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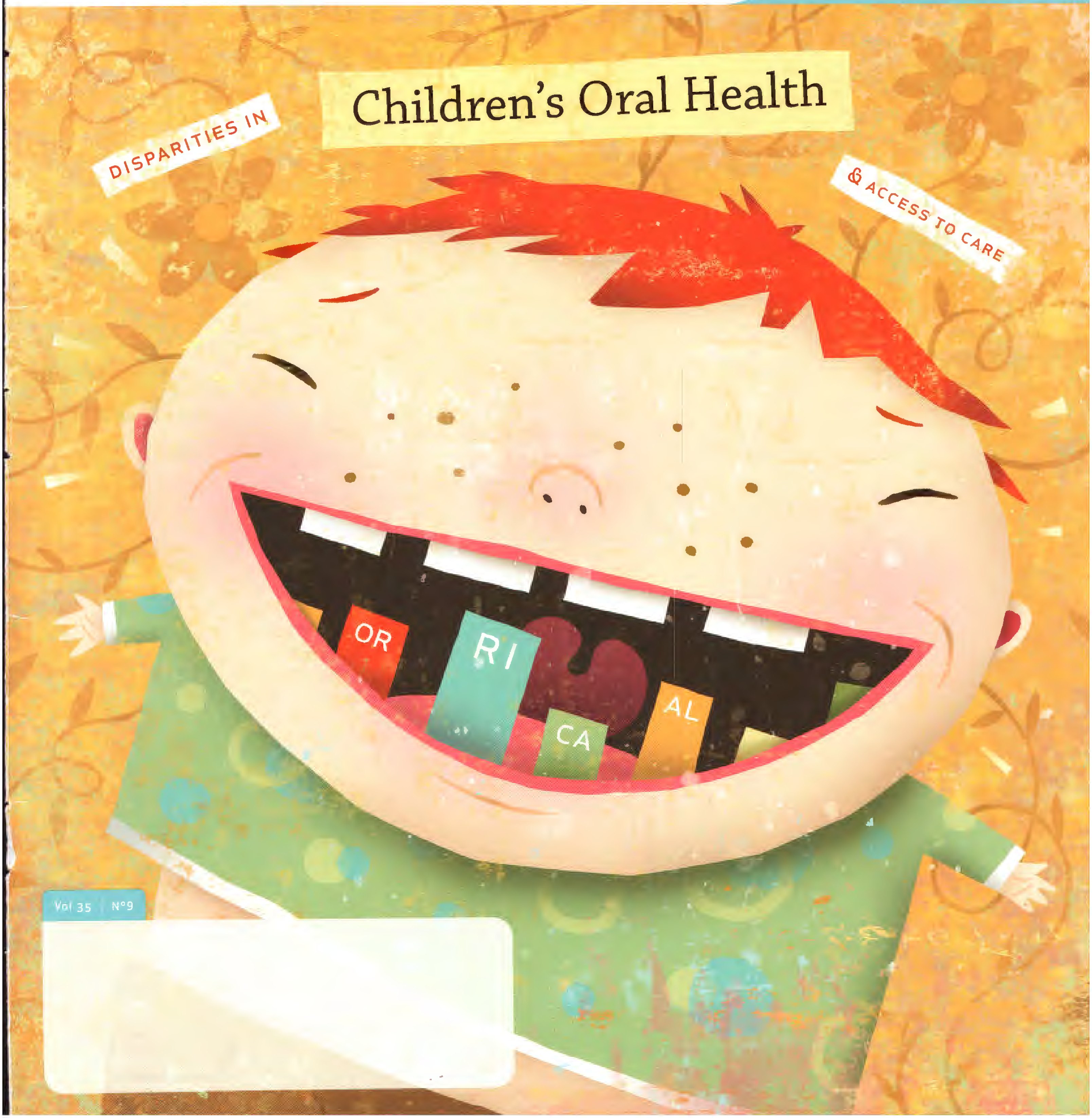
Impressions and Working Casts



