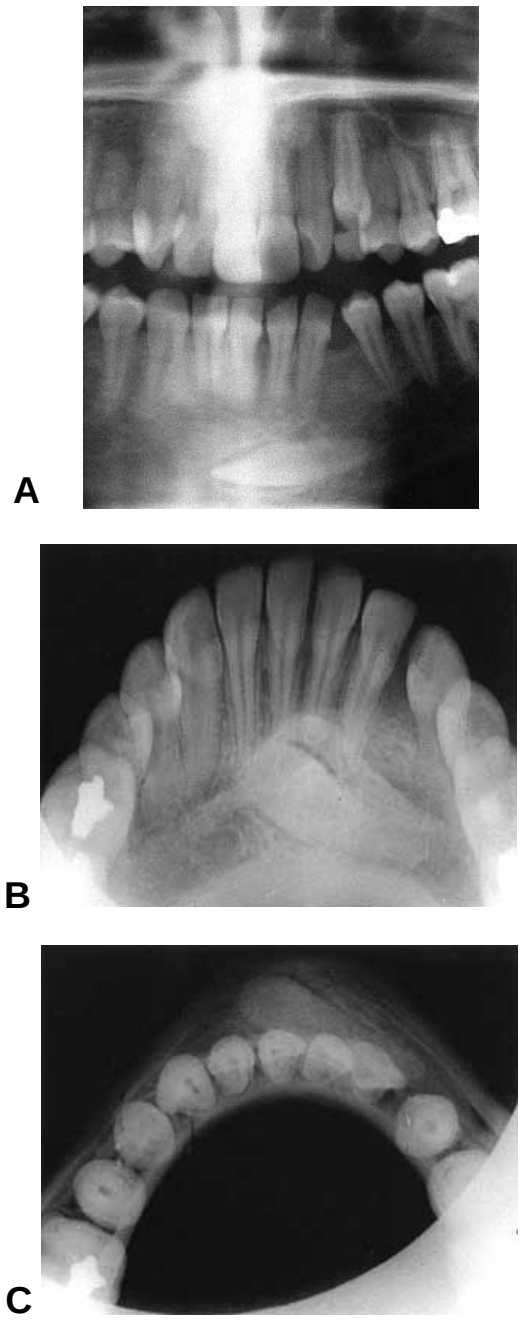

Fig 4. A, Cropped panoramic radiograph shows mandibular left permanent canine is unerupted. Superior margin of crown 8 mm below apex of right mandibular central incisor. **B**, Mandibular anterior occlusal radiograph shows superior margin of left canine crown is above apex of right central incisor. **C**, Mandibular axial occlusal radiograph shows unerupted canine is labial.

Case 3

The panoramic radiograph of a 10-year-old boy (Fig 5*A*) shows that the mandibular left central incisor is unerupted. The –90° occlusal radiograph (Fig 5*B*) suggests that the unerupted incisor may be positioned lingually. However, the vertical tube shift between Fig

