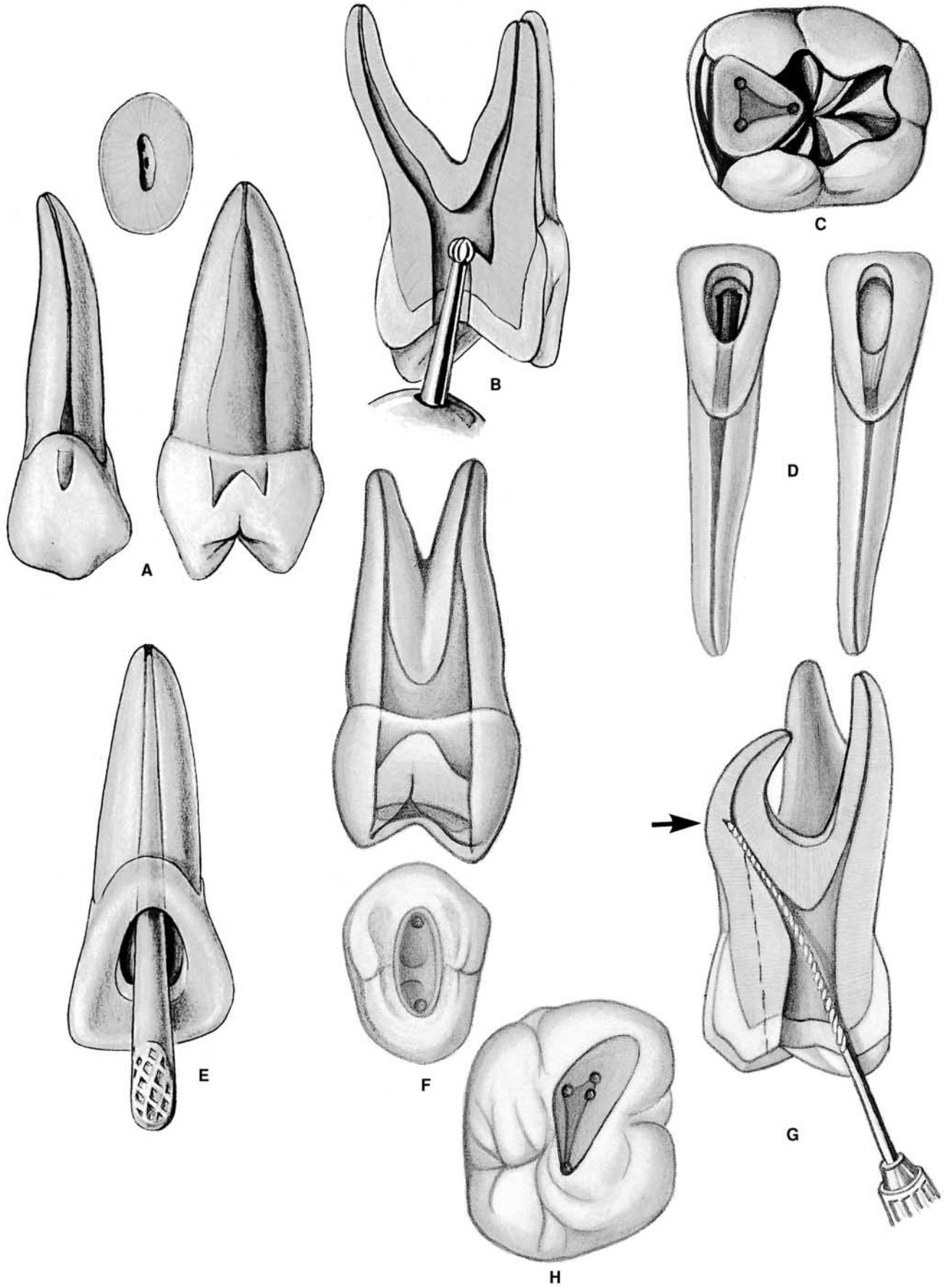


## PLATE 1

### Outline Form

- A. A standard radiograph (**left**) in buccolingual projection provides only a two-dimensional view of what is **actually a three-dimensional problem**. If a **mesiodistal** x-ray projection could be made (**right**), one would find the pulp of the maxillary second premolar to be flat tapering “ribbon” rather than round “thread” visualized on the initial radiograph. The final ovoid occlusal cavity preparation (F) will mirror the internal anatomy rather than the buccolingual x-ray image.
- B. Coronal preparation of a maxillary first molar illustrating the major principle of endodontic cavity outline form: **the internal anatomy of the tooth (pulp) dictates the external outline form**. This is accomplished by extending preparation from inside of the tooth to the outside surface, that is, working from inside to outside.
- C. Endodontic cavity preparation, mandibular first molar, superimposed on inlay, restoring proximal-occlusal surfaces. **Black’s outline form of inlay** is related to the external anatomy and environment of the tooth, that is, the extent of carious lesions, grooves, and fissures and the position of the approximating premolar. A **triangular or rhomboidal outline form of endodontic preparation**, on the other hand, is related to the internal anatomy of the pulp. No relationship exists between the two outline forms.
- D. Size and shape of endodontic coronal preparations in mandibular incisors related to **size and shape of the pulp and chamber**. A contrast in outline form between a “young” incisor (**left**) with a large pulp and an adult incisor (**right**) is apparent. The large triangular preparation in a youngster reflects pulpal horn extension and size of the pulp chamber, whereas ovoid preparation in an adult relates to a grossly receded pulp. Extension toward the incisal allows central-axis access for instruments.
- E. Large size and shape of coronal preparation in a recently calcified incisor relate to huge pulp housing. To remove all pulp remnants and to accommodate large endodontic instruments and filling materials, coronal preparation must be an extensive, triangular, funnel-shaped opening. Actually, no more than the lingual wall of pulp chamber has been removed. In lower incisors, the outline form may well be extended into the incisal edge. This preparation allows absolutely **direct** access to apex.
- F. The outline form of the **endodontic** coronal cavity in the **maxillary** first premolar is a narrow, elongated oval in buccolingual projection (**bottom**), which reflects the size and shape of a broad, flat pulp chamber of this particular tooth.
- G. **Buccal** view of an **inadequate** coronal preparation in a maxillary molar with a defalcated mesiobuccal root. There has been no compensation in cavity preparation for severe curvature of the mesial canal or for the obtuse direction by which the canal leaves the chamber. The operator can no longer maintain control of the instrument, and a ledge has been produced (**arrow**). Extension of the outline form and internal preparation to the mesial (**dot-dashed line**) would have obviated this failure.
- H. “**Shamrock preparation.**” Modified outline form to accommodate the instrument unrestrained in the severely curved mesial canal seen in G.

PLATE 1



## PLATE 2

### Convenience Form

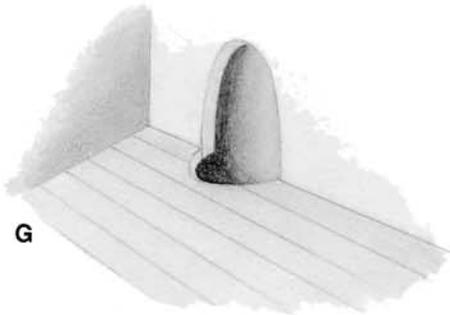
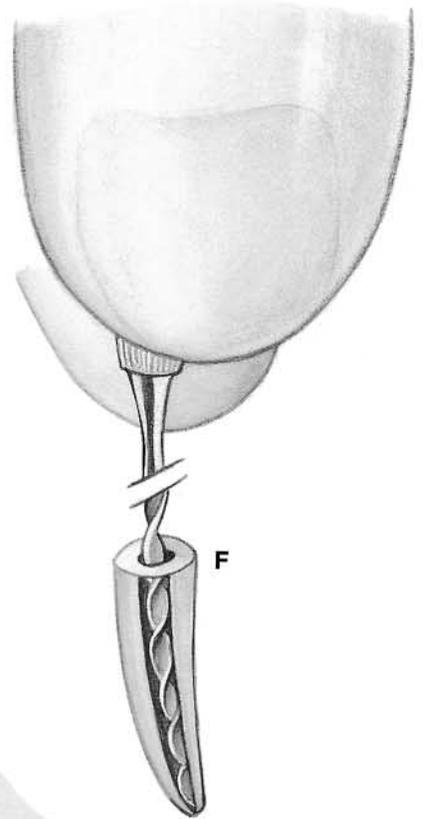
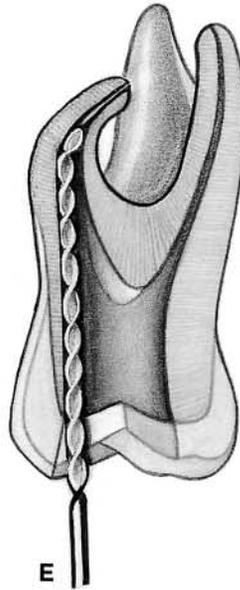
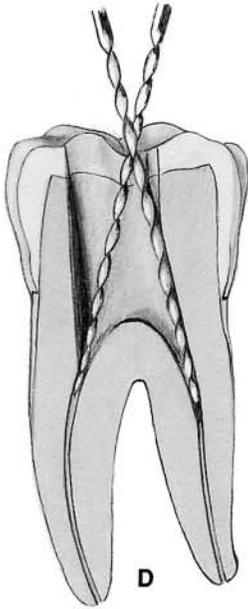
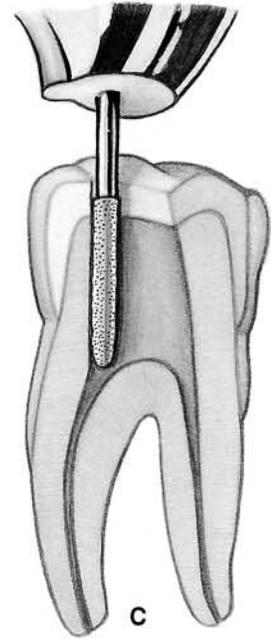
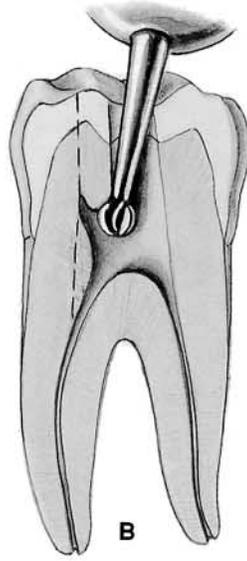
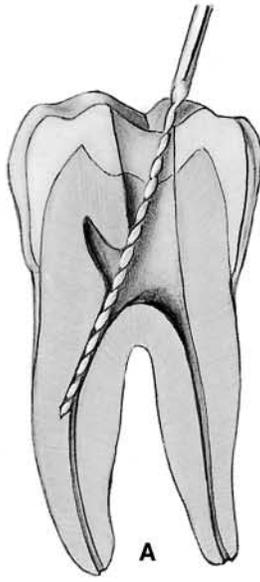
- A. **Obstructed access** to mesial canals in a mandibular first molar. The overhanging roof of the pulp chamber misdirects the instrument mesially, with resulting ledge formation in the canal. It is virtually impossible to see and difficult to locate mesial canal orifices each time the instrument is introduced.
- B. **Internal cavity preparation.** Removing the roof completely from the pulp chamber will bring canal orifices into view and allow immediate access to each orifice. Using a round bur and working from the inside out will accomplish this end.
- C. **Final finish of the convenience form** is completed with a fissure bur, diamond point, or non-end-cutting batt bur. The entire cavity slopes toward the mesial direction of approach, which greatly simplifies instrument placement.
- D. **Unobstructed access to canal orifices.** The mesial wall has been sloped to mesial for the approach to the mandibular molar is from the mesial. The tip of the instrument follows down the mesial wall at each corner of the triangular preparation and literally “falls” into orifices. After the position of each orifice has been determined, the mouth mirror may be laid aside.
- The distal wall of preparation also slopes to the mesial and is easily entered from the mesial approach.
- E. **Direct access to apical foramen.** Extensive removal of coronal tooth structure is necessary to allow complete freedom of endodontic instruments in the coronal cavity and **direct access to the apical canal.** This is especially true when the root is severely curved or leaves the chamber at an obtuse angle.

Walls are generally reduced with burs or long, thin diamond points (see B and C above) and with endodontic files, Gates-Glidden drills, or orifice openers. Burs are rarely used in the floor or immediate orifice area. In the event that a second canal is suspected in the mesiobuccal root of the maxillary molar, the cavity outline would be extended in both of these directions to broaden the search.

Depending on the technique used to fill the canal, the outline form may also be expanded somewhat to accommodate pluggers used in obturation.

- F. **The complete authority of the enlarging instrument is maintained** when all intervening tooth structure is removed and the instrument is controlled by the clinician’s fingers on the handle of the instrument and the tip of the instrument is free in the lumen of the canal.
- G. **Complete authority of enlarging instrument.** If the lateral wall of the cavity has not been sufficiently extended and the pulpal horn portion of the orifice still remains in the wall, the orifice will have the appearance of a tiny “mouse hole.” This **lateral wall** will then impinge on enlarging the instrument and will dictate the direction of the instrument tip. The operator will have lost control of the instrument and the situation.
- H. **By extending the lateral wall** of the cavity, thus removing all intervening dentin from the orifice, the “mouse hole” in the wall will be eliminated and the **orifice will appear completely in the floor.** Now the enlarging instrument will stand free of the walls, and the **operator will regain control of the instrument** (see F above).

PLATE 2

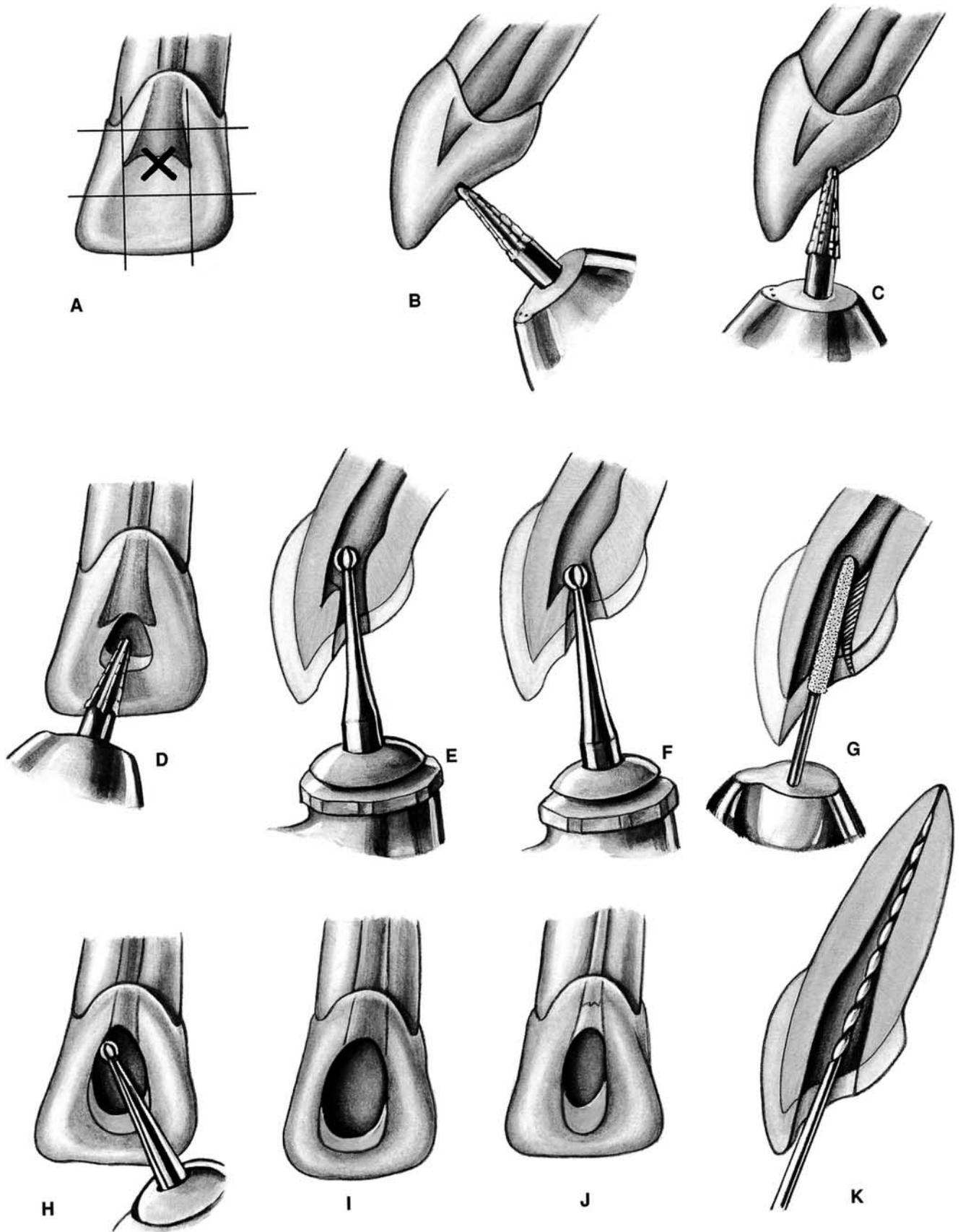


## PLATE 3

### Endodontic Preparation of Maxillary Anterior Teeth

- A. Entrance is **always** gained through the lingual surface of **all** anterior teeth. Initial penetration is made in the exact center of the lingual surface at the position marked “X.” A common error is to begin the cavity too far gingivally.
- B. Initial entrance is prepared with a round-point tapering fissure bur in an **accelerated-speed** contra-angle handpiece with air coolant, operated at a **right angle** to the long axis of the tooth. **Only enamel is penetrated at this time.** Do not force the bur; allow it to cut its own way.
- C. **Convenience extension** toward the incisal continues the initial penetrating cavity preparation. Maintain the point of the bur in the central cavity and rotate the handpiece toward the incisal so that the bur **parallels** the long axis of the tooth. Enamel and dentin are beveled toward the incisal. **Entrance into the pulp chamber should not be made with an accelerated-speed instrument.** Lack of tactile sensation with these instruments **precludes their use inside** the tooth.
- D. The preliminary cavity outline is funneled and fanned incisally with a fissure bur. Enamel has a **short** bevel toward the incisal, and a “nest” is prepared in the dentin to receive the round bur to be used for penetration.
- E. A **surgical-length** No. 2 or 4 round bur in a **slow-speed** contra-angle handpiece is used to penetrate the pulp chamber. If the pulp has greatly receded, a No. 2 round bur is used for initial penetration. Take advantage of **convenience extension** toward the incisal to allow for the shaft of the penetrating bur, operated nearly parallel to the long axis of the tooth.
- F. **Working from inside the chamber to outside**, a round bur is used to remove the lingual and labial walls of the pulp chamber. The resulting cavity is smooth, continuous, and flowing from cavity margin to canal orifice.
- G. After the outline form is completed, the surgical-length bur is carefully passed into the canal. **Working from inside to outside**, the lingual “shoulder” is removed to give continuous, smooth-flowing preparation. Often a long, tapering diamond point will better remove the lingual “shoulder.”
- H. Occasionally, a No. 1 or 2 round bur must be used laterally and incisally to eliminate pulpal horn debris and bacteria. This also prevents future discoloration.
- I. Final preparation relates to the **internal anatomy** of the chamber and canal. In a “young” tooth with a large pulp, the outline form reflects a large triangular internal anatomy—an extensive cavity that allows thorough cleansing of the chamber as well as passage of large instruments and filling materials needed to prepare and fill a large canal. Cavity extension toward the incisal allows greater access to the midline of the canal.
- J. Cavity preparations in “adult” teeth, with the chamber obturated with secondary dentin, are ovoid in shape. Preparation **funnels** down to the orifice of the canal. The further the pulp has receded, the more difficult it is to reach to this depth with a round bur. Therefore, when the radiograph reveals advanced pulpal recession, **convenience extension must be advanced further incisally** to allow the bur shaft and instruments to operate in the central axis.
- K. Final preparation with the reamer in place. The instrument shaft **clears** the incisal **cavity margin** and **reduced** lingual “shoulder,” allowing an unrestrained approach to the apical third of the canal. The instrument remains under the complete control of the clinician. An optimal, **round, tapered cavity** may be prepared in the apical third, tailored to the requirements of **round, tapered filling** materials to follow. The remaining ovoid part of the canal is cleaned and shaped by circumferential filing or Gates-Glidden drills.