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Dental Anatomical Anomalies in Asians and Pacific Islanders

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ABSTRACT Dental anatomical anomalies having a significant impact on endodontic diagnosis and treatment are the talon cusp, tuberculated premolars, three-rooted mandibular molars, and C-shaped molars. Asian and Pacific Islander ethnic groups have the highest percentage of these dental anatomical anomalies compared to the general population. As the population of Asians and Pacific Islanders continues to grow in California and other western states, dentists should be aware of the diagnostic and treatment complexities associated with specific patient groups.

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All races and ethnic groups have some degree of dental anatomical variation. Groups that have the most varied dental anatomy and provide the most concern for the practice of endodontics are those of Asians and Pacific Islanders. The widest variation in coronal shape, external root form, and internal canal space morphology will be encountered with "Pacific Rim" cases.

Anthropological relationships among Western Coastal Native Americans compound the occurrence of anatomical variants in the Pacific Rim geographical area because Western Native Americans share virtually all anatomical anomalies with Asian populations.

According to March 2002 U.S. Census Bureau statistics, 12.5 million Asians and Pacific islanders lived in the United States. That 12.5 million represents 4.4 percent of the total U.S. population. Fifty-one percent of that total population resides in the western United States that includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Asians account for 10.9 percent of California's total population while native Hawaiian and other Pacific Islanders account for 0.3 percent of the population. The national Asian and Pacific Islander population is growing at a rate of approximately 4.5 percent per year.[1]

Several different anatomical variations occur both externally on the tooth crown and within the root canal system. Examples of anomalies seen throughout all races and ethnic groups are dens invaginatus, dens evaginatus, shovel-shaped incisors, Cusps of Carabelli, taurodonts, multiple roots, and root form bifurcations. However, the most common anatomical variants associated with Asians and Pacific Island-

FIGURE 1. Central incisor talon cusp with developmental fissure caries.

FIGURE 2. Caries removal in the fissured area resulted in a near exposure of the pulp extension.

FIGURE 3. Dens evaginatus presenting as a projection of the lingual cusp.

FIGURE 4. Radiograph of Figure 3 demonstrating arrested root development from the exposed necrotic pulp.

FIGURE 5. Premolar example of a prominent tubercle arising from the central groove with nonvital pulp and arrested root development.

ers that will have an impact on diagnosis and treatment are talon cusps, three-rooted mandibular molars, C-shaped molars, and tuberculated premolars.

While some anomalies, such as dens invaginatus were described and reported in the 19th century, literature reports of some of the most common anatomical variants are surprisingly recent.[2] For example, C-shaped molars were first reported in the literature by Cooke and Cox in 1979.[3]

There are several reasons for studying dental anatomical variants in any population. The most significant reason, in clinical terms, concerns enhanced diagnosis and treatment planning. Establishing a diagnosis without a cause or etiology for a disease is risky and inappropriate. Inaccurate diagnosis quite often leads to improper treatment planning.

Some anatomical variants can cause pulpal or periradicular disease that does not have a very obvious cause. A prime example of this can be found with occurrences of apical pathosis associated with otherwise unrestored teeth. This is most often seen in cases of maxillary lateral incisor dens invaginatus and maxillary and mandibular premolar dens evaginatus, also known as the tuberculated premolar. The etiology for pulpal disease may not be clinically apparent since many of these cases involve unrestored teeth and there is no evidence of crown fracture or history of trauma.

Recognizing anatomical variation prevents procedural errors. Treating mandibular molars without angled pretreatment radiographs can lead to missed third roots. The occurrence of three-rooted mandibular molars in Caucasians is only 1 percent to 4 percent compared to approximately 40 percent for some Pacific Rim populations.

Instrumenting the thin isthmuses found in C-shaped molars can lead to catastrophic strip-perforations. Instrumentation errors can be avoided by studying radiographic characteristics common to C-shaped molars. Referral for specialty care before procedural problems arise is an important aspect of proper treatment planning.