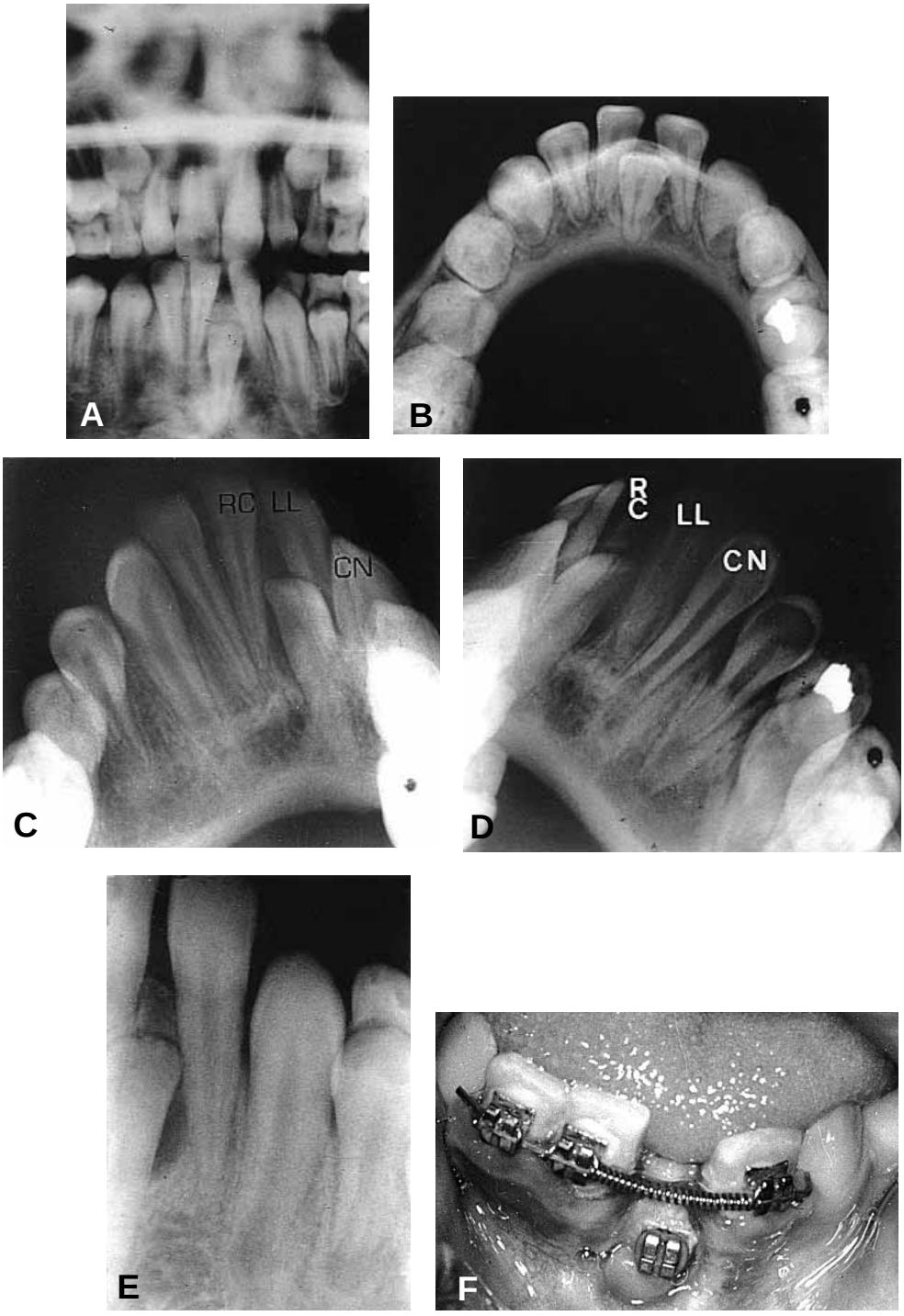

Fig 5. A, Cropped panoramic radiograph shows mandibular left central incisor is unerupted. **B**, –90° occlusal radiograph suggests central incisor may be lingual. **C**, Mandibular anterior occlusal radiograph taken at –55° shows unerupted left central incisor and erupted right central incisor *(RC)*, left lateral incisor *(LL)*, and left canine *(CN)*. **D**, Mandibular left lateral occlusal radiograph shows unerupted incisor. There are overlap-free contacts between left canine *(CN)* and first premolar while right central *(RC)* and right lateral incisors overlap. Distal of unerupted left central incisor barely contacts mesial of left lateral incisor *(LL)*. **E**, Periapical radiograph of left central incisor. **F**, Intraoral photograph taken after labially positioned left central incisor surgically uncovered.

5*A* and 5*B* supply the correct answer about the position of the incisor. The panoramic radiograph (Fig 5*A*) is taken at an effective angle of +7° to the occlusal plane and the occlusal radiograph in Fig 5*B* at –90°, an angular difference of 97°. As the tube moved down from the position for taking the panoramic radiograph (Fig 5*A*) into the position for taking the –90° occlusal radiograph (Fig 5*B*), the image of the unerupted incisor moved up the images of the right central and left lateral incisors (the reference teeth) toward the crowns of these teeth, (the left central incisor moves in a direction opposite to the shift of the tube). Therefore, it can be deduced that the unerupted tooth is labially positioned.