PLATE 3



## PLATE 4

### Maxillary Central Incisor

#### Pulp Anatomy and Coronal Preparation

- A. **Lingual** view of a recently calcified incisor with a large pulp. A radiograph will reveal
1. extent of the pulp horns
  2. mesiodistal width of the pulp
  3. apical-distal curvature (8% of the time)
  4. 2-degree mesial-axial inclination of the tooth
- These factors seen in the radiograph are borne in mind when preparation is begun.

- B. **Distal** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. presence of a **lingual** “shoulder” at the point where the chamber and canal join
  2. broad labiolingual extent of the pulp
  3. 29-degree lingual-axial angulation of the tooth

The operator must recognize that

- a. the lingual “shoulder” must be removed with a tapered diamond point to allow better access to the canal.
- b. these “unseen” factors affect the **size, shape, and inclination** of final preparation.

- C. Cross-sections at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical level**: the pulp is enormous in a young tooth, wider in the mesiodistal dimension. Débridement in this area is accomplished by **extensive perimeter filing**.
  2. **Midroot level**: the canal continues ovoid and requires perimeter filing and multiple point filing.
  3. **Apical third level**: the canal, generally round in shape, is enlarged by reshaping the cavity into a **round tapered** preparation. Preparation terminates at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex. An unusually large apical third canal is more ovoid in shape, must be prepared with **perimeter filing** rather than reaming, and must be obturated with multiple points or warm gutta-percha.

- D. Large, triangular, funnel-shaped **coronal preparation** is necessary to adequately débride the chamber of all pulp remnants. (The pulp is “ghosted” in the background.) Note the beveled extension toward the incisal that will carry the preparation

labially and thus nearer the central axis. Incisal extension allows better access for large instruments and filling materials used in the apical third canal.

- E. **Lingual** view of an **adult** incisor with extensive secondary dentin formation. A radiograph will reveal
1. full pulpal recession
  2. apparently straight canal
  3. 2-degree mesial-axial inclination of the tooth
- F. **Distal** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. narrow labiolingual width of pulp
  2. reduced size of the lingual shoulder
  3. apical-labial curvature (9% of the time)
  4. 29-degree lingual-axial angulation of the tooth

The operator must recognize that

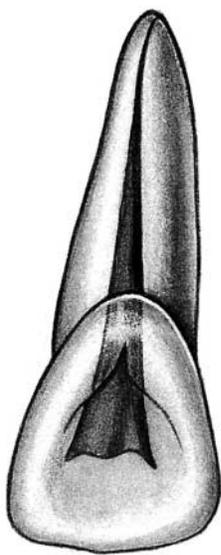
- a. a small canal orifice is difficult to find.
  - b. **apical-labial curvature, not usually seen radiographically**, can be determined by exploration with a fine curved file and mesially oriented radiographs.
  - c. axial inclination of the root calls for careful orientation and alignment of the bur to prevent “gouging.”
- G. Cross-sections at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical level**: the canal, only slightly ovoid, becomes progressively more round.
  2. **Midroot level**: the canal varies from slightly ovoid to round.
  3. **Apical third level**: the canal is generally round in the older patient.

- H. Ovoid, funnel-shaped coronal preparation provides adequate access to the root canal. The pulp chamber, obturated by secondary dentin, need not be extended for coronal débridement. “Adult” cavity preparation is narrow in the mesiodistal width but is almost as extensive in the incisogingival direction as preparation in a young tooth. This beveled incisal extension carries preparation nearer the central axis, allowing better access to the curved apical third.

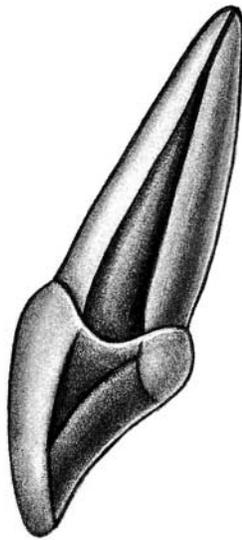
PLATE 4

*Maxillary Central Incisors*

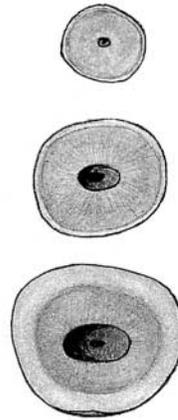
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Average Length	23.3 mm	One canal	23%	13%	Straight	75%
Maximum Length	25.6 mm	100%			Distal Curve	8%
Minimum Length	21.0 mm				Mesial Curve	4%
Range	4.6 mm				*Labial Curve	9%
					*Lingual Curve	4%
					*Not apparent in radiograph	



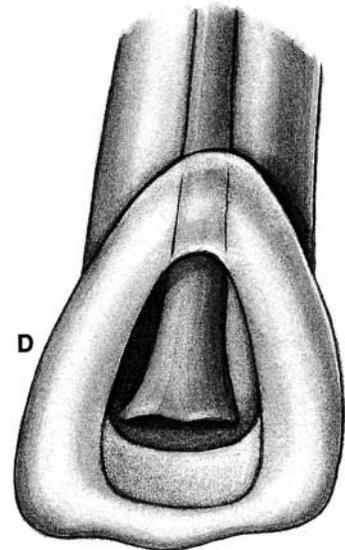
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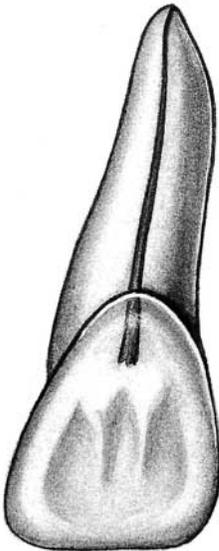
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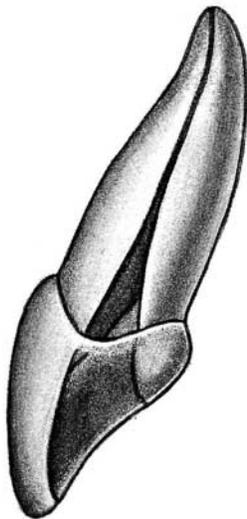
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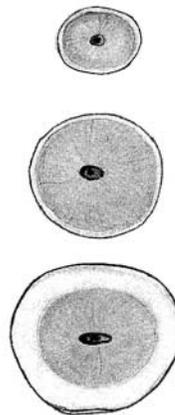
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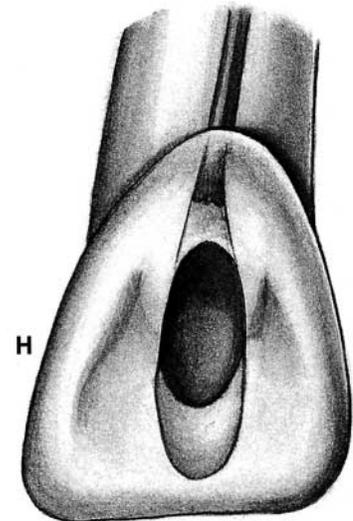
E



F



G



H

## PLATE 5

### Maxillary Lateral Incisor

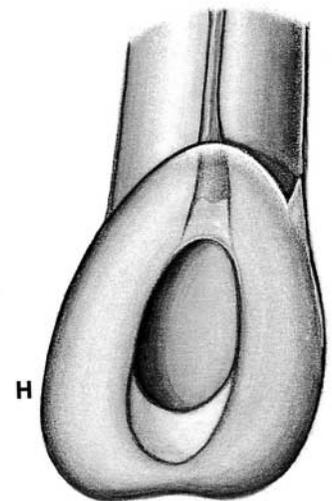
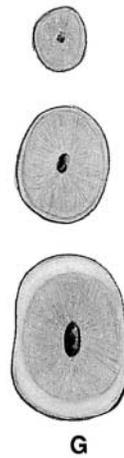
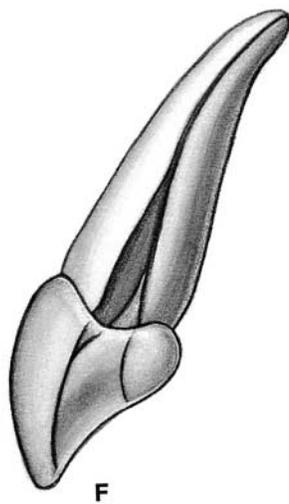
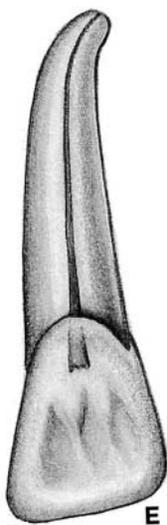
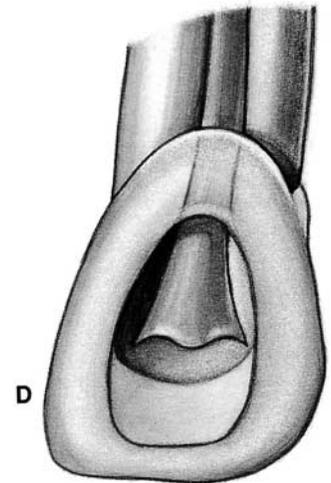
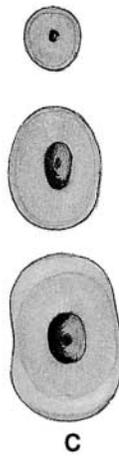
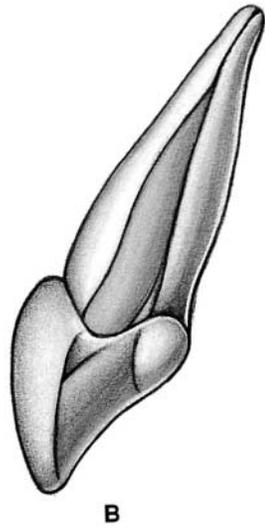
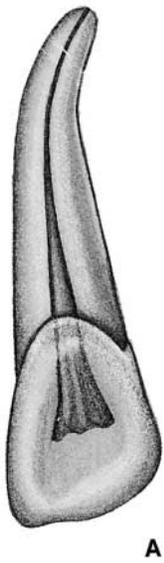
#### Pulp Anatomy and Coronal Preparation

- A. Lingual view of a recently calcified incisor with a large pulp. A radiograph will reveal
1. extent of the pulp horns
  2. mesiodistal width of the pulp
  3. apical-distal curvature (53% of the time)
  4. 16-degree mesial-axial inclination of the tooth
- Factors seen in the radiograph are borne in mind when preparation is begun.
- B. Distal view of the same tooth demonstrating details **not apparent in the radiograph**:
1. presence of a lingual “shoulder” at the point where the chamber and canal join
  2. broad labiolingual extent of the pulp
  3. 29-degree lingual-axial angulation of tooth
- The operator must recognize that
- a. the lingual “shoulder” must be removed with a tapered diamond point to allow better access to the canal.
  - b. these “unseen” factors will affect the **size, shape, and inclination** of final preparation.
- C. Cross-sections at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical level**: the pulp is large in a young tooth and wider in the labiolingual dimension. Débridement in this area is accomplished by extensive perimeter filing.
  2. **Midroot level**: the canal continues ovoid and requires additional filing to straighten the gradual curve. Multiple point filling is necessary.
  3. **Apical third level**: the canal, generally round and **gradually curved**, is enlarged by filing to a straightened trajectory. Preparation is completed by shaping the cavity into a **round, tapered** preparation. Preparation terminates at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- D. Large, triangular, funnel-shaped coronal preparation is necessary to adequately débride the chamber of all pulpal remnants. (The pulp is “ghosted” in the background.) Note the beveled extension toward the incisal, which will carry the preparation labially and thus nearer the central axis. Incisal extension allows better access to the apical third of the canal.
- E. **Lingual view of an adult incisor with extensive secondary dentin formation.** A radiograph will reveal
1. full pulp recession
  2. severe apical curve to the distal
  3. 16-degree mesial-axial inclination of the tooth
- F. **Distal view of the same tooth demonstrating details not apparent in the radiograph**
1. narrow labiolingual width of the pulp
  2. reduced size of the lingual shoulder
  3. apical-lingual curvature (4% of the time)
  4. 29-degree lingual-axial angulation of the tooth
- The operator must recognize that
- a. a small canal orifice is difficult to find.
  - b. apical-lingual curvature, **not usually seen radiographically**, can be determined by exploration with a fine curved file and mesially oriented radiographs.
  - c. axial inclination of the root calls for careful orientation and alignment of the bur to prevent labial “gouging.” A “corkscrew” curve, to the distal and lingual, complicates preparation of the apical third of the canal.
- G. Cross-sections at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical level**: the canal is only slightly ovoid and becomes progressively rounder.
  2. **Midroot level**: the canal varies from slightly ovoid to round.
  3. **Apical third level**: the canal is generally round in the older patient.
- A curved canal is enlarged by alternate reaming and filing. Ovoid preparation will require multiple point filling.
- H. Ovoid, funnel-shaped coronal preparation should be only slightly **skewed** toward the mesial to present better access to the apical-distal. It is not necessary to extend preparation for coronal débridement, but an extensive bevel is necessary toward the incisal to carry preparation nearer the central axis, allowing better access to the apical third.

PLATE 5

*Maxillary Lateral Incisors*

<i>Length of tooth</i>		<i>Canal</i>	<i>Lateral canals</i>	<i>Apical ramifications</i>	<i>Root curvature</i>	
<i>Average Length</i>	22.8 mm	One canal	10%	12%	Straight	30%
<i>Maximum Length</i>	25.1 mm	99.9%			Distal Curve	53%
<i>Minimum Length</i>	20.5 mm				Mesial Curve	3%
<i>Range</i>	4.6 mm				*Labial Curve	4%
					*Bayonet and Gradual Curve	6%
					*Not apparent in radiograph	



## PLATE 6

### Maxillary Canine

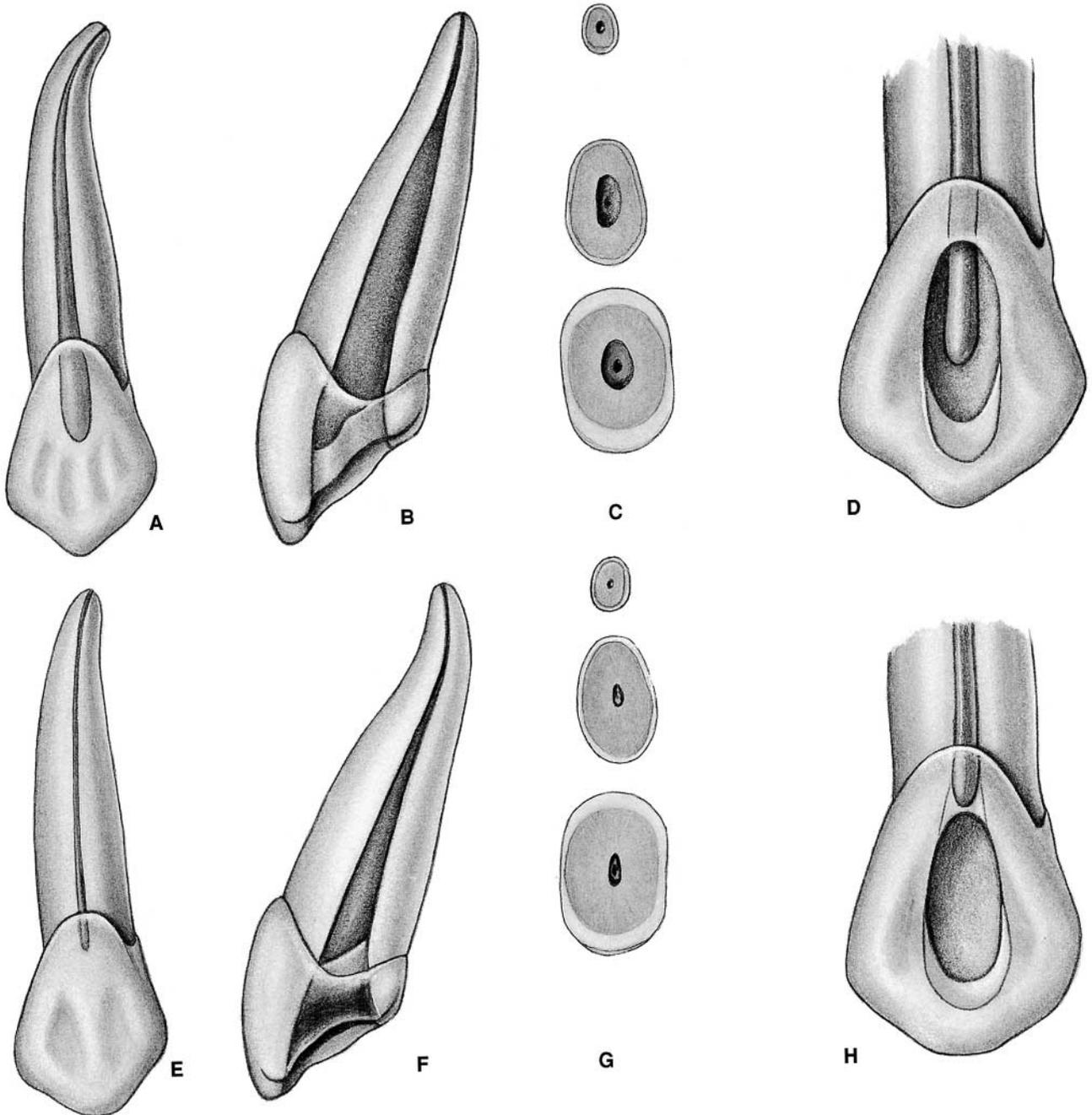
#### Pulp Anatomy and Coronal Preparation

- A. **Lingual** view of a recently calcified canine with a large pulp. A radiograph will reveal
1. coronal extent of the pulp
  2. **narrow** mesiodistal width of the pulp
  3. apical-distal curvature (32% of the time)
  4. 6-degree distal-axial inclination of the tooth
- These factors, **seen** in the radiograph, are borne in mind when preparation is begun, particularly the severe apical curve.
- B. **Distal** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. huge ovoid pulp, larger labiolingually than the radiograph would indicate
  2. presence of a **labial** “shoulder” just below the cervical
  3. narrow canal in the apical third of the root
  4. 21-degree lingual-axial angulation of the tooth
- These “unseen” factors will affect the **size, shape, and inclination** of the final preparation.
- C. Cross-section is at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical** level: the pulp is enormous in a young tooth, much wider in the **labiolingual** direction. Débridement in this area is accomplished with a long, tapered diamond point and extensive perimeter filing.
  2. **Midroot** level: the canal continues ovoid in shape and requires perimeter filing and multiple point filling.
  3. **Apical third** level: the straight canal (39% of time), generally round in shape, is prepared by shaping the cavity into **round tapered** preparation. Preparation should terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex. If unusually large or curved, the apical canal requires perimeter filing and multiple point or warm gutta-percha filling.
- D. Extensive, **ovoid**, funnel-shaped **coronal preparation** is necessary to adequately débride the chamber of all pulpal remnants. (The pulp is “ghosted” in the background.) Note the long, beveled extension toward the incisal, which will carry the preparation labially and thus nearer the central axis. Incisal extension allows better access for large instruments and filling materials used in the apical third of the canal.
- E. **Lingual** view of an **adult** canine with extensive secondary dentin formation. A radiograph will reveal
1. full pulp recession
  2. straight canal (39% of the time)
  3. 6-degree distal-axial inclination of tooth
- F. **Distal** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. narrow labiolingual width of the pulp
  2. apical **labial** curvature (13% of the time)
  3. 21-degree lingual-axial angulation of the tooth
- The operator should recognize that
- a. a small canal orifice is difficult to find.
  - b. apical **labial** curvature, not seen radiographically, can be determined only by exploration with a fine curved file and mesially oriented radiographs.
  - c. distal-lingual axial inclination of the root calls for careful orientation and alignment of the bur to prevent “gouging.”
  - d. **apical foramen** toward the labial is a problem.
- G. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical** level: the canal is slightly ovoid.
  2. **Midroot** level: the canal is smaller but remains ovoid.
  3. **Apical third** level: the canal becomes progressively rounder.
- H. Extensive, ovoid, funnel-shaped preparation must be **nearly as large** as for a young tooth. A beveled incisal extension carries preparation nearer the central axis, allowing better access to the curved apical third. Discovery by exploration of an **apical-labial** curve calls for even greater incisal extension.