An often underestimated but important reason for studying anatomical variation is for forensic value. Two anatomical variations related to cusp morphology, that may not have diagnostic or endodontic implications but can be significant for forensic identification, are Cusps of Carabelli and shovel-shaped incisors.

The Cusps of Carabelli represents the cuspal tuberosity frequently observed on the lingual surface of maxillary molars while the shovel trait is seen as very prominent mesial and distal marginal ridges on maxillary incisors. Unlike the tuberculated premolar, Cusps of Carabelli do not contain a pulp horn extension into the cusp. Chinese populations differ from Western Europeans groups by having a high prevalence of the shovel trait on incisors and low presence of Carabelli's trait on molars.[4]

The following material is a review of characteristic anatomical variation that will be commonly found in the practice of Pacific Rim dentistry.

Talon Cusps

Histologically, the talon cusp and dens evaginatus are identical. The histology has been described by Lau as being an axial core defect of the dental germ. There is an extrusion of uncoordinated tissue proliferation into the stellate reticulum of the tooth germ during the bell stage of tooth development. This proliferation of tissue is followed by a preodontoblast layer of the dentin over which the enamel is subsequently built up. The cylinder of dentin and enamel contains a fine pulpal extension.[5,6]

FIGURE 6. Radiographic verification of an MTA apical barrier. Note that the first molar has a third root proximal to the mesial and distal roots that appears very short.

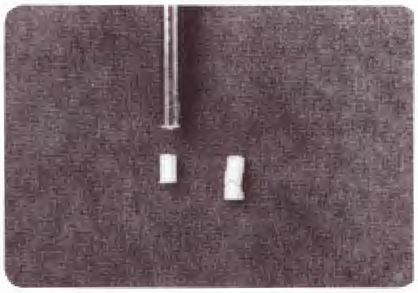

FIGURE 7. MTA plugs delivered by a micro-carrier.

FIGURE 8. Obturation over barrier placement.

The talon cusp occurs 90 percent of the time in the permanent dentition and infrequently in deciduous teeth. Talon cusps are present in overall populations with less than 1 percent frequency. Northern Indian and Malaysian groups, for example, have a high frequency of talon cusp occurrence.[6]

The talon cusp contains a pulp extension that has diagnostic and restorative clinical significance. The developmental fissures around the talon are subject to caries (**FIGURE 1**). Radiographically, the talon can mimic a superimposed mesiodens or a compound odontoma. Issues with talon cusps are primarily related to pulp exposure from normal occlusion attrition or pulp exposure from fissure caries (**FIGURE 2**). As with dens evaginatus, the pulpal extension inside the talon is subject to exposure from occlusal wear. Except for problems with fissure caries or possible occlusion interference, the talon cusp is not a very significant anomaly. From an endodontic treatment standpoint, the canal space has no unusual ramifications and will appear as a typical tubular canal space form.

Developmental fissures can be treated with minimally invasive restorations keeping in mind that the talon does contain a pulpal extension and is subject to exposure.

Dens Evaginatus

Dens evaginatus has also been described as the tuberculated premolar. Dens evaginatus occurs in approximately 2 percent of Asian populations and rarely in other ethnic groups. The highest percentages within the Asian groups were identified in Eskimo-Inuit, Filipino, and Thai populations.[7] A higher incidence of dens evaginatus is observed in Eskimos-Inuits and Native North Americans, further evidence that there is an anthropological link between Native Americans and other Pacific Rim ethnic groups.[8]

This anomaly is responsible for most cases that have nonvital pulp in unrestored teeth. Nonvital pulp in tuberculated premolars frequently occurs at such a young age that apical root development is rarely completed. As pulp necrosis reaches apically to Hertwig's epithelial root sheath, further root growth will be arrested. Pulpal necrosis may occur, however, as late as the second decade.