A vertical tube shift can also be carried out between the panoramic radiograph (Fig 5*A*), taken at an effective angle of +7° to the occlusal plane, and the mandibular anterior occlusal radiograph (Fig 5*C*) taken at –55°. There is an effective difference of 62° between the 2 radiographs. It is more difficult to see the shift of the image of the left incisor, in the opposite direction to the shift of the tube, between the panoramic radiograph (Fig 5*A*) and the anterior occlusal radiograph (Fig 5*C*) than between the panoramic radiograph (Fig 5*A*) and the –90° occlusal radiograph (Fig 5*B*).

Table I shows (1) the length of the right central incisor (the reference tooth), and (2) the distances between the incisal edge of the impacted incisor and the apex of the right central incisor in the 3 radiographs and the incisal edge of the right central incisor. In the panoramic radiograph (Fig 5*A*), the incisal edge of the left central incisor is approximately 33% of the length of the right central incisor above the apex of that incisor. In the anterior occlusal radiograph (Fig 5*C*), it is 50% above the apex; in the –90° occlusal radiograph (Fig 5*B*), it is 60%. The greater shift of the image of the left incisor that results with the panoramic radiograph (Fig 5*A*) and –90° occlusal radiograph (Fig 5*B*) combination compared with the panoramic radiograph (Fig 5*A*) and anterior occlusal radiograph (Fig 5*C*) combination occurs because of the greater distance of movement of the tube with the former combination, 97° and 62°, respectively.

Fig 5*D* is another occlusal radiograph of this case. If the teeth are aligned normally in the mouth, as they are here, then the direction of the central beam in the horizontal plane on the occlusal radiograph is through the teeth with no overlapping contact points. In Fig 5*D*, there are overlap-free contacts between the left canine and first premolar, whereas the right central and lateral incisors overlap. This indicates that the occlusal radiograph is a left lateral occlusal radiograph. In Fig 5*C* (the anterior occlusal radiograph), the opposite situation exists with overlap in the left buccal segment and no overlap anteriorly. A horizontal tube shift is evident between these 2 occlusal radiographs. In Fig 5*C* (the anterior occlusal radiograph), the distoincisal line angle of the impacted left central incisor is in contact with the pulp canal of the left lateral incisor. In Fig 5*D* (the lateral occlusal radiograph), the distoincisal line angle of the impacted tooth barely contacts the mesial surface of the left lateral incisor, moved distally from Fig 5*C* to 5*D*, the impacted incisor moved mesially. Therefore, again it can be concluded that the unerupted tooth is labial.

Table I. Length of reference tooth and distance of incisal edge of unerupted tooth to incisal edge and apex of reference tooth in 3 radiographs

	Panoramic radiograph	*Anterior occlusal*	*–90° occlusal*
Length (mm) right central incisor	23	21	13.5
Distance (mm) incisal edge left central incisor from			
1. apex right incisor	8	10	8
2. incisal edge right incisor	15	11	5.5

Fig 5*E*, a periapical radiograph, is an example of why Keur[8,9] advocated taking occlusal radiographs rather than periapical radiographs for tube shifts. In Fig 5*E*, the whole of the impacted tooth has not been captured on the radiograph. In this case, the periapical radiograph is not useful for carrying out a tube shift or for seeing all the fine detail of the impacted tooth or its reference tooth. Fig 5*F*, the intraoral photograph taken after the impacted tooth had been surgically uncovered, confirms the deduction that this tooth was labially positioned.

CONCLUSION

A rotational panoramic radiograph with an anterior occlusal radiograph is the preferred combination of radiographs to localize unerupted mandibular anterior teeth. This combination uses a tube shift in the vertical plane. The rotational panoramic radiograph is taken at an effective angle of +7° to the occlusal plane, and the anterior occlusal radiograph is usually taken at –55°, a difference of 62°.

The literature is confusing about the terms *true occlusal radiograph* and *cross-sectional occlusal radiograph*. The two should be synonymous and used for radiographs that have been taken with the central beam of the x-ray tube directed along the long axis of the reference tooth. Preferably, for occlusal radiographs, the descriptors true and cross-sectional should no longer be used. Instead, a modifier should be added that iden-

tifies the reference tooth, eg, an occlusal radiograph axial to the mandibular left central incisor. If the occlusal radiograph has been taken at –90° to the film but the x-ray beam has not been directed along the long axis of the reference tooth, then the radiograph should be termed a –90° occlusal radiograph.

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