PLATE 6

Maxillary Canines

Length of tooth		Canal	Lateral canals	Apical ramifications	Root curvature	
Average Length	26.0 mm	One canal	24%	8%	Straight	39%
Maximum Length	28.9 mm	100%			Distal Curve	32%
Minimum Length	23.1 mm				Mesial Curve	0%
Range	5.8 mm				*Labial Curve	13%
					*Lingual Curve	7%
					Bayonet and Gradual Curve	7%
					*Not apparent in radiograph	

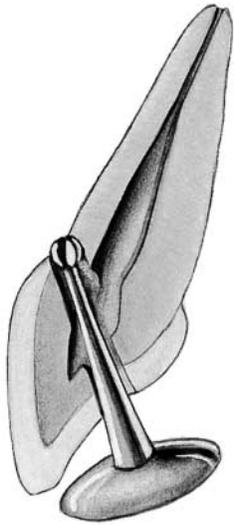


## PLATE 7

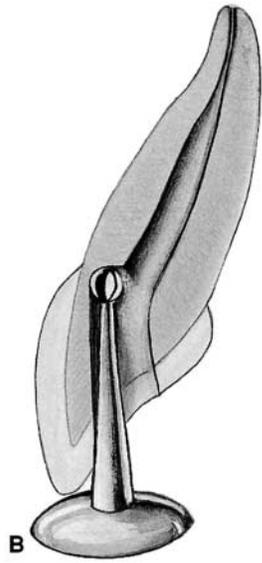
### Maxillary Anterior Teeth ERRORS in Cavity Preparation

- A. PERFORATION at the labiocervical caused by **failure to complete convenience extension** toward the incisal, prior to the entrance of the shaft of the bur.
- B. GOUGING of the labial wall caused by **failure to recognize** the 29-degree lingual-axial angulation of the tooth.
- C. GOUGING of the distal wall caused by **failure to recognize** the 16-degree mesial-axial inclination of the tooth.
- D. PEAR-SHAPED PREPARATION of the apical canal caused by **failure to complete convenience extensions**. The shaft of the instrument rides on the cavity margin and lingual "shoulder." Inadequate débridement and obturation ensure failure.
- E. DISCOLORATION of the crown caused by failure to remove pulp debris. The access cavity is too far to the gingival with no incisal extension.
- F. LEDGE formation at the apical-distal curve caused by using an uncurved instrument too large for the canal. The cavity is adequate.
- G. PERFORATION at the apical-distal curve caused by using too large an instrument through an **inadequate** preparation placed too far gingivally.
- H. LEDGE formation at the apical-labial curve caused by **failure to complete the convenience extension**. The shaft of the instrument rides on the cavity margin and "shoulder."

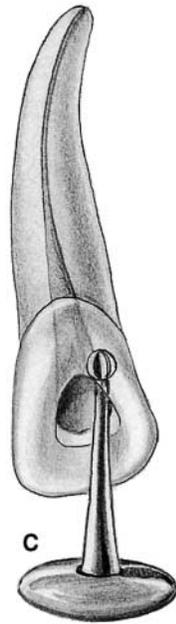
PLATE 7



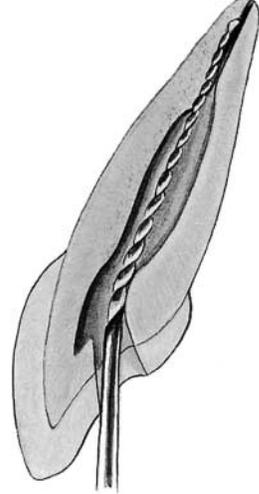
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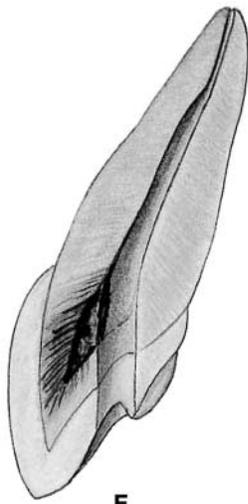
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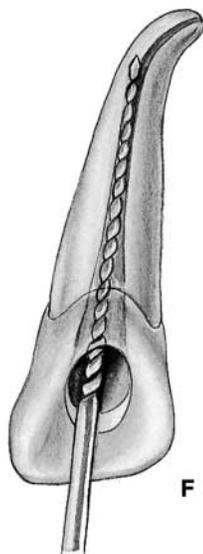
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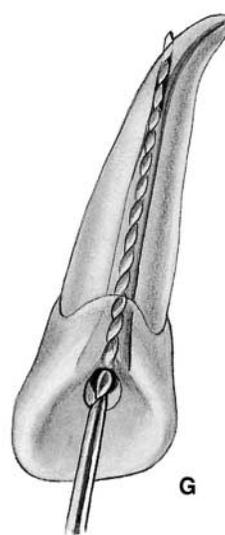
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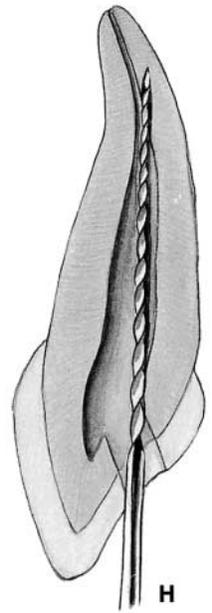
E



F



G



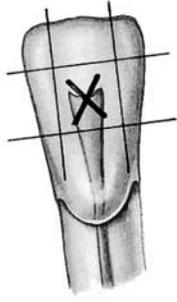
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## PLATE 8

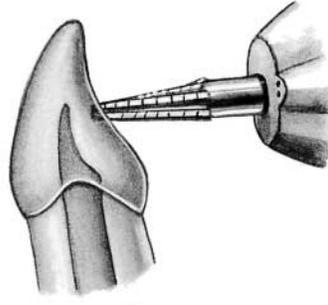
### Endodontic Preparation of Mandibular Anterior Teeth

- A. Entrance is always gained through the lingual surface of all anterior teeth. Initial penetration is made in the exact center of the lingual surface at the position marked "X." A common error is to begin too far gingivally.
- B. The initial entrance cavity is prepared with a 701 U tapering fissure bur in an **accelerated-speed** contra-angle handpiece with air coolant, operated at a **right angle** to the long axis of the tooth. **Only enamel is penetrated at this time.** Do not force the bur; allow it to cut its own way.
- C. **Convenience extension** toward the incisal continues initial penetrating cavity. Maintain the point of the bur in the central cavity and rotate the handpiece toward the incisal so that the bur **parallels** the long axis of the tooth. Enamel and dentin are beveled toward the incisal. **Entrance into the pulp chamber should not be made with an accelerated-speed instrument.** Lack of tactile sensation with these instruments **precludes their use inside** the tooth.
- D. The preliminary cavity outline is funneled and fanned incisally with a fissure bur. The enamel has a short bevel toward the incisal, and a "nest" is prepared in the dentin to receive the round bur to be used for penetration.
- E. A **surgical-length** No. 2 round bur in a **slow-speed** contra-angle handpiece is used to penetrate into the pulp chamber. If the pulp has greatly receded, the No. 2 round bur is used for initial penetration. Take advantage of **convenience extension** toward the incisal to allow for the shaft of the penetrating bur, operated nearly parallel to the long axis of the tooth.
- F. **Working from inside the chamber to the outside**, a round bur is used to remove the lingual and labial walls of the pulp chamber. The resulting cavity is smooth, continuous, and flowing from cavity margin to canal orifice.
- G. After the outline form is completed, a surgical-length bur is carefully passed down into the canal. **Working from inside to outside**, the lingual "shoulder" is removed with a long, fine, tapered diamond point to give a continuous, smooth-flowing preparation.
- H. Occasionally, a No. 1 round bur must be used laterally and incisally in the cavity to eliminate pulpal horn debris and bacteria. This also prevents future discoloration.
- I. Final preparation related to the **internal anatomy** of the chamber and canal. In a "young" tooth with a large pulp, the outline form reflects triangular internal anatomy—an extensive cavity that allows thorough cleansing of the chamber as well as passage of large instruments and filling materials needed to prepare and fill the large canal. Note extension toward the incisal to allow better access to the central axis.
- J. Cavity preparations in an "adult" tooth with the chamber obliterated with secondary dentin are ovoid. Preparation **funnels** down to the orifice of the canal. The further the pulp has receded, the more difficult it is to reach to this depth with a round bur. Therefore, when a radiograph reveals advanced pulpal recession, **convenience extension** must be advanced further incisally to allow the bur shaft to operate in the central axis. The incisal edge may even be invaded and later restored by composites.
- K. Final preparation showing the reamer in place. The instrument shaft **clears** the incisal **cavity margin** and reduced lingual shoulder, allowing an unrestrained approach to the apical third of the canal. The instruments remain under the complete control of the clinician. **Great care must be taken to explore for additional canals, particularly to the lingual of the pulp chamber.** An optimal **round, tapered cavity** may be prepared in the apical third, tailored to requirements of round, tapered filling materials to follow. The remaining ovoid part of the canal is cleaned and shaped by extensive filing.

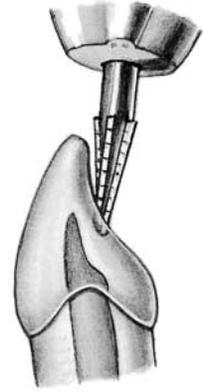
PLATE 8



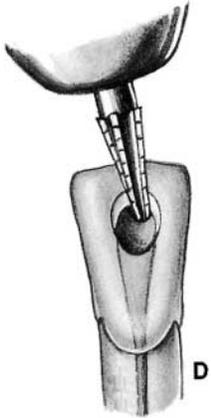
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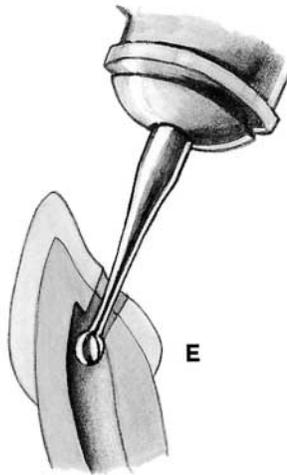
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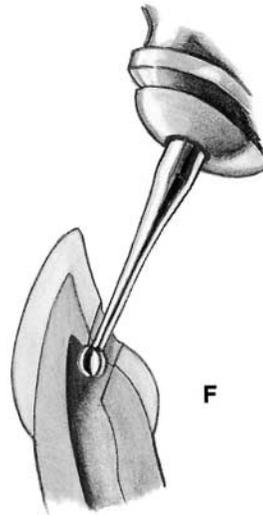
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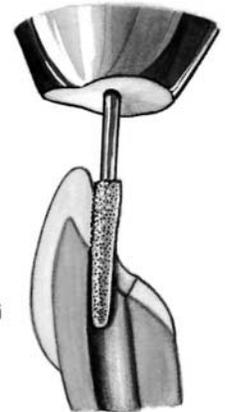
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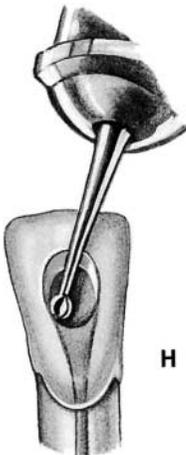
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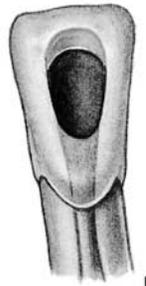
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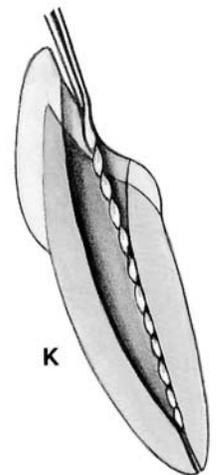
H



I



J



K

## PLATE 9

### Mandibular Central and Lateral Incisors

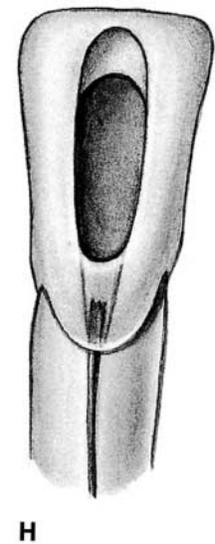
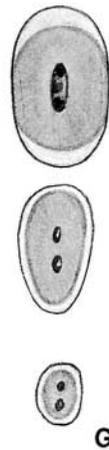
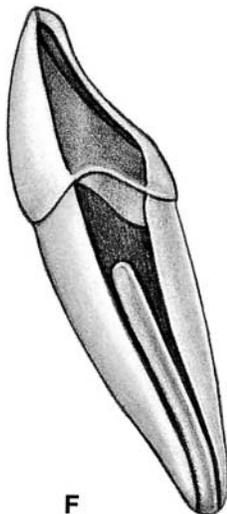
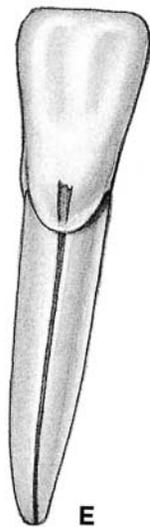
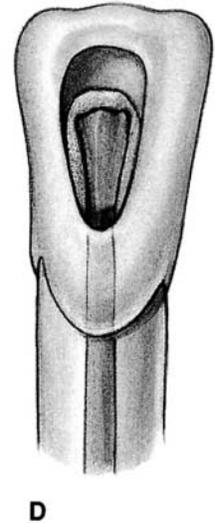
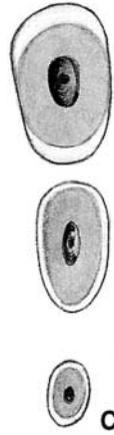
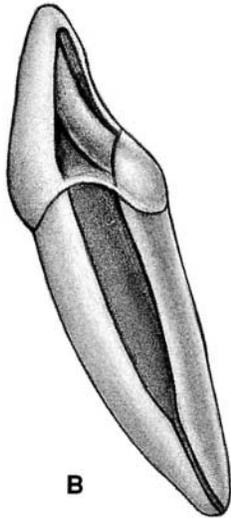
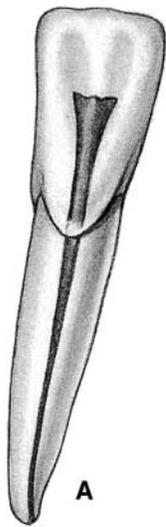
#### Pulp Anatomy and Coronal Preparation

- A. **Lingual** view of a recently calcified incisor with a large pulp. A radiograph will reveal
1. extent of the pulp horns
  2. mesiodistal width of the pulp
  3. slight apical-distal curvature of the canal (23% of the time)
  4. mesial-axial inclination of the tooth (central incisor 2 degrees, lateral incisor 17 degrees).
- These factors, seen in the radiograph, are borne in mind when preparation is begun.
- B. **Distal** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. presence of a lingual “shoulder” at the point where the chamber and canal join
  2. broad labiolingual extent of the pulp
  3. 20-degree lingual-axial angulation of the tooth
- The operator must recognize that
- a. the lingual “shoulder” must be removed with a fine, tapered diamond point to allow better access to the canal.
  - b. these “unseen” factors affect the **size, shape, and inclination** of the final preparation.
- C. Cross-sections at three levels: 1, cervical; 2, midroot; 3, apical third:
1. **Cervical** level: the pulp is enormous in a young tooth, wider in the labiolingual dimension. Débridement in this area is accomplished by **extensive perimeter** filing.
  2. **Midroot** level: the canal continues ovoid and requires perimeter filing and multiple point filling.
  3. **Apical third** level: the canal, generally round in shape, is enlarged by shaping the cavity into a **round, tapered** preparation. Preparation terminates at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- D. Large, triangular, funnel-shaped coronal preparation is necessary to adequately débride the chamber of all pulp remnants. (The pulp is “ghosted” in the background.) Note the beveled extension toward the incisal, which will carry the preparation labially and thus nearer the central axis. Incisal extension allows better access for instruments and filling materials used in the apical third of the canal.
- E. **Lingual** view of an **adult** incisor with extensive secondary dentin formation. A radiograph will reveal:
1. full pulp recession
  2. an apparently straight canal
  3. mesial-axial inclination of the tooth (central incisor 2 degrees, lateral incisor 17 degrees).
- F. **Distal** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. labiolingual width of the pulp
  2. reduced size of the lingual shoulder
  3. **unsuspected presence of bifurcation of pulp into the labial and lingual canals nearly 30% of the time**
  4. 20-degree lingual-axial angulation of the tooth
- The operator must recognize that
- a. smaller canal orifices are more difficult to find.
  - b. **labial and lingual** canals are discovered by exploration with a fine curved file to **both labial and lingual**.
  - c. axial inclination of the root calls for careful orientation and alignment of the bur to prevent “gouging.”
- G. Cross-sections at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical** level: the canal is only slightly ovoid.
  2. **Midroot** level: the two canals are essentially round.
  3. **Apical third** level: the canals are round and curve toward the labial.
- It is important that all mandibular anterior teeth be explored to both labial and lingual for the possibility of two canals.**
- H. Ovoid, funnel-shaped coronal preparation provides adequate access to the root canal. An “adult” cavity is narrow in the mesiodistal width but is as extensive in the incisogingival direction as preparation in a young tooth. This beveled incisal extension carries preparation nearer to the central axis. The incisal edge may even be invaded. This will allow better access to **both canals** and the **curved apical third**. **Ideal lingual extension and better access will often lead to discovery of the second canal.**

PLATE 9

Mandibular Central and Lateral Incisors

Length of tooth	Central Incisors	Lateral Incisors	Canals	Central Incisors	Lateral Incisors	Root curvature	
Average Length	21.5 mm	22.4 mm	One canal One foramen	70.1%	56.9%	Straight	60%
Maximum Length	23.4 mm	24.6 mm	Two canals One foramen	23.4%	14.7%	Distal Curve	23%
Minimum Length	19.6 mm	20.2 mm	Two canals Two foramens	6.5%	29.4%	Mesial Curve	0%
Range	3.8 mm	4.4 mm	Lateral canals	5.2%	13.9%	*Labial Curve	13%
						*Lingual Curve	0%
						*Not apparent in radiograph	



## PLATE 10

### Mandibular Canine

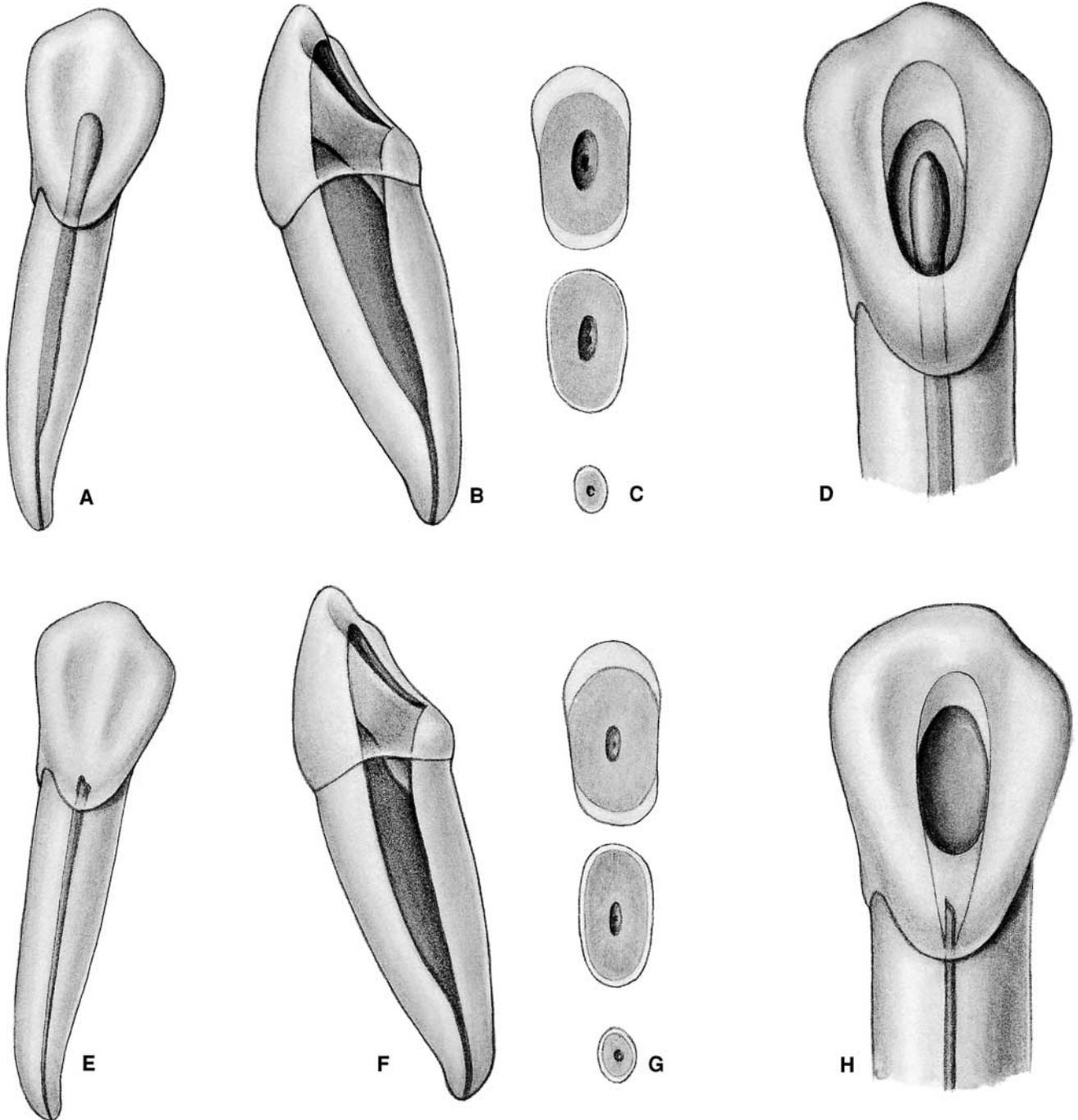
#### Pulp Anatomy and Coronal Preparation