The histologic-embryologic generation of dens evaginatus is the same as that for the talon cusp. However, in posterior teeth it is described as dens evaginatus. There is typically a bilateral distribution and a predilection for females. The evaginated pulp containing tubercle can be present on a cuspal inclination, in the center of the occlusal surface, or simply be an enlargement of the buccal or lingual cusp[5] (**FIGURE 3**).

Pulpal necrosis ranges from 14 percent to 40 percent in all teeth with evaginated tubercles. The tubercle arises predominately from the lingual ridge of the buccal cusps. The location of the tubercle on the cuspal ridge makes it prone to occlusal wear in lateral excursive movement, resulting in exposure of the pulp projection within the extra cusp. In another variant, the cusp arises as a tubercular projection from the center of the occlusal surface.[8,9] The fragile enamel covering the cusp can be crushed during an occlusion episode even before it is exposed through normal wear. If recognized early, the cusp can be reinforced by placing bonded composite around it if it doesn't interfere with occlusion.[10]

When instrumenting canal spaces associated with dens evaginatus in premolars, special care must be taken to locate all radicular spaces. Mandibular premolars are known to have deep bifurcations that are not radiographically evident since the position of the bifurcation is buccolingual.

The most significant endodontic treatment challenge with dens evaginatus involves the apical management of incompletely formed roots. The tubercle is usually exposed from wear or crushed within a short time after the tooth is in occlusion resulting in necrotic pulp and incomplete root development (**FIGURES 4, 5**).

Open root apices can be managed with either apexification or placement of an artificial barrier. Many materials such as calcium hydroxide and tricalcium phosphate, both in paste and dry powder form, have been recommended for apexification.[11,12] The disadvantage of using calcium hydroxide is the necessity for multiple visits, patient compliance, and long time periods required to complete the process of apexification.

A more contemporary technique employs the use of mineral trioxide aggregate, MTA, placed as a barrier. The procedure can be completed in two visits with obturation and immediate restora-

FIGURE 9. Three-rooted mandibular molar. Straight on view obscures the third root.

FIGURE 10. Angled radiographs separate the third root in the obturation view of the preop tooth in Figure 9.

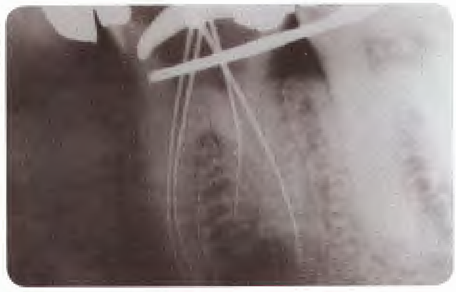

FIGURE 11. Instrument placement in a mandibular first molar. Because of the radiographic angulation, the third root appears very short. The third root curves back toward the buccal.

FIGURE 12. Buccal view of an extracted C-shaped mandibular second molar demonstrating the fusion groove. There are no coronal anomalies indicating unusual root form.

FIGURE 13. Mid- and apical sections of the tooth in Figure 13 showing that the root canal spaces are eccentric toward the fused groove. This is an example of a Melton Type I Continuous C-shape.

tion. At the first visit, the necrotic tissue is removed and the canal space soaked with sodium hypochlorite. Calcium hydroxide is then used as an intracanal medication for at least a week. At the second visit, MTA is placed to the apical extent of the undeveloped root and carefully packed as a barrier using radiographs to verify extent and completeness of the barrier (**FIGURES 6-8**). The entire canal can be obturated with MTA or traditional root canal obturation materials can be added over an apical barrier of MTA.[13]

Three-rooted Mandibular Molars

The incidence of three-rooted mandibular first molars in Caucasians ranges from 0.9 percent to 4.3 percent. There is great variation across Asian populations. Occurrence in Aleutian ethnic groups is reported as high as 43 percent, while neighboring Inuit populations are reported at approximately 12.5 percent. Japanese and Thai populations range from 19 percent to 20 percent with a comparative low in Chinese population of 8 percent.[14]

The third root can present a diagnostic problem if multiple-angled radiographs are not exposed for endodontic treatment planning. The average diagnostic periapical film is usually exposed straight on rather than angled, and the third root is frequently superimposed and obscured by the distal root in this view (**FIGURES 9, 10**).