- A. **Lingual** view of a recently calcified canine with a large pulp. A radiograph will reveal
1. coronal extent of the pulp
  2. narrow mesiodistal width of the pulp
  3. apical-distal curvature (20% of the time)
  4. 13-degree mesial-axial inclination of tooth
- These factors, **seen** in the radiograph, are borne in mind when preparation is begun.
- B. **Distal** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. broad labiolingual extent of the pulp
  2. narrow canal in the apical third of the root
  3. apical-labial curvature (7% of time)
  4. 15-degree lingual-axial angulation of the tooth
- These “unseen factors” affect the **size, shape, and inclination** of the final preparation.
- C. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level**: the pulp is enormous in a young tooth, wider in the labiolingual direction. Débridement in this area is accomplished with **extensive perimeter filing**.
  2. **Midroot level**: the canal continues ovoid and requires perimeter filing and multiple gutta-percha point filling.
  3. **Apical third level**: the canal, generally round, is enlarged by filing to reduce the curve to a relatively straight canal. This canal is then completed by shaping action into **round, tapered** preparation. Preparation terminates at the cementodentinal junction, 0.5 to 1.0 mm from the radiograph apex. If unusually large or ovoid, the **apical canal** requires perimeter filing.
- D. Extensive ovoid, funnel-shaped **coronal preparation** is necessary to adequately débride the chamber of all pulp remnants. (The pulp is “ghosted” in the background.) Note the beveled extension toward the incisal, which will carry the preparation labially and thus nearer the central axis. Incisal extension allows better access for large instruments and filling materials used in the apical third canal.
- E. **Lingual** view of an **adult** canine with extensive secondary dentin formation. A radiograph will reveal
1. full pulp recession
  2. slight distal curve of the canal (20% of the time)
  3. 13-degree mesial-axial inclination of the tooth
- F. Distal view of the same tooth demonstrating details **not apparent in the radiograph**:
1. labiolingual width of the pulp
  2. 15-degree lingual-axial angulation of the tooth
- The operator must recognize that
- a. a small canal orifice, positioned well to the **labial**, is difficult to find.
  - b. lingual-axial angulation calls for careful orientation of the bur to prevent “gouging.”
  - c. apical-labial curvature (7% of the time).
- G. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level**: the canal is slightly ovoid.
  2. **Mid-root level**: the canal is smaller but remains ovoid.
  3. **Apical third level**: the canal becomes progressively rounder.
- The canal is enlarged by filing and is filled.
- H. Extensive ovoid, funnel-shaped preparations must be as large as preparation for a young tooth. The cavity should be extended incisogingivally for room to find the orifice and enlarge the apical third without interference. An apical-labial curve would call for increased extension incisally.

PLATE 10

Mandibular Canines

Length of tooth		Canals		Lateral canals	Root curvature	
Average Length	25.2 mm	One canal	94%	9.5%	Straight	68%
Maximum Length	27.5 mm	Two canals			Distal Curve	20%
Minimum Length	22.9 mm	Two foramina	6%		Mesial Curve	1%
Range	4.6 mm				*Labial Curve	7%
					*Lingual Curve	0%
					Bayonet Curve	2%
					*Not apparent in radiograph	

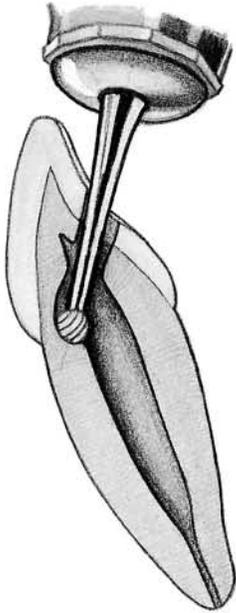


## PLATE 11

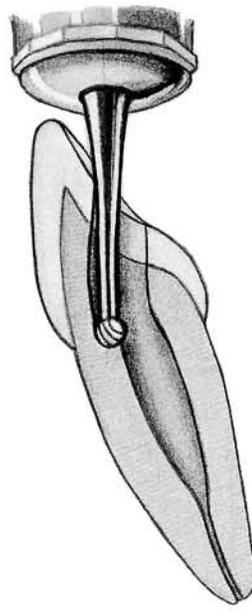
### Mandibular Anterior Teeth ERRORS in Cavity Preparation

- A. GOUGING at the labiocervical caused by **failure to complete convenience extension** toward the incisal prior to entrance of the shaft of the bur.
- B. GOUGING of the labial wall caused by failure to recognize the 20-degree lingual-axial angulation of the tooth.
- C. GOUGING of the distal wall caused by **failure to recognize** the 17-degree mesial-axial angulation of the tooth.
- D. FAILURE to explore, débride, or fill the second canal caused by **inadequate incisogingival extension of the access cavity**.
- E. DISCOLORATION of the crown caused by failure to remove pulp debris. The access cavity is too far to the gingival with no incisal extension.
- F. LEDGE formation caused by complete loss of control of the instrument passing through the access cavity prepared in proximal restoration.

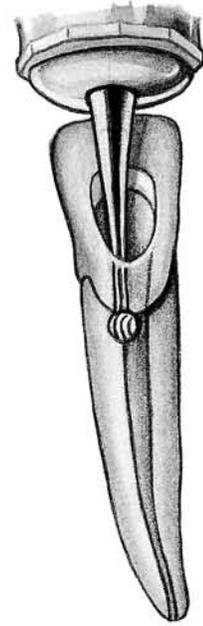
PLATE 11



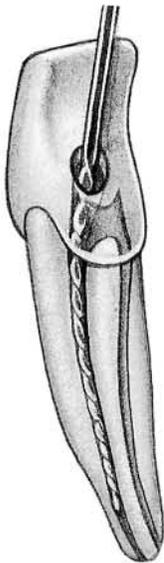
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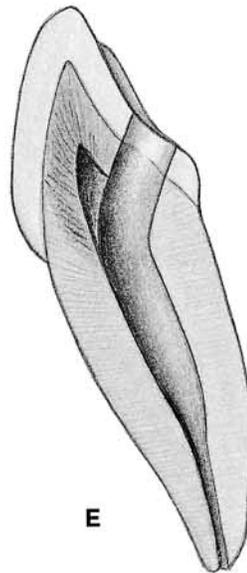
B



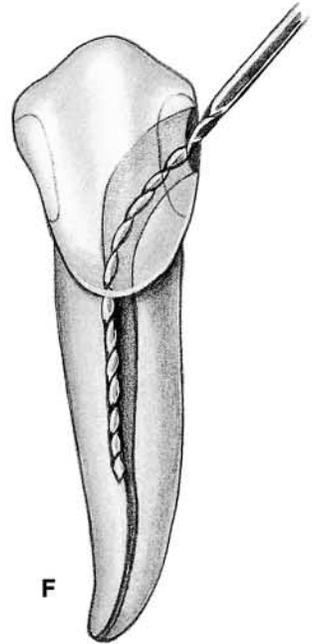
C



D



E



F

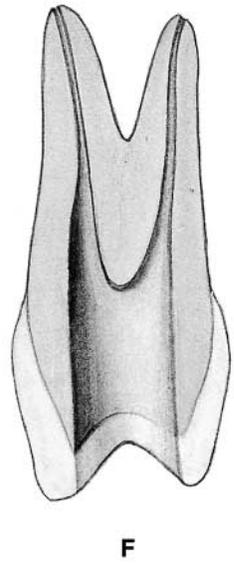
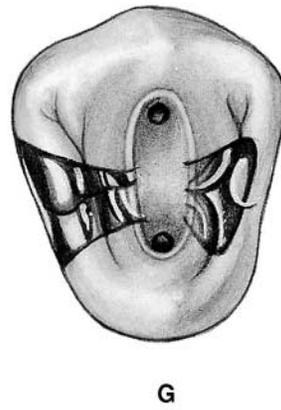
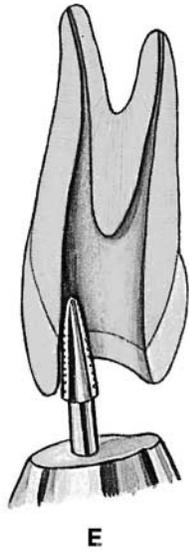
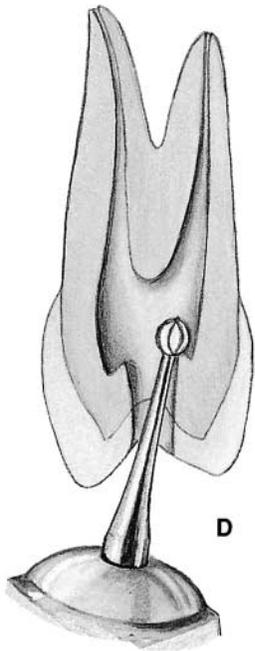
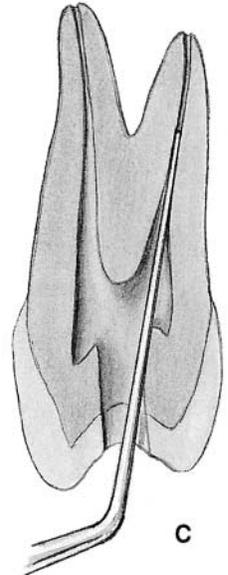
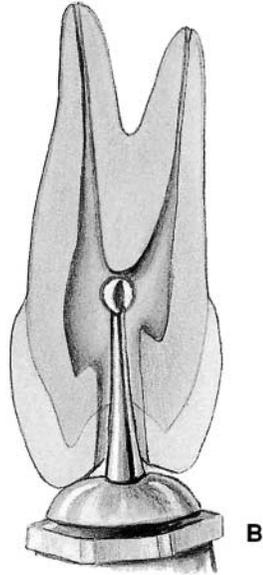
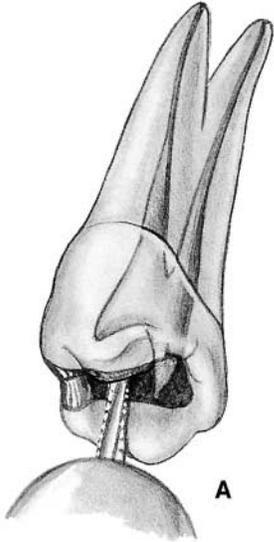
## PLATE 12

### Endodontic Preparation of Maxillary Premolar Teeth

- A. Entrance is **always** gained through the **occlusal** surface of all posterior teeth. Initial penetration is made parallel to the long axis of the tooth in the exact center of the central groove of the maxillary premolars. The 701 U tapering fissure bur in an accelerated-speed contra-angle handpiece is ideal for penetrating gold casting or virgin enamel surface to the depth of the dentin. Amalgam fillings are opened with a No. 4 round bur in a slow-speed contra-angle handpiece.
- B. A **regular-length** No. 2 or 4 round bur is used to open into the pulp chamber. The bur will be felt to “drop” when the pulp chamber is reached. If the chamber is well calcified and the “drop” is not felt, vertical penetration is made until the contra-angle handpiece rests against the occlusal surface. This depth is approximately 9 mm, the position of the floor of the pulp chamber that lies at the cervical level. In removing the bur, **the orifice is widened buccolingually** to twice the width of the bur to allow room for exploration for canal orifices. If a surgical-length bur is used, care must be exercised not to perforate the furca.
- C. An endodontic explorer is used to locate orifices to the **buccal** and **lingual** canals in the **first premolar** or the **central canal** in the **second premolar**.

Tension of the explorer shaft against the walls of preparation will indicate the amount and direction of extension necessary.
- D. Working from inside the pulp chamber to outside, a round bur is used at low speed to extend the cavity buccolingually by removing the roof of the pulp chamber.
- E. Buccolingual extension and finish of cavity walls are completed with a 701 U fissure bur at accelerated speed.
- F. Final preparation should provide unobstructed access to canal orifices. Cavity walls should not impede complete authority over enlarging instruments.
- G. **Outline form** of final preparation will be **identical for both newly erupted and “adult” teeth**. Buccolingual ovoid preparation reflects the anatomy of the pulp chamber and the position of the buccal and lingual canal orifices. The cavity must be extensive enough to allow for instruments and filling materials needed to enlarge and fill canals. **Further exploration** at this time is imperative. It may reveal the orifice to an additional canal, a **second canal** in the second premolar, or a **third canal** in the first premolar.

PLATE 12



## PLATE 13

### Maxillary First Premolar

#### Pulp Anatomy and Coronal Preparation

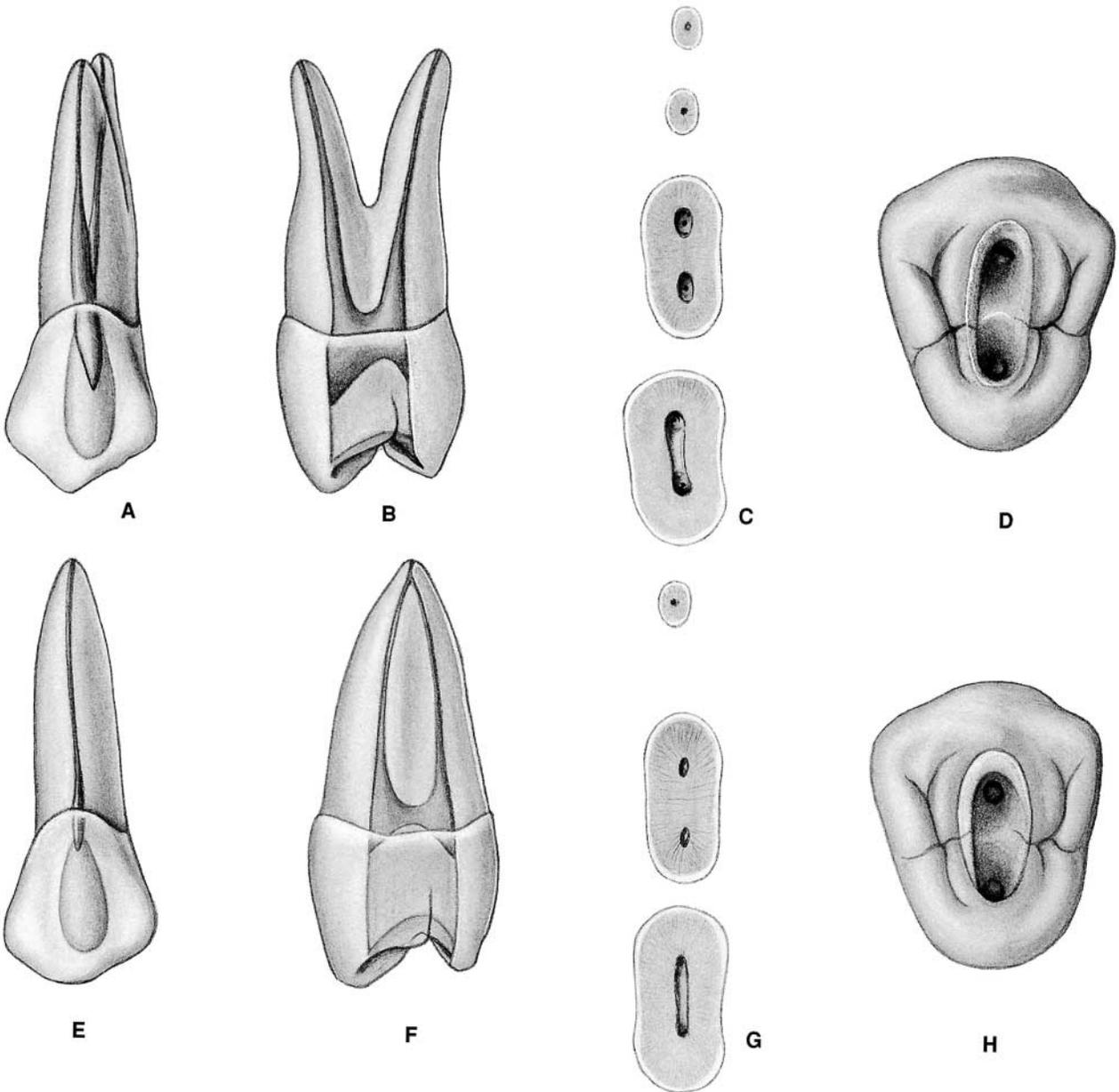
- A. **Buccal view of a recently calcified first premolar with a large pulp.**  
A radiograph, if exposed slightly from the mesial, will reveal
1. mesiodistal width of the pulp
  2. presence of two pulp canals
  3. apparently straight canals
  4. 10-degree distal-axial inclination of the tooth
- These factors, seen in the radiograph, are borne in mind when preparation is begun. One should always expect two and occasionally three canals.
- B. **Mesial view of the same tooth demonstrating details not apparent in the radiograph:**
1. height of the pulp horns
  2. broad buccolingual dimension of the pulp
  3. two widespread and separate roots, each with a single straight canal
  4. 6-degree buccal-axial angulation of the tooth
- These “unseen” factors will affect the size and shape of the final preparation. Pulp horns in the roof of the pulp chamber are not to be confused with true canal orifices in the cavity floor. Verticality of the tooth simplifies orientation and bur alignment.
- C. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level:** the pulp is enormous in a young tooth, very wide in the buccolingual direction. Débridement of the chamber is completed in coronal cavity preparation with a round bur. Canal orifices are found well to the buccal and lingual.
  2. **Midroot level:** the canals are only lightly ovoid and may be enlarged to a round, tapered cavity.
  3. **Apical third level:** the canals are round and are shaped into **round, tapered** preparations. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- D. **Ovoid coronal preparation** need not be as long buccolingually as the pulp chamber. However, the **outline form** must be large enough to provide two filling points at same time. Buccal and lingual walls smoothly flow to orifices.
- E. **Buccal view of an adult first premolar with extensive secondary dentin formation.** A radiograph will reveal
1. full pulp recession and thread-like appearance of the pulp
  2. **radiographic appearance** of only one canal
  3. 10-degree distal-axial inclination of the tooth
- Owing to misalignment of the bur, **perforation of the mesiocervical, at the point of mesial indentation, may occur.**
- F. **Mesial view of the same tooth demonstrating details not apparent in the radiograph:**
1. pulp recession and a greatly flattened pulp chamber
  2. buccolingual width revealing the pulp to be “ribbon shaped” rather than “thread-like”
  3. single root with **parallel canals and a single apical foramen**
  4. 6-degree buccal-axial angulation of the tooth
- The operator must recognize that
- a. small canal orifices are found well to the buccal and lingual and are difficult to locate.
  - b. the direction of each canal is determined only by exploration with a fine curved instrument.
  - c. a single apical foramen cannot be determined; therefore, two canals must be managed as two separate canals.
  - d. **virtually always** there will be two and occasionally three canals.
- G. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level:** the chamber is very narrow ovoid, and canal orifices are at the buccal and lingual termination of the floor.
  2. **Midroot level:** the canals are round.
  3. **Apical third level:** the canals are round.
- H. **Ovoid coronal preparation** must be more extensive in the buccolingual direction because of parallel canals. More extensive preparation allows instrumentation without interference.

PLATE 13

Maxillary First Premolars

				Curvature of Roots			
				Single Root	Double Roots		
					Buccal	Palatal	
<i>Length of tooth</i>		<i>Canals</i>		<i>Direction</i>			
Average Length	21.8 mm	One canal	9%	Straight	38%	28%	45%
Maximum Length	23.8 mm	One foramen		Distal Curve	37%	14%	14%
Minimum Length	18.8 mm	Two canals	13%	Mesial Curve	0%	0%	0%
Range	5 mm	One foramen		*Buccal Curve	15%	14%	28%
		Two canals	72%	*Lingual Curve	3%	36%	9%
		Two foramina		Bayonet Curve	0%	8%	0%
		Three canals	6%				
		Three foramina					

\*Not apparent in radiograph



## PLATE 14

### Maxillary Second Premolar

#### Pulp Anatomy and Coronal Preparation

- A. **Buccal** view of a recently calcified second premolar with a large pulp. A radiograph will reveal
1. narrow mesiodistal width of the pulp
  2. apical-distal curvature (34% of the time)
  3. 19-degree distal-axial inclination of the tooth
- These factors, **seen** in the radiograph, are borne in mind when preparation is begun.
- B. **Mesial** view of the same tooth demonstrating details **not apparent** in the radiograph:
1. broad buccolingual width revealing the pulp to be “ribbon shaped”
  2. single root with a large single canal
  3. 9-degree lingual-axial angulation of the tooth
- The pulp is shown to be a broad “ribbon” rather than a “thread” as it appears from radiograph. These “unseen” factors affect the **size, shape, and inclination** of the final preparation.
- C. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level:** the pulp is enormous in a young tooth, very wide in the buccolingual direction. Débridement of the chamber is completed during coronal cavity preparation with a round bur. The canal orifice is directly in the center of the tooth.
  2. **Midroot level:** the canal remains ovoid in shape and requires perimeter filing.
  3. **Apical third level:** the canal, round in shape, is filed and then shaped into a **round, tapered** preparation. Preparation terminates at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- D. Ovoid preparation allows débridement of the entire pulp chamber and funnels down to the ovoid midcanal.
- E. **Buccal** view of an **adult** second premolar with extensive secondary dentin formation. A radiograph, if exposed slightly from the mesial, will reveal
1. pulp recession and the “thread-like” appearance of the pulp
  2. roentgen appearance of two roots (2% of the time)
  3. bayonet curve of the roots (20% of the time)
  4. 19-degree distal-axial inclination of the tooth
- F. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph:**
1. buccolingual width revealing the coronal pulp to be “ribbon shaped” rather than “thread-like”
  2. high bifurcation and two separate apical third roots
  3. 9-degree lingual-axial angulation of the tooth
- The operator must recognize that
- a. small canal orifices are deeply placed in the root and will be difficult to locate.
  - b. the direction of each canal is determined by exploration with a **fine curved** file carried down the wall until the orifice is engaged. Then, by half-rotation, the file is turned to match the first curve of the canal, followed by penetration until the tip again catches on the curved wall. A second half-turn and further penetration will carry the tip of the instrument to within 0.5 to 1.0 mm of the radiographic apex. Retraction will remove dentin at both curves.
- G. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level:** the chamber, very narrow ovoid, extends deeply into the root.
  2. **Midroot level:** the bayonet curve and round canal orifices are apparent.
  3. **Apical third level:** the canals are round. The severe curve at the “bayonet” is reduced by filing action into a gradual curve.
- H. An ovoid coronal cavity is prepared **well to the mesial** of the occlusal surface, with a depth of penetration **skewed toward the bayonet curvature**. **Skewing the cavity** allows an unrestrained approach to the first curve.

PLATE 14

Maxillary Second Premolars

Length of tooth

Average Length	21 mm
Maximum Length	23 mm
Minimum Length	19 mm
Range	4 mm

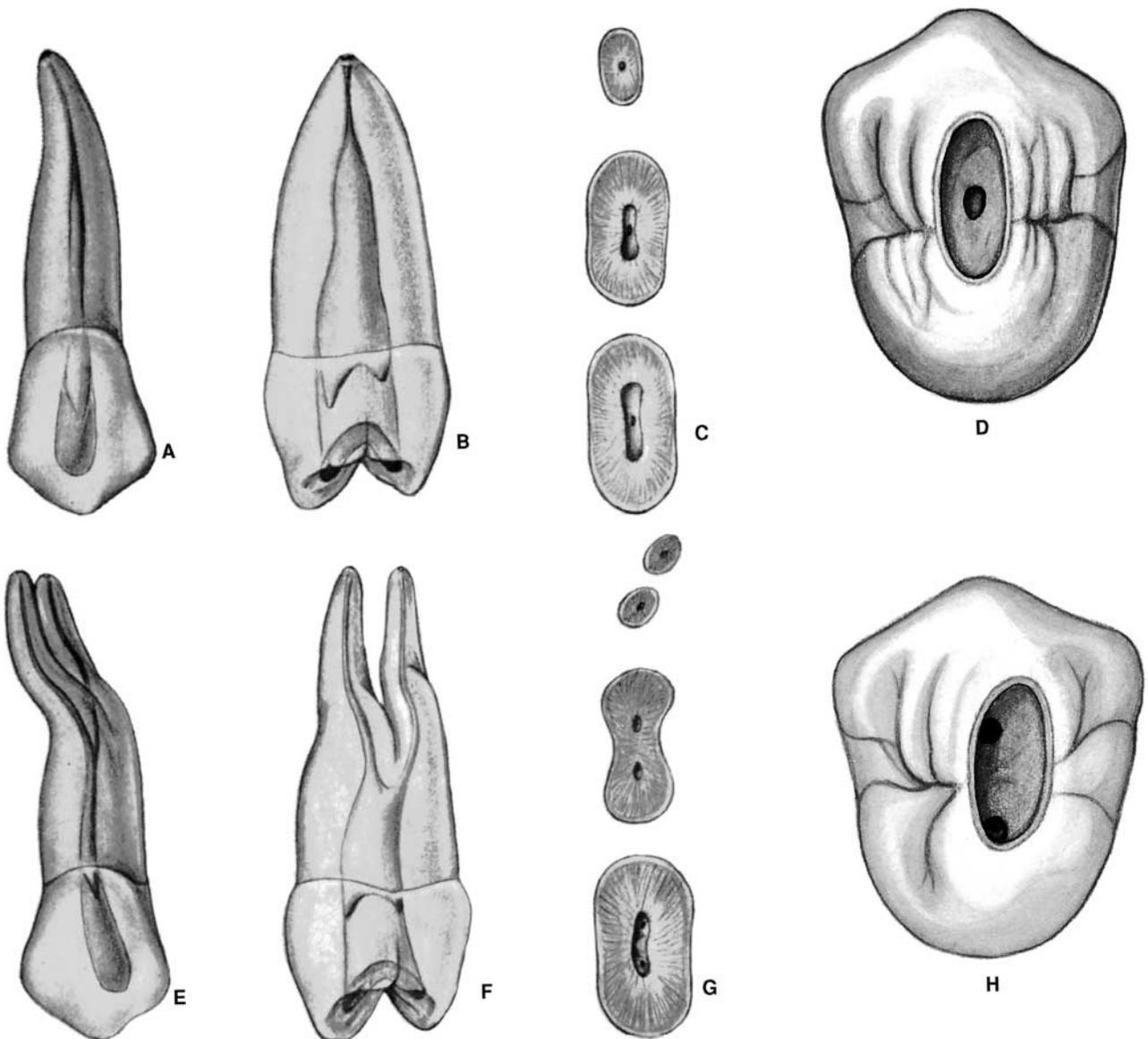
Canals

One canal	75%
One foramen	
Two canals	24%
Two foramina	
Three canals	1%

Curvature

Straight	9.5%
Distal Curve	27.0%
Mesial Curve	1.6%
Buccal Curve	12.7%
*Lingual Curve	4.0%
Bayonet Curve	20.6%

\*Not apparent in radiograph

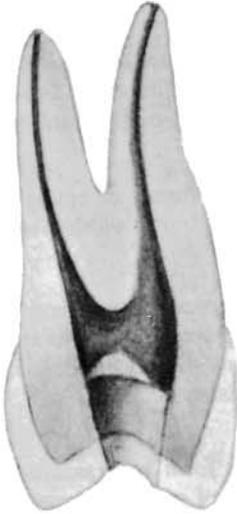
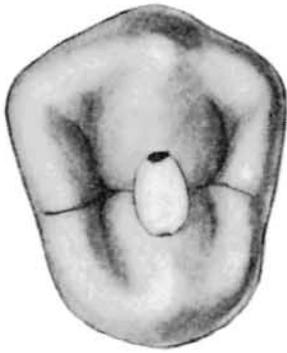


## PLATE 15

### Maxillary Premolar Teeth ERRORS in Cavity Preparation

- A. UNDEREXTENDED preparation exposing only pulp horns. Control of enlarging instruments is abdicated to cavity walls. The **white color** of the **roof of the chamber** is a clue to a shallow cavity.
- B. OVEREXTENDED preparation from a fruitless search for a receded pulp. The enamel walls have been completely undermined. Gouging relates to failure to refer to the radiograph, which clearly indicates pulp recession.
- C. PERFORATION at the mesiocervical indentation. Failure to observe the distal-axial inclination of the tooth led to **bypassing** receded pulp and perforation. The maxillary first premolar is one of the most commonly perforated teeth.
- D. FAULTY ALIGNMENT of the access cavity through **full veneer restoration** placed to “straighten” the crown of a rotated tooth. Careful examination of the radiograph would reveal the rotated body of the tooth.
- E. BROKEN INSTRUMENT twisted off in a “cross-over” canal. This frequent occurrence may be obviated by extending the internal preparation to straighten the canals (**dotted line**).
- F. FAILURE to explore, débride, and obturate the third canal of the maxillary **first** premolar (6% of the time).
- G. FAILURE to explore, débride, and obturate the second canal of the maxillary **second** premolar (24% of the time).

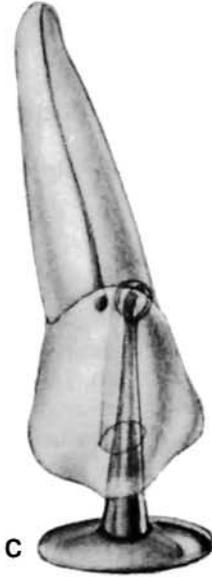
PLATE 15



A



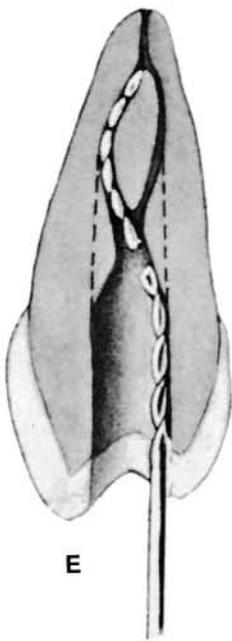
B



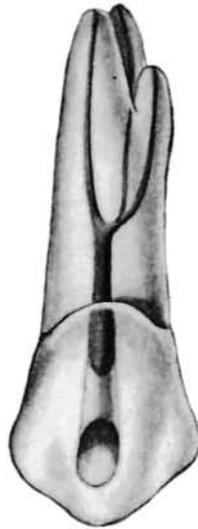
C



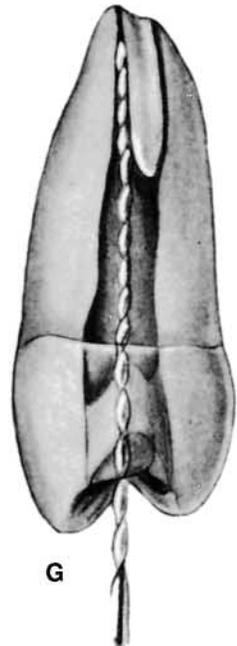
D



E



F



G

## PLATE 16

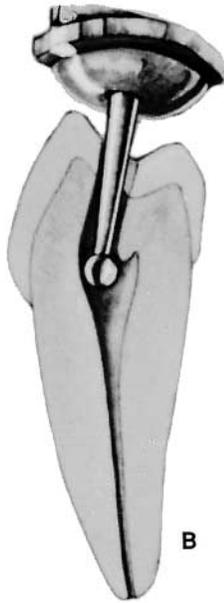
### Endodontic Preparation of Mandibular Premolar Teeth Pulp Anatomy and Coronal Preparation

- A. Entrance is **always** gained through the occlusal surface of **all** posterior teeth. Initial penetration is made in the exact center of the central groove of mandibular premolars. The bur is directed parallel to the long axis of the tooth. The 702 U taper fissure bur in an **accelerated-speed** contra-angle handpiece is ideal for perforating gold casting or virgin enamel surface **to the depth of the dentin**. Amalgam fillings are penetrated with a round bur in a high-speed contra-angle handpiece.
- B. A regular-length No. 4 round bur is used to open vertically into the pulp chamber. The bur will be felt to “drop” when the pulp chamber is reached. If the chamber is **well calcified**, initial penetration is continued until the contra-angle handpiece rests against the occlusal surface. This depth of 9 mm is the usual position of the canal orifice that lies at the cervical level. In removing the bur, the occlusal opening is widened buccolingually to twice the width of the bur to allow room for exploration.
- C. An endodontic explorer is used to locate the central canal. Tension of the explorer against the walls of preparation will indicate the amount and direction of extension necessary.
- D. **Working from inside the pulp chamber to outside**, a regular-length No. 2 or 4 round bur is used to extend the cavity buccolingually by removing the roof of the pulp chamber.
- E. Buccolingual extension and finish of cavity walls are completed with a 702 U fissure bur at accelerated speed.
- F. Final ovoid preparation is a tapered funnel from the occlusal to the canal, providing **unobstructed access** to the canal. No overhanging tooth structure should impede complete authority over enlarging instruments.
- G. Buccolingual ovoid **outline form** reflects the anatomy of the pulp chamber and position of the centrally located canal. The cavity is extensive enough to allow for instruments and filling the materials needed to enlarge and fill canals. **Further exploration** at this time **may reveal** the orifice to an **additional canal**, especially a **second canal** in the **first premolar**. The outline form of the final preparation will be identical for both newly erupted and “adult” teeth.

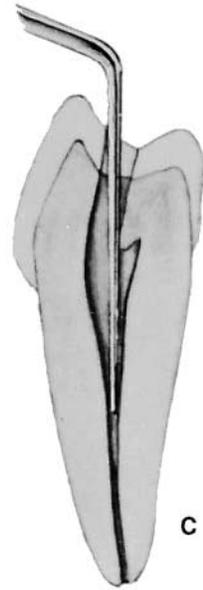
PLATE 16



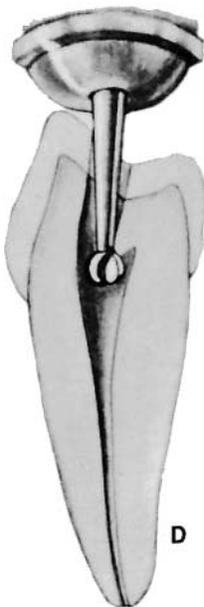
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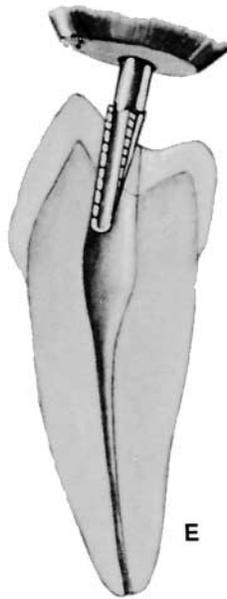
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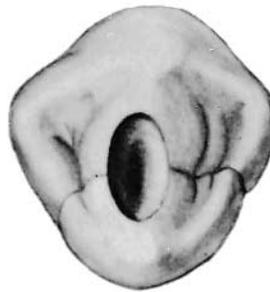
C



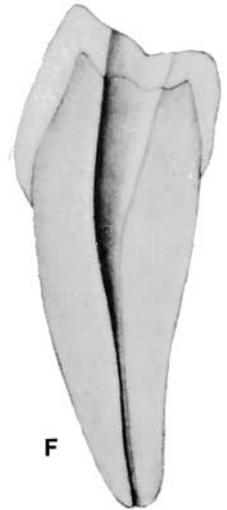
D



E



G



F

## PLATE 17

### Mandibular First Premolar

#### Pulp Anatomy and Coronal Preparation

- A. **Buccal** view of a recently calcified first premolar with a large pulp. A radiograph, if exposed slightly from the mesial, will reveal:
1. narrow mesiodistal width of the pulp
  2. presence of one pulp canal
  3. relatively straight canal
  4. 14-degree distal-axial inclination of the root
- All of these factors, **seen** in radiograph, are borne in mind when preparation is begun.
- B. **Mesial** view of the same tooth demonstrating details not apparent from the radiograph:
1. height of the pulp horn
  2. broad buccolingual extent of the pulp
  3. apical-buccal curvature (2% of the time)
  4. 10-degree lingual-axial angulation of the root
- These “unseen” factors will affect the **size, shape, and inclination** of the final preparation. Severe apical curvature can be detected only by exploration with a fine curved file. Near-verticality of the tooth simplifies orientation and bur alignment.
- C. Cross-sections at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical** level: the pulp is enormous in a young tooth, very wide in the buccolingual dimension. Débridement of the ovoid chamber is completed during coronal cavity preparation with a round bur.
  2. **Midroot** level: the canal continues ovoid and requires perimeter filing.
  3. **Apical third** level: the canal, generally round in shape, is enlarged by shaping into a **round, tapered** preparation. Preparation terminates at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- D. **Ovoid** coronal preparation allows débridement of the entire pulp chamber, funnels down to the ovoid midcanal, and is large enough buccolingually to allow passage of instruments used to enlarge and fill the canal space.
- E. **Buccal** view of an **adult** first premolar with extensive secondary dentin formation. A radiograph will reveal
1. pulp recession and “thread-like” appearance of the pulp
  2. radiographic appearance of only one canal
  3. 14-degree distal-axial inclination of the root
- F. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. buccolingual “ribbon-shaped” coronal pulp
  2. single-root, bifurcated canal at the midroot level and a single apical foramen
  3. 10-degree lingual-axial angulation of the root
- The operator must recognize that
- a. small orifices are difficult to locate.
  - b. the presence of a bifurcated canal is determined only by exploration with a fine curved file.
  - c. a single apical foramen can be determined by placing instruments in both canals at the same time. The instruments will be heard and felt to grate against each other.
- G. Cross-sections at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical** level: the chamber is very narrow ovoid.
  2. **Midroot** level: the two branches of the canal are round.
  3. **Apical third** level: the canal is round. Divisions of the canal are enlarged by filing. The buccal canal would be filled to the apex and the lingual canal to the point where the canals rejoin.
- H. **Ovoid** funnel-shaped coronal preparation must be extensive enough buccolingually to allow for enlarging and filling both canals.