If there is wide separation of the roots and the third root comes off the root trunk at a 45-degree angle, the third root may appear radiographically very short and may be difficult to visualize (**FIGURES 9-11**).

The third root is lingual to the mesial and distal roots, and if not properly treated endodontically, it will present a challenge for possible apical surgery.

Third roots are anatomically separate and independent from the main distal root but the orifice location is always situated in closer proximity to the distal root orifice. This location is important for endodontic treatment. If a third root is present, the operator may actually have to search for five orifices in total, mesiobuccal, mesiolingual, then the distobuccal, distolingual, and the orifice of the third root. The orifice of the third root may be relatively in the same location as the distobuccal and distolingual.

The apical extent of the third root frequently swings toward the buccal in the same manner that the apical third of a palatal root of a maxillary molar is inclined buccally. If the buccal curvature is not properly negotiated it can be easily ledged (**FIGURE 11**).

Since there is a high incidence of three-rooted mandibular molars, dens evaginatus, and C-shaped molars in Asian populations, these anomalies will frequently occur together. In Figures 6 and 8, note the presence of the three-rooted molar distal to the tooth being treated for dens evaginatus. The third root, radiographically proximal to the mesial and distal roots appears very foreshortened radiographically (**FIGURES 6, 8, 11**).

C-shaped Molars

The C-shaped root canal system anatomy is now well-recognized in the literature. As an anatomical anomaly, it is a relatively late bloomer as it was first reported by Cooke and Cox in 1979.

The C-shaped canal system occurs in mandibular first molars and maxillary molars but is most common in mandibular second molars. The incidence of C-shaped molars in the general population

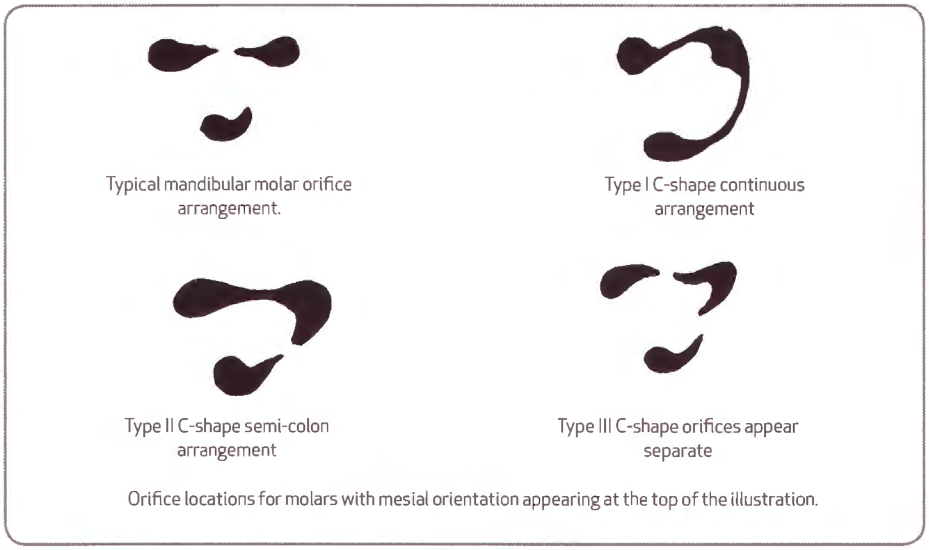

FIGURE 14. Orifice orientations for Melton's C-shaped molar classifications.

FIGURE 15. An example of a Type II Semicolon C-shaped orifice arrangement.