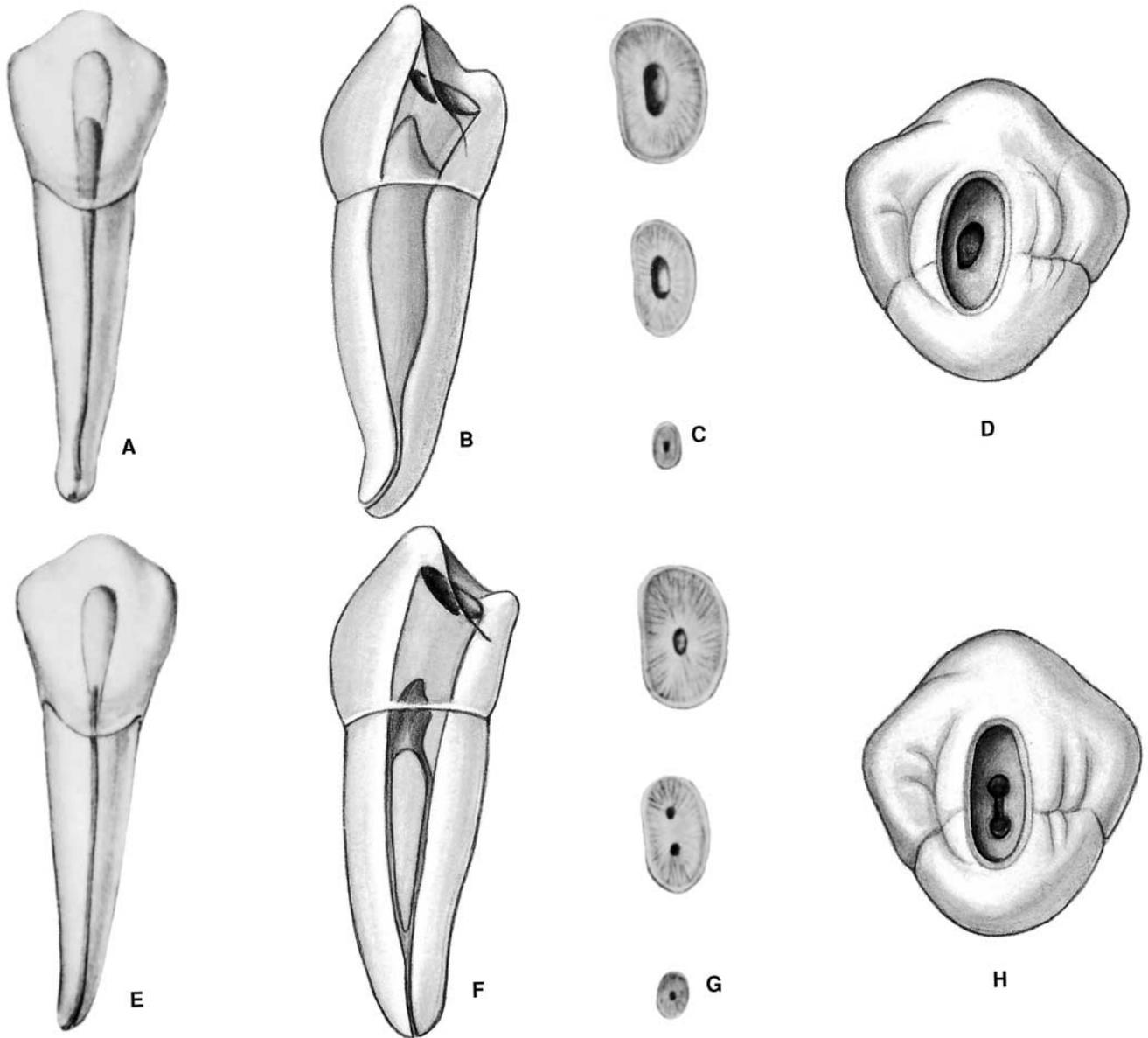
PLATE 17

*Mandibular First Premolar*

<i>Length of tooth</i>		<i>Canals</i>		<i>Curvature of root</i>			
Average Length	22.1 mm	One canal	73.5%	Straight	48%	†Buccal Curve	2%
Maximum Length	24.1 mm	One foramen		Distal Curve	35%	†Lingual Curve	7%
Minimum Length	20.1 mm	Two canals*	6.5%	Mesial Curve	0%	Bayonet Curve	7%
Range	4.0 mm	One foramen					
		Two canals*	19.5%				
		Two foramina					
		Three canals	0.5%				

\*Incidence higher in black persons than in white persons

†Not apparent in radiograph



## PLATE 18

### Mandibular Second Premolar

#### Pulp Anatomy and Coronal Preparation

- A. **Buccal** view of a recently calcified second premolar with a large pulp. A radiograph will reveal
1. mesiodistal width of the pulp
  2. apical-distal curvature (40% of the time)
  3. 10-degree distal-axial inclination of the root
- These factors, **seen** in the radiograph, are borne in mind when preparation is begun.
- B. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. broad buccolingual “ribbon-shaped” coronal pulp
  2. single root with pulpal bifurcation in the apical third
  3. 34-degree buccal-axial angulation of the root
- These “unseen” factors affect the **size, shape, and inclination** of the final preparation. Apical third bifurcation, **unseen in the radiograph**, emphasizes the necessity of careful canal exploration.
- C. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level**: the pulp is large in a young tooth, very wide in the buccolingual dimension. Débridement of the chamber is completed during coronal cavity preparation with a round bur.
  2. **Midroot level**: the canal continues to be long ovoid and requires perimeter filing.
  3. **Apical third level**: the canals, generally round, are shaped into **round, tapered** preparations. Preparation terminates at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- D. **Ovoid**, coronal funnel-shaped preparation allows débridement of the entire pulp chamber down to the ovoid midcanal. The cavity is large enough buccolingually to allow enlarging and filling of both canals.
- E. **Buccal** view of an **adult** second premolar with extensive secondary dentin formation. A radiograph, if exposed slightly from the mesial, will reveal
1. pulp recession and “thread-like” appearance of the pulp
  2. sweeping distal curve of the apical third of the root of the tooth (40% of the time)
  3. 10-degree distal-axial angulation of the root
- F. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. buccolingual “ribbon-shaped” pulp
  2. minus 34-degree buccal-axial angulation of the root
- The operator should recognize that
- a. a small canal orifice will be difficult to locate.
  - b. the direction of the canal is best explored with a fine curved file that is carried to within 0.5 to 1.0 mm of the radiographic apex. Retraction will then remove dentin at the curve.
- G. Cross-sections at three levels: 1, cervical; 2, mid-root; and 3, apical third:
1. **Cervical level**: the chamber is very narrow ovoid.
  2. **Midroot level**: the canal is less ovoid.
  3. **Apical third level**: the canal is round.
- The sweeping curve at the apical third is filed to a gradual curve.
- H. **Ovoid** funnel-shaped coronal cavity is modest in size and skewed slightly to the mesial, allowing adequate room to instrument and fill the curved apical third.

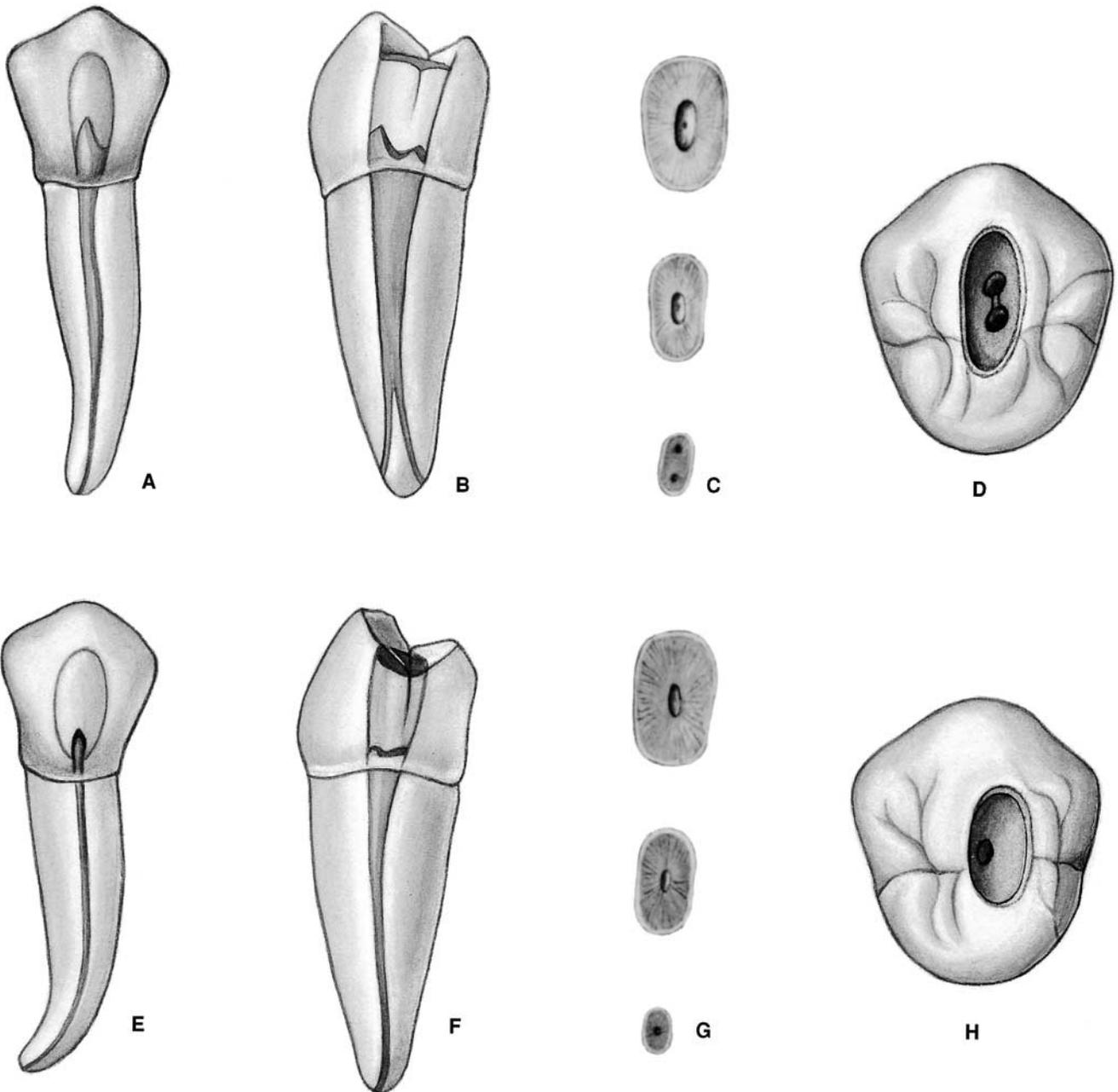
PLATE 18

Mandibular Second Premolars

Length of tooth		Canals		Curvature of root			
Average Length	21.4 mm	One canal	85.5%	Straight	39%	†Lingual Curve	3%
Maximum Length	23.7 mm	One foramen		Distal Curve	40%	Bayonet Curve	7%
Minimum Length	19.1 mm	Two canals*	1.5%	Mesial Curve	0%	Trifurcation Curve	1%
Range	4.6 mm	One foramen		†Buccal Curve	10%		
		Two canals*	11.5%				
		Two foramina					
		Three canals	0.5%				

\*Incidence much higher in black persons than in white persons

†Not apparent in radiograph

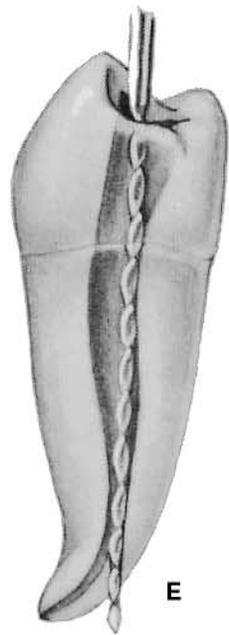
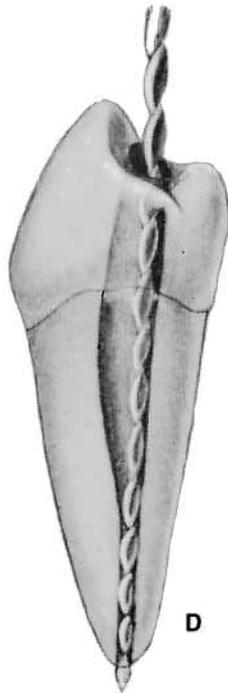
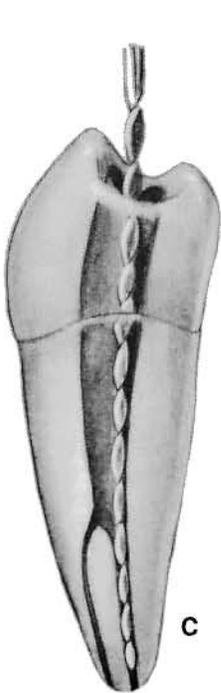
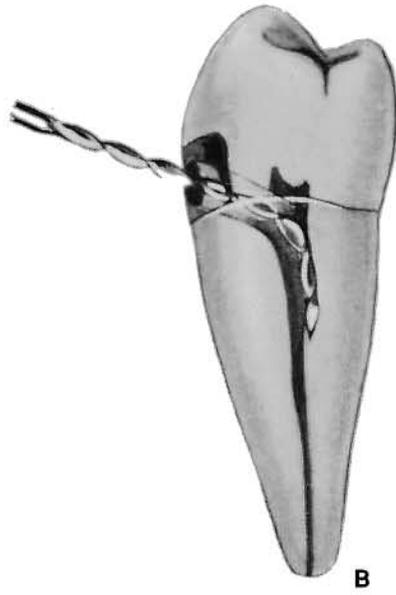
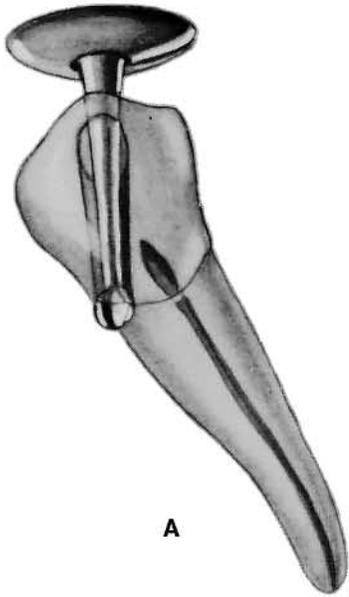


## PLATE 19

### Mandibular Premolar Teeth ERRORS in Cavity Preparation

- A. PERFORATION at the distogingival caused by failure to recognize that the premolar has tilted to the distal.
- B. INCOMPLETE preparation and possible instrument breakage caused by total loss of instrument control. Use only occlusal access, never buccal or proximal access.
- C. BIFURCATION of a canal completely missed, caused by failure to adequately explore the canal with a curved instrument.
- D. APICAL PERFORATION of an invitingly straight conical canal. Failure to establish the exact length of the tooth leads to trephination of the foramen.
- E. PERFORATION at the apical curvature caused by failure to recognize, by exploration, buccal curvature. A standard buccolingual radiograph will not show buccal or lingual curvature.

PLATE 19

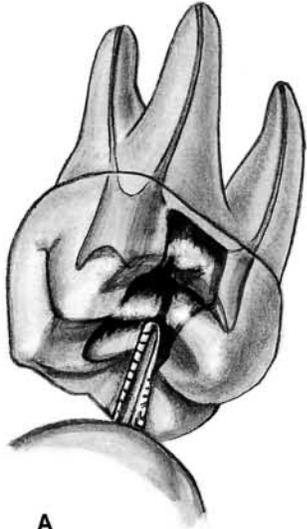


## PLATE 20

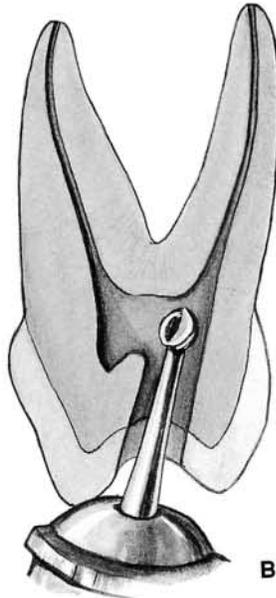
### Endodontic Preparation of Maxillary Molar Teeth

- A. Entrance is **always** gained through the occlusal surface of all posterior teeth. Initial penetration is made in the exact center of the mesial pit, with the bur directed toward the lingual. The 702 U tapering fissure bur in an **accelerated-speed** contra-angle handpiece is ideal for perforating gold casting or virgin enamel surface **to the depth of dentin**. Amalgam fillings are penetrated with a No. 4 or 6 round bur operating in a slow-speed contra-angle handpiece.
- B. According to the size of the chamber, a **regular-length** No. 4 round bur is used to open into the pulp chamber. The bur should be **directed toward the orifice of the palatal canal or toward the mesiobuccal canal orifice**, where the greatest space in the chamber exists. It will be felt to “drop” when the pulp chamber is reached. If the chamber is **well calcified**, initial penetration is continued until the contra-angle rests against the occlusal surface. This depth of 9 mm is the usual position of the floor of the pulp chamber, which lies at the cervical level. Working from inside out, back toward the buccal, the bur removes enough roof of the pulp chamber for exploration.
- C. An endodontic explorer is used to locate orifices of the **palatal, mesiobuccal, and distobuccal** canals. Tension of the explorer against the walls of preparation will indicate the amount and direction of extension necessary. **Orifices of canals form the perimeter** of preparation. **Special care must be taken to explore for a second canal in the mesiobuccal root.**
- D. Again, working at slow speed from inside to outside, a round bur is used to remove the roof of the pulp chamber. Internal walls and floor of preparation should not be cut into unless difficulty is encountered in locating orifices. In that case, **surgical-length** No. 2 round burs are necessary to explore the floor of the chamber.
- E. Final finish and funneling of cavity walls are completed with a 702 U fissure bur or tapered diamond points at accelerated speed.
- F. Final preparation provides unobstructed access to canal orifices and should not impede complete authority of enlarging instruments. Improve ease of access by **“leaning” the entire preparation toward the buccal**, for all instrumentation is introduced from the buccal. Notice that the preparation extends almost to the height of the buccal cusps. The walls are perfectly smooth, and the orifices are located **at the exact pulpal-axial angles** of the cavity floor.
- G. Extended outline form reflects the anatomy of the pulp chamber. The base is toward the buccal and the apex is to the lingual, with the canal orifice positioned at each angle of the triangle. The cavity is entirely within the mesial half of the tooth and need not invade the transverse ridge but is extensive enough, buccal to lingual, to allow positioning of instruments and filling materials. Outline form of final preparation is identical for both a newly erupted and an “adult” tooth. **Note the orifice to the fourth canal.**

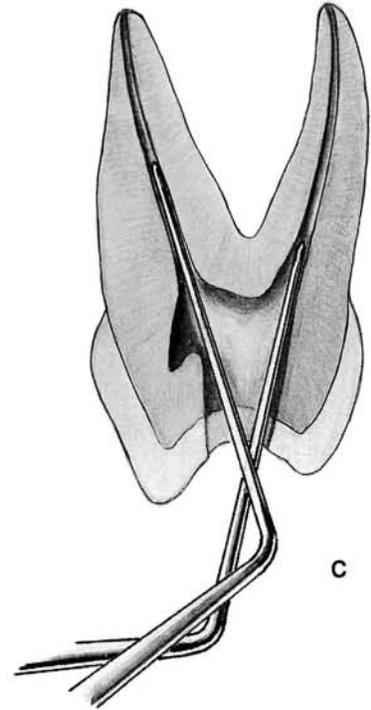
PLATE 20



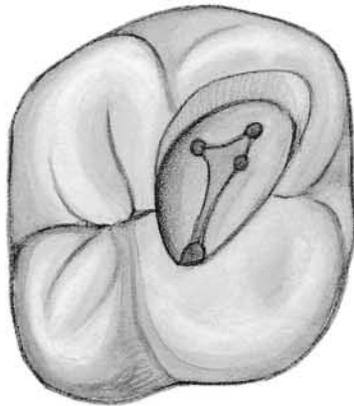
A



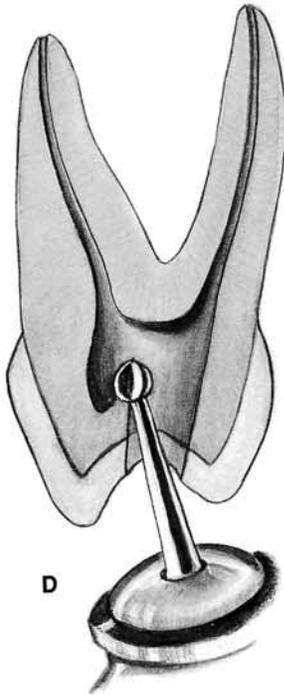
B



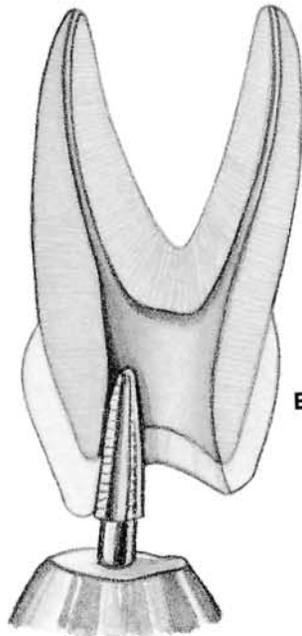
C



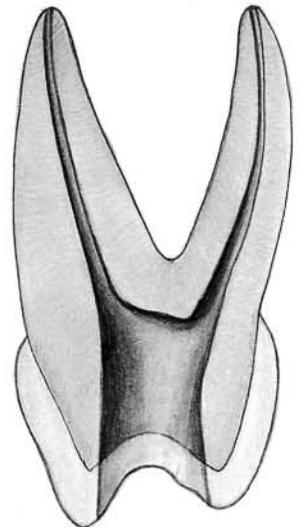
G



D



E



F

## PLATE 21

### Maxillary First Molar

#### Pulp Anatomy and Coronal Preparation

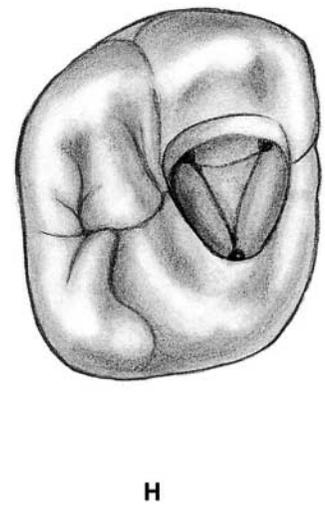
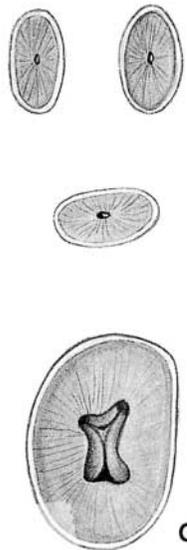
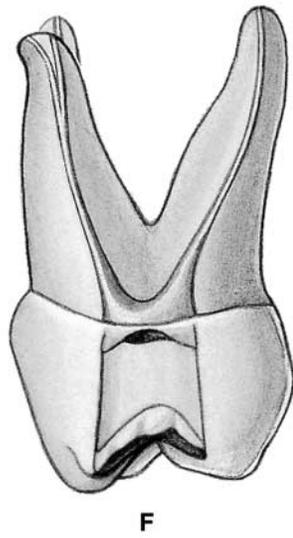
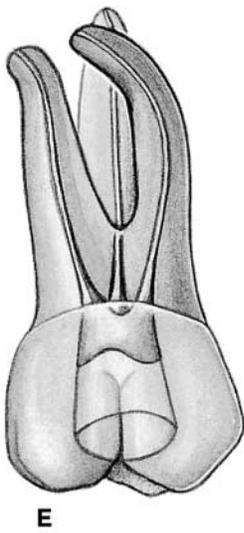
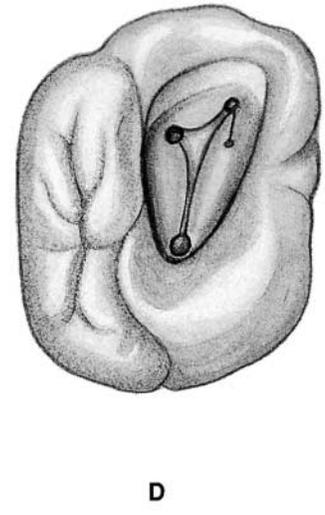
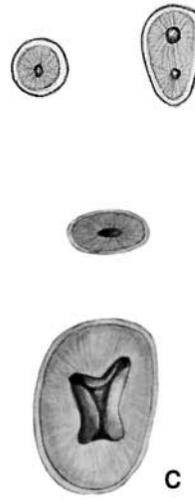
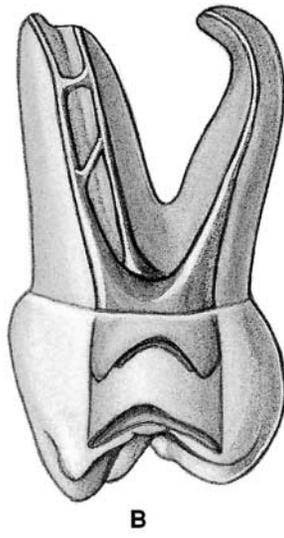
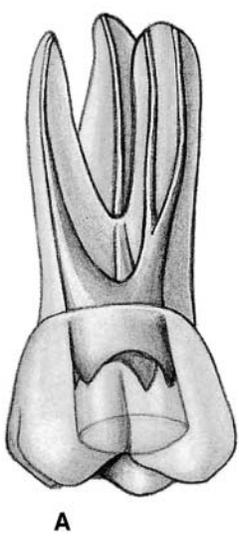
- A. **Buccal** view of a recently calcified first molar with large pulp. A radiograph will reveal
1. large pulp chamber
  2. mesiobuccal root with two separate canals, distobuccal, and palatal roots, each with one canal
  3. slightly curved buccal roots
  4. slightly curved palatal root
  5. vertical axial alignment of the **tooth**
- These factors, **seen** in radiograph, are borne in mind when preparation is begun. Care must be taken to explore for an additional mesiobuccal canal.
- B. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. buccolingual width of the pulp chamber
  2. apical-buccal curvature of the palatal root (55% of the time)
  3. buccal inclination of buccal roots
  4. vertical axial alignment of the **tooth**
- These “unseen” factors will affect the **size, shape, and inclination** of the final preparation. Sharp **buccal curvature** of the **palatal canal requires great care** in exploration and instrumentation. Canals must be carefully explored with **fine curved files**. Enlargement of buccal canals is accomplished by reaming and filing and of the palatal canal by step-back filing.
- C. Cross-section at two levels: 1, cervical; and 2, apical third:
1. **Cervical level**: the pulp is enormous in a young tooth. Débridement of a **triangular** chamber is completed with a round bur. A **dark** cavity floor with “**lines**” connecting orifices is in marked contrast to white walls. A palatal canal requires perimeter filing.
  2. **Apical third level**: the canals are essentially round. Buccal canals are shaped into **round, tapered** preparations. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- D. **Triangular outline form**, with the base toward the buccal and the apex toward the lingual, reflects the anatomy of the pulp chamber, with the orifice positioned at each angle of the triangle. Both **buccal and lingual walls slope buccally**. Mesial and distal walls **funnel** slightly **outward**. The cavity is entirely within the mesial half of the tooth and should be extensive enough to allow positioning of instruments and filling materials needed to enlarge and fill canals. The orifice to an **extra middle mesial canal** may be found in the groove near the mesiobuccal canal.
- E. **Buccal** view of an **adult** first molar with extensive secondary dentin formation. A radiograph will reveal
1. pulp recession and “thread-like” pulp
  2. mesiobuccal, distobuccal, and palatal roots, each with one canal
  3. straight palatal root, apical curve, distal root
  4. apical-distal curvature of the mesial root (78% of the time)
  5. vertical axial alignment of the **tooth**
- F. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. pulp recession
  2. relatively straight palatal root
  3. buccal inclination of the buccal roots
  4. vertical axial alignment of the **tooth**
- The operator must recognize that
- a. careful exploration for orifices and canals is imperative.
  - b. severe curvature of buccal roots will require careful enlargement with curved instruments.
- G. Cross-section at two levels: 1, cervical; and 2, apical third:
1. **Cervical level**: a triangular chamber constricted from secondary dentin formation is débrided during coronal cavity preparation with a round bur. Round palatal and distobuccal canals will be shaped to a **round, tapered** preparation.
  2. **Apical third level**: the canals are round. A curved mesiobuccal canal is enlarged by step-back filing. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- H. **Triangular outline form** reflects the anatomy of the pulp chamber. Both **buccal and lingual walls slope buccally**. The **mesial wall slopes mesially** to allow for instrumentation of a severely curved mesiobuccal canal. If an **additional canal** is found in the mesiobuccal root, its orifice will usually be in the groove leading to the palatal canal.

PLATE 21

Maxillary First Molars

Length of Tooth	Mesiobuccal	Distobuccal	Palatal	Canal		Curvature of roots			Canals in the mesiobuccal root		
						Direction	Palatal	Mesial			Distal
Average Length	19.9 mm	19.4 mm	20.6 mm	Three canals	41.1%	Straight	40%	21%	54%	One canal	41.1%
Maximum Length	21.6 mm	21.2 mm	22.5 mm	Four canals	56.5%	Distal Curve	1%	78%	17%	One foramen	
Minimum Length	18.2 mm	17.6 mm	17.6 mm	Five canals	2.4%	Mesial Curve	4%	0%	19%	Two canals	40%
Range	3.4 mm	3.6 mm	3.8 mm			*Buccal Curve	*55%	0%	0%	One foramen	
						*Lingual Curve	0%	0%	0%	Two canals	18.9%
						Bayonet Curve	0%	1%	10%	Two foramina	

\*Not apparent in radiograph



## PLATE 22

### Maxillary Second Molar

#### Pulp Anatomy and Coronal Preparation

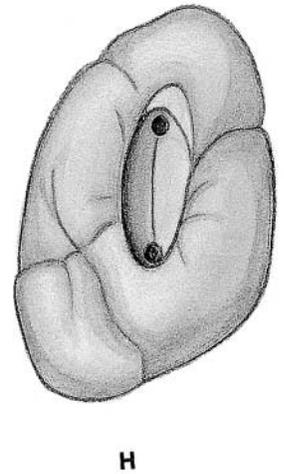
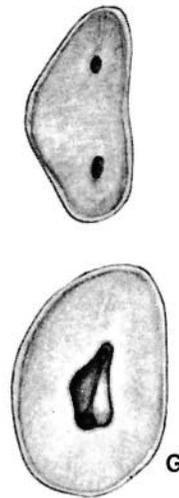
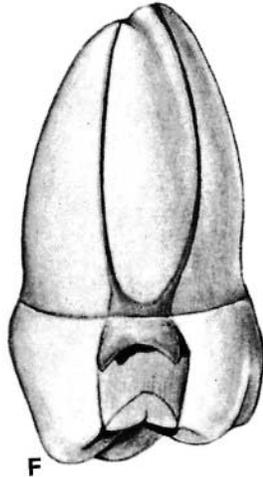
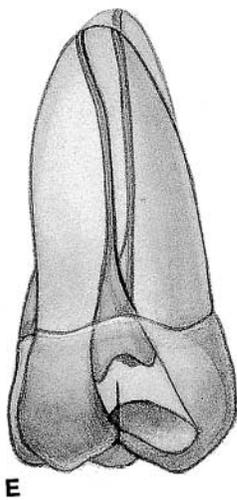
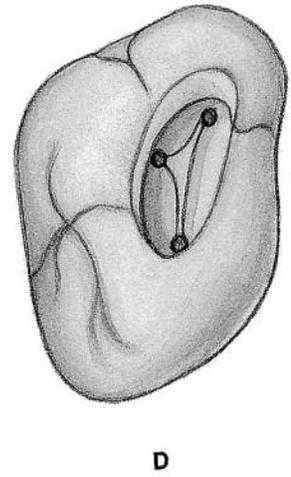
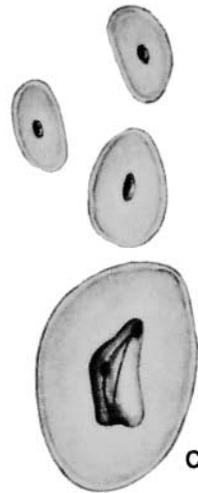
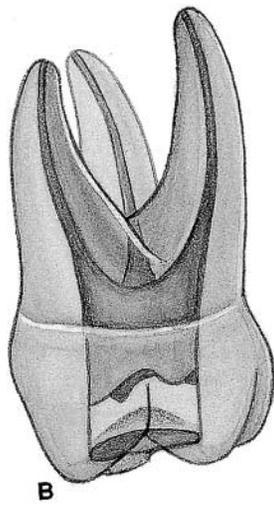
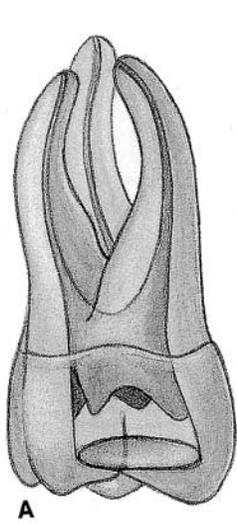
- A. **Buccal** view of a recently calcified second molar with a large pulp. A radiograph will reveal
1. large pulp chamber
  2. mesiobuccal, distobuccal, and palatal roots, each with one canal
  3. gradual curvature of all three canals
  4. vertical axial alignment of the **tooth**
- These factors, **seen** in radiograph, are borne in mind when preparation is begun.
- B. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. buccolingual width of the pulp chamber
  2. gradual curvature in two directions of all three canals
  3. buccal inclination of the buccal roots
  4. vertical axial alignment of the **tooth**
- These “unseen” factors will affect the **size, shape, and inclination** of the final preparation.
- C. Cross-section at two levels: 1, cervical; and 2, apical third:
1. **Cervical level**: the pulp is enormous in a young tooth. Débridement of a **triangular** chamber is completed with round burs. The **dark** cavity floor with “**lines**” connecting orifices is in marked contrast to white walls.
  2. **Apical third level**: the canals are essentially round and are shaped into a **round, tapered** preparation. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 from the radiographic apex.
- D. **Triangular outline form** is “flattened” as it reflects the internal anatomy of the chamber. Note that the distobuccal canal orifice is nearer the center of the cavity floor. The entire preparation sharply slopes to the buccal and is extensive enough to allow positioning of instruments and filling materials needed to enlarge and fill canals.
- E. **Buccal** view of an adult second molar with extensive secondary dentin formation. A radiograph will reveal
1. pulp recession and “thread-like” pulp
  2. **anomalous** appearance of only **one root and two canals**
  3. vertical axial alignment of the **tooth**
- F. **Mesial** view of the same tooth demonstrating details **not apparent in the radiograph**:
1. pulp recession
  2. **anomalous** appearance of only **one root and two canals**
  3. sweeping curvature of the lingual canal
  4. vertical axial alignment of the **tooth**
- The operator must recognize that
- a. canal orifices are difficult to find by exploration.
  - b. a **detailed search must be made for the third canal.**
- G. Cross-sections at two levels: 1, cervical; and 2, apical third.
1. **Cervical level**: **ovoid** pulp chamber is débrided during cavity preparation with a round bur.
  2. **Apical third level**: canals are round. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.
- H. **Ovoid** outline form reflects the internal anatomy of the pulp chamber and elongated parallelogram shape of the occlusal surface. The entire preparation slopes sharply to the buccal.

PLATE 22

Maxillary Second Molars

Length of Tooth	Mesiobuccal	Distobuccal	Palatal	Number of Roots	Curvature of roots			Canals in the mesiobuccal root			
					Direction	Palatal	Mesial			Distal	
Average Length	20.2 mm	19.4 mm	20.8 mm	Three	54%	Straight	63%	22%	54%	One canal	63%
Maximum Length	22.2 mm	21.3 mm	22.6 mm	Fused	46%	Distal	0%	54%	?	One foramen	
Minimum Length	18.2 mm	17.5 mm	19.0 mm			Mesial	0%	0%	17%	Two canals	13%
Range	4.0 mm	3.8 mm	3.6 mm			*Buccal	37%			One foramen	
						Lingual	0%			Two canals	24%
										Two foramina	

\*Not apparent in radiograph

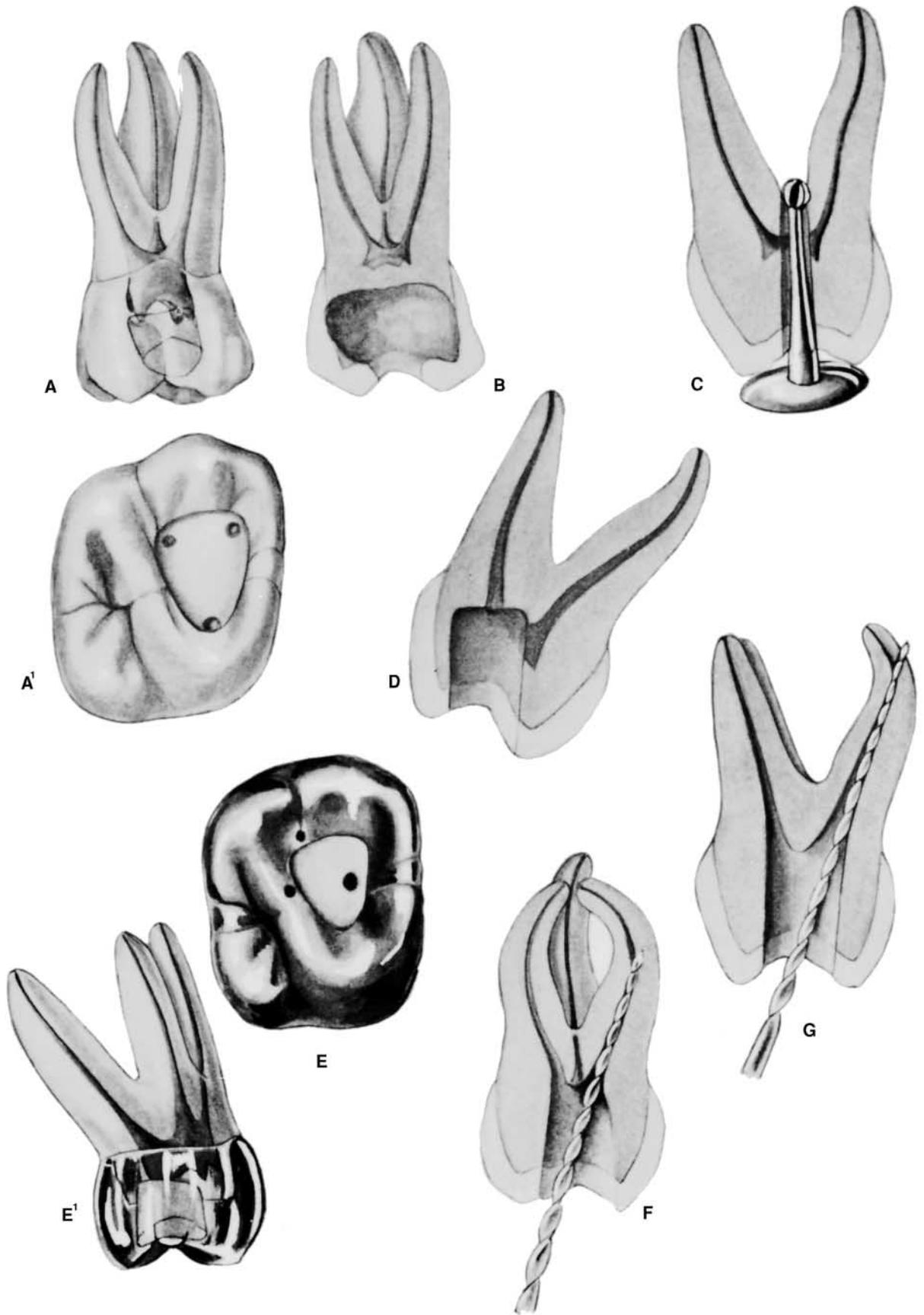


## PLATE 23

### Maxillary Molar Teeth ERRORS in Cavity Preparation

- A. UNDEREXTENDED preparation. Pulp horns have merely been “nicked,” and the entire roof of the pulp chamber remains. “White” color dentin of the roof is a clue to underextension (A<sup>1</sup>). Instrument control is lost.
- B. OVEREXTENDED preparation undermining enamel walls. The crown is badly gouged owing to failure to observe pulp recession in the radiograph.
- C. PERFORATION into furca using a **surgical-length** bur and failing to realize that the narrow pulp chamber had been passed. Operator error in failure to compare the length of the bur to the depth of the pulp canal floor. Length should be marked on the bur shank with Dycal.
- D. INADEQUATE vertical preparation related to failure to recognize severe buccal inclination of an unopposed molar.
- E. DISORIENTED occlusal outline form exposing only the palatal canal. A faulty cavity has been prepared in full crown, which was placed to “straighten” a **rotated molar** (E<sup>1</sup>). Palpating for mesiobuccal root prominence would reveal the severity of the rotation.
- F. LEDGE FORMATION caused by using a large straight instrument in a curved canal.
- G. PERFORATION of a palatal root commonly caused by assuming the canal to be straight and failing to explore and enlarge the canal with a fine curved instrument.