FIGURE 16. An extracted C-shaped mandibular first molar. The flat apical area is a clue to the presence of fused roots for this anatomical anomaly. Note the thin dentin isthmus connecting the main mesial and distal roots. The isthmus was perforated during instrumentation and obturation.

FIGURE 17. This mesially inclined mandibular second molar is C-shaped. The canals spaces are eccentric toward the furcation. That appearance provides another radiographic clue that the internal anatomy will be of the C-shaped variety.

FIGURE 18. Instrument placement in the molar of Figure 17 shows that the instruments are near the furcation and close to a perforation.

is approximately 8 percent, but can be as high as 31 percent in Asian ethnic groups.[3]

C-shaped molars develop when Hertwig's epithelial root sheath fails to fuse either on the buccal or lingual surface. That fusion failure results in a groove on the opposite side of the root that is present coronoapically[15] (**FIGURES 12, 13**).

A classification system was proposed by Melton and others that detailed the external and internal anatomical and histological features of C-shaped molar anatomy.[16] In a study of 15 extracted teeth, they described the dentin-canal space isthmus as occurring approximately equally on both the buccal and lingual. In the Type 1 continuous form, the internal canal space is seen as a single continuous crescent-shaped space without separate orifices. The Type 2 Semicolon arrangement may have two connected orifices with a separate space, and the Type 3 arrangement is represented by three separate orifices that are connected to varying degrees throughout to body of the root (**FIGURES 14, 15**).

Diagnostic interpretation and instrumentation modifications are required to overcome the clinical challenges presented by C-shaped canal systems. In the case of this anatomical anomaly, internal canal space form cannot be ascertained from clinical crown shape. Radiographic examination, however, can provide information supporting the diagnosis of a C-shaped root.

Not all teeth in this category have conical-tapered root apices but there are radiographic clues that may indicate the presence of a C-shaped molar. Frequently, the tooth will appear as a typical two-rooted mandibular molar because the dentin isthmus connecting the main mesial and distal root areas is very thin and not radiographically evident. In other instances, the roots will appear with flattened apices as this area represents the connecting dentin isthmus (**FIGURE 16**). Canal spaces seen radiographically in C-shaped molars may appear unusually eccentric toward the furcation (**FIGURES 17, 18**).

Instrument placement in the thin dentin isthmus may appear radiographi-

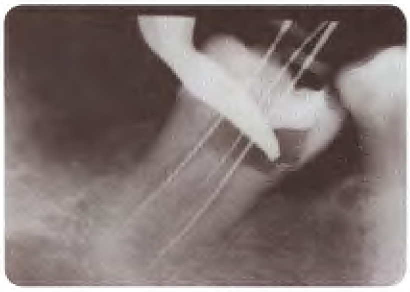

FIGURE 19. The middle instrument has been placed in a thin connecting isthmus of this C-shaped molar. The file appears to have perforated the furcation since the isthmus is too thin to be radiographically evident.

FIGURE 20. Obturated C-shaped molar with Type II Semicolon arrangement. The connecting isthmus has been appropriately debrided and obturated.

FIGURE 21. C-shaped mandibular second molar with a deep connecting isthmus.

cally as a furcation perforation (**FIGURE 19**). The dentin in this area is too thin to be radiographically opaque. Debridement and flaring in this area has to be minimal to prevent strip-perforation of the thin isthmus (**FIGURE 16**). With careful debridement and soaking with sodium hypochlorite, the thin isthmus can be safely debrided and obturated (**FIGURES 20, 21**).

Internal fiber optic light transillumination can be used to enhance canal space anatomy when searching for spaces. When the tip of a fiber optic light is placed under the rubber dam, the canal space will appear as a dark line or area demarcating the pulp space.

The use of thin ultrasonic tips in isthmus areas is invaluable for safe debridement. Warm vertical gutta-percha compaction is an essential method for complete obturation of the various internal space configurations