PLATE 23

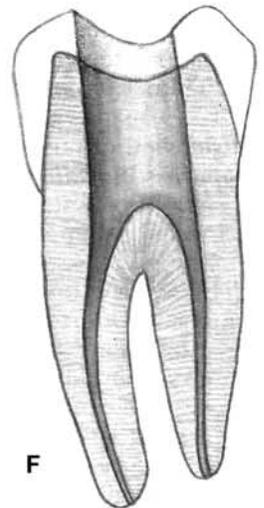
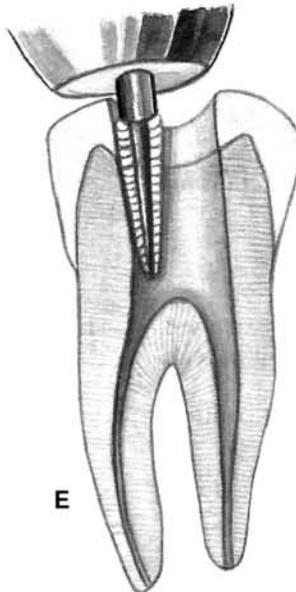
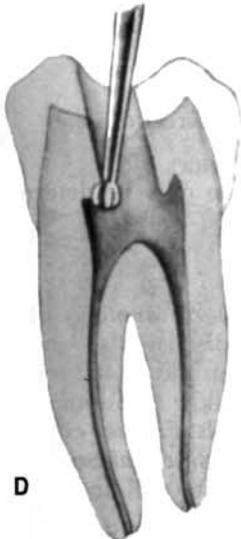
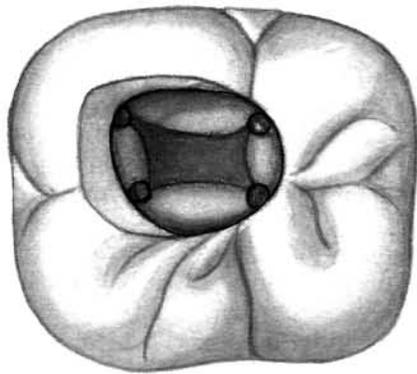
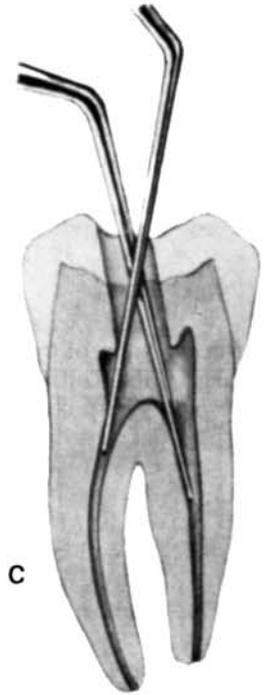
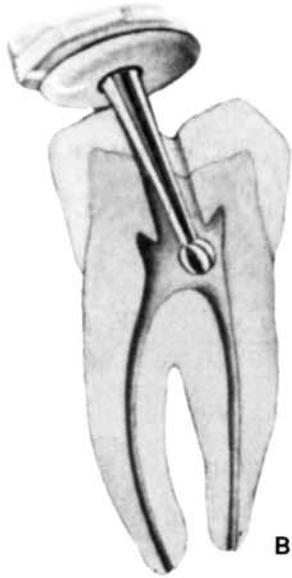


## PLATE 24

### Endodontic Preparation of Mandibular Molar Teeth

- A. Entrance is **always** gained through the occlusal surface of **all** posterior teeth. Initial penetration is made in the exact center of the mesial pit, with the bur directed toward the distal. The 702 U tapering fissure bur in an **accelerated-speed** contra-angle handpiece is ideal for perforating gold casting or virgin enamel surface to the **depth of dentin**. Amalgam fillings are penetrated with a No. 4 round bur operating in a high-speed contra-angle handpiece.
- B. According to the size of the chamber, a regular-length No. 4 or 6 round bur is used to open into the pulp chamber. The bur should be **directed toward the orifice** of the **mesiobuccal or distal canal**, where the greatest space in the chamber exists. It will be felt to “drop” when the pulp chamber is reached. If the chamber is well calcified, initial penetration is continued until the contra-angle handpiece rests against the occlusal surface. This depth of 9 mm is the usual position of the floor of the pulp chamber, which lies at the cervical level. Working from inside out, back toward the mesial, the bur removes enough roof of the pulp chamber for exploration.
- C. An endodontic explorer is used to locate orifices of the **distal, mesiobuccal, and mesiolingual** canals. Tension of the explorer against the walls of preparation indicates the amount and direction of extension necessary. **Orifices of the canals form the perimeter** of preparation. **Special care must be taken to explore for an additional canal in the distal root.** The distal canal should form a triangle with two mesial canals. If it is asymmetric, always look for the fourth canal 29% of the time.
- D. Again, working at slow speed from the inside to outside, a round bur is used to remove the roof of the pulp chamber. Internal walls and floor of preparation should not be cut into unless difficulty is encountered in locating orifices. In that case, **surgical-length** No. 2 or 4 round burs are necessary to explore the floor of the chamber.
- E. Final finish and funneling of cavity walls are completed with a 702 U fissure bur or diamond point at accelerated speed.
- F. Final preparation provides unobstructed access to canal orifices and should not impede the complete authority of enlarging instruments. Improve ease of access by **“leaning” the entire preparation toward the mesial**, for all instrumentation is introduced from the mesial. Notice that the cavity outline extends to the height of the mesial cusps. The walls are perfectly smooth and the orifices located **at the exact pulpal-axial angle** of the cavity floor.
- G. “Square” outline form reflects the anatomy of the pulp chamber. Both mesial and distal walls slope mesially. The cavity is primarily within the mesial half of the tooth but is extensive enough to allow positioning of the instrument and filling materials. The outline form of the final preparation will be identical for both a newly erupted and an “adult” tooth. Further exploration should determine if a fourth canal can be found in the distal. If so, the outline is extended in that direction. In that case, an orifice will be positioned at each angle of the square.

PLATE 24



## PLATE 25

### Mandibular First Molar

#### Pulp Anatomy and Coronal Preparation

- A. **Buccal view** of a recently calcified first molar with large pulp. The initial radiograph will reveal
1. large pulp chamber
  2. mesial and distal roots, each **apparently** containing one canal
  3. vertical distal root with a severe apical curvature
  4. curvature of the mesial root (84% of the time)
  5. distal-axial inclination of the **tooth**
- These factors, **seen** in radiograph, are borne in mind when preparation is begun.

- B. **Mesial view** of the same tooth demonstrating details **not apparent in the radiograph**:
1. **single mesial root with two canals**
  2. minus 58-degree buccal-axial inclination of the **roots**
- All of these **unseen** factors will affect the **size, shape, and inclination** of the final preparation.

- C. Cross-section at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical level**: the pulp, enormous in a young tooth, is débrided during coronal cavity preparation with a round bur.
  2. **Midroot level**: the canals are ovoid. Severe indentation on the distal surface of the mesial root brings the canal within 1.5 mm of the external surface, an area frequently perforated by “stripping.”
  3. **Apical third level**: the canals are round and are shaped into **round, tapered** preparations. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.

- D. **Distal view** of the same tooth demonstrating details **not apparent in the radiograph**:
1. height of distal pulp horns
  2. “ribbon-shaped” distal canal

- E. **Buccal view** of an **adult** first molar with extensive secondary dentin formation. A radiograph will reveal
1. pulp recession and “thread-like” pulp
  2. mesial and distal roots, each **apparently** containing one canal
  3. mesial curvature of the distal root (5% of the time) and distal curvature of the mesial root (84% of the time)

4. distal-axial inclination of the tooth

- F. **Mesial view** of the same tooth demonstrating details **not apparent in the radiograph**:
1. pulp recession
  2. **mesial root, two canals**, and a single foramen
  3. minus 58-degree buccal-axial inclination of the **roots**

The operator must recognize that

- a. careful exploration with two instruments at the same time reveals a common apical foramen.
- b. mesial canals curve in two directions.

- G. Cross-section at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical level**: the chamber is débrided during coronal cavity preparation with a round bur.
  2. **Midroot level**: the canals are nearly round and are enlarged during reaming of an apical third.
  3. **Apical third level**: the canals are round and are shaped into a **round, tapered** preparation. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.

- H. **Distal view** of the same tooth demonstrating details **not apparent in the radiograph**:
1. pulp recession
  2. **distal root with the usual single canal**
  3. buccal-axial inclination of the roots
  4. distal canal curves in two directions

The operator should recognize that

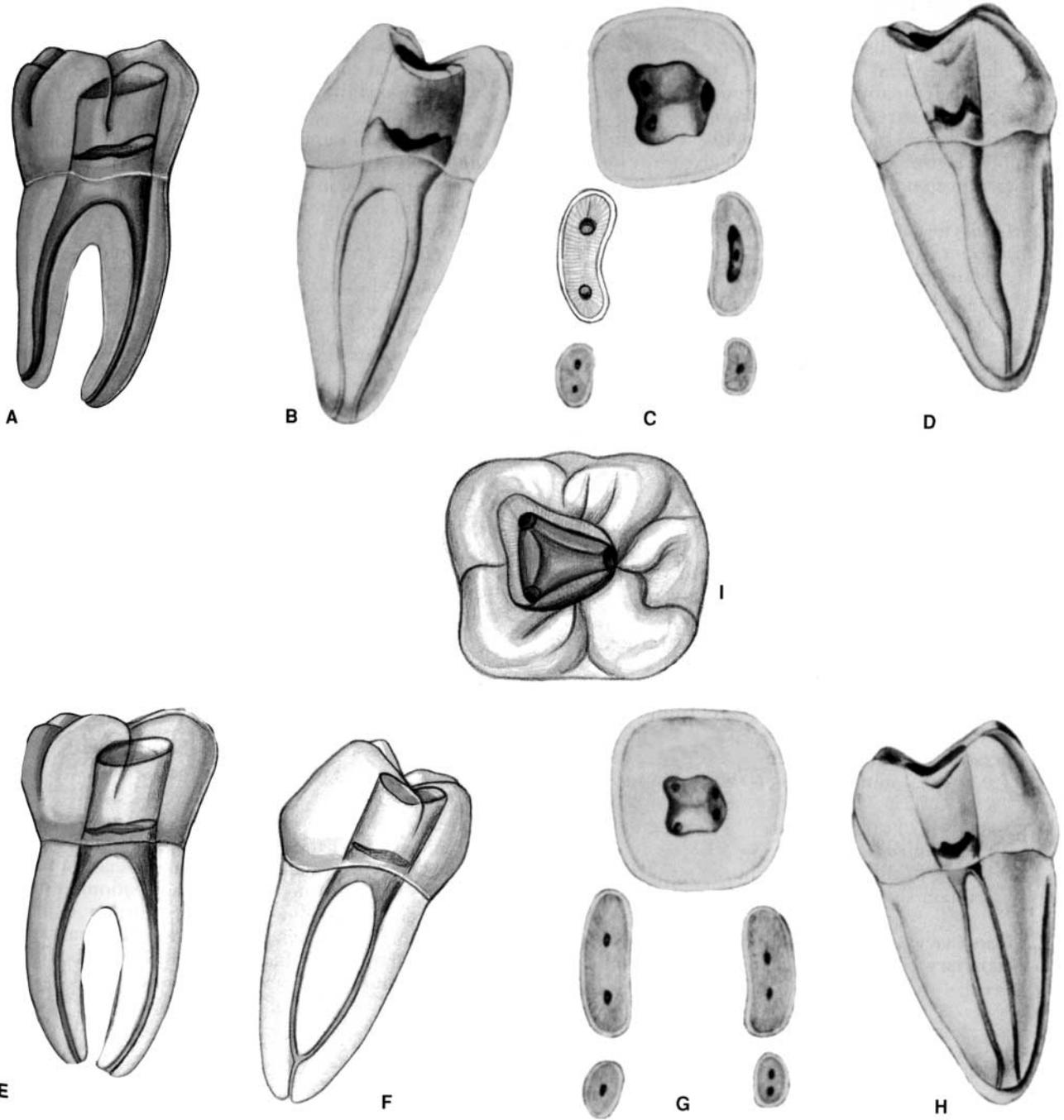
- a. the presence of a fourth canal can be determined only by careful exploration.

- I. **Triangular outline form** reflects the anatomy of the pulp chamber. Both mesial and distal walls slope mesially. The cavity is primarily within the mesial half of the tooth but is extensive enough to allow positioning of instruments and filling materials. **Further exploration should determine whether a fourth canal can be found in the distal.** In that case, an orifice will be positioned at each angle of the rhomboid.

PLATE 25

Mandibular First Molars

Length of Tooth	Mesial	Distal	Roots	Canals	Canals		Curvature of Roots						
					Mesial	Distal	Direction	Mesial	Distal				
Average Length	20.9 mm	20.9 mm	Two roots	97.8%	Two canals	6.7%	Two canals One foramen	40.5%	One canal	71.1%	Straight	16%	74%
Maximum Length	22.7 mm	22.6 mm	Three roots	2.2%	Three canals	64.4%	Two canals Two foramina	59.5%	Two canals	28.9%	Distal	84%	21%
Minimum Length	19.1 mm	19.2 mm			Four canals	28.9%			Two canals One foramen	61.5%	Mesial	0%	5%
Range	3.6 mm	3.4 mm							Two canals Two foramina	38.5%	Buccal	0%	0%
											Lingual	0%	0%



## PLATE 26

### Mandibular Second Molar Pulp Anatomy and Coronal Preparation

- A. **Buccal view** of a recently calcified second molar with a large pulp. A radiograph will reveal
1. large pulp chamber
  2. mesial and distal roots, each **apparently** containing one canal
  3. mesial curvature of the distal root (10%)
  4. bayonet curvature of the mesial root (7%)
  5. distal-axial inclination of the **tooth**

These factors, **seen** in radiograph, are borne in mind when preparation is begun.

- B. **Mesial view** of the same tooth demonstrating details **not apparent in the radiograph**:
1. **mesial** root with **two** canals
  2. lingual curvature of the mesiobuccal canal
  3. “S” curvature of the mesiolingual canal
  4. minus 52-degree buccal-axial inclination of the **roots**

These **unseen** factors will affect the **size, shape, and inclination** of the final preparation. Canals must be carefully explored with a fine curved file. The **double “S” curvature** of the **mesiolingual** canal is especially challenging. All three canals are enlarged by step-back or step-down filing.

- C. Cross-section at three levels: 1, cervical; 2, midroot; and 3, apical third:
1. **Cervical level**: the pulp, enormous in a young tooth, is débrided during coronal cavity preparation with a round bur.
  2. **Midroot level**: the canals are ovoid. Carefully avoid filing against the distal surface of the mesial root, where “stripping” perforation often occurs.
  3. **Apical third level**: the canals are round and are shaped into **round, tapered** preparations. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.

- D. **Distal view** of the same tooth demonstrating details **not apparent in the radiograph**:
1. height of the distal pulp horns
  2. “ribbon-shaped” distal canal

- E. **Buccal view** of an **adult** second molar with extensive secondary dentin formation. A radiograph will reveal:

1. pulp recession and a “thread-like” pulp
2. mesial and distal roots, each **apparently** containing one canal
3. “straight” distal root (58%) and distal curvature of the mesial root (84%)
4. distal-axial inclination of the **tooth**

- F. **Mesial view** of the same tooth demonstrating details **not apparent in the original radiograph**:

1. pulp recession
2. **mesial** root with **two** canals that join and “cross over”
3. minus 52-degree buccal-axial inclination of the roots

The operator should recognize that

- a. careful exploration with curved instruments is imperative.
- b. mesial canals curve in two directions.

- G. Cross-section at three levels: 1, cervical; 2, midroot; and 3, apical third:

1. **Cervical level**: the chamber is débrided during coronal cavity preparation with a round bur.
2. **Midroot level**: the canals, only slightly ovoid in shape, will be enlarged by step-back filing of the apical third of the canals.
3. **Apical third level**: the canals are round and are shaped into **round, tapered** preparations. Preparations terminate at the cementodentinal junction, 0.5 to 1.0 mm from the radiographic apex.

- H. **Distal view** of the same tooth demonstrating details **not apparent in the radiograph**:

1. pulp recession
2. single distal root with a usual single canal
3. buccal-axial inclination of the tooth

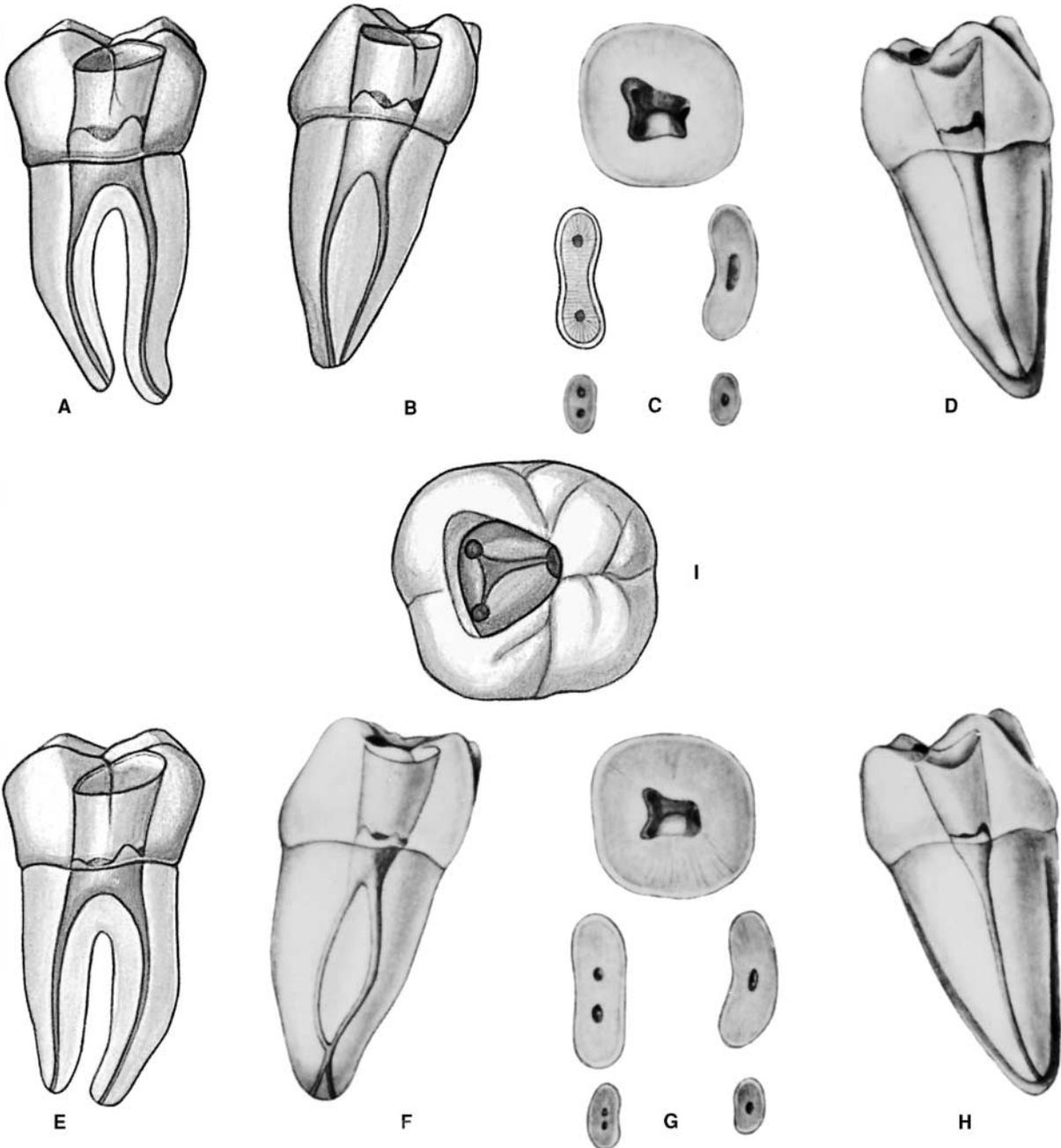
- I. Triangular outline form reflects the anatomy of the pulp chamber. Both mesial and distal walls slope mesially. The cavity is primarily within the mesial half of the tooth but is extensive enough to allow positioning of instruments and filling materials. Further exploration should determine whether a fourth canal can be found in the distal. In that case, an orifice will be found at each angle of the rhomboid.

PLATE 26

Mandibular Second Molars

Length of Tooth	Mesial	Distal		Canals		Direction	Curvature of roots		
				Mesial	Distal		Single Root	Double Root	
							Mesial	Distal	
Average Length	20.9 mm	20.8 mm	One canal	13%	92%	Straight	53%	58%	
Maximum Length	22.6 mm	22.6 mm	One foramen			Distal Curve	26%	18%	
Minimum Length	19.2 mm	19.0 mm	Two canals	49%	5%	Mesial Curve	0%	10%	
Range	3.4 mm	3.6 mm	One foramen			*Buccal Curve	0%	4%	
			Two canals	38%	3%	*Lingual Curve	2%	0%	
			Two foramina			Bayonet Curve	19%	6%	

\*Not apparent in radiograph



## PLATE 27

### Mandibular Molar Teeth ERRORS in Cavity Preparation

- A. OVEREXTENDED preparation undermining enamel walls. The crown is badly gouged owing to failure to observe pulp recession in the radiograph.
- B. PERFORATION into furca caused by using a longer bur and failing to realize that the narrow pulp chamber had been passed. The bur should be measured against the radiograph and the depth to the pulpal floor marked on the shaft with Dycal.
- C. PERFORATION at the mesial-cervical caused by failure to orient the bur with the long axis of the molar severely **tipped** to the mesial.
- D. DISORIENTED occlusal outline form exposing only the mesiobuccal canal. A faulty cavity has been prepared in full crown, which was placed to “straighten up” a lingually tipped molar (D<sup>1</sup>).
- E. FAILURE to find a **second distal** canal owing to lack of exploration for a fourth canal.
- F. LEDGE FORMATION caused by faulty exploration and using too large of an instrument.
- G. PERFORATION of the curved distal root caused by using a large straight instrument in a severely curved canal.

PLATE 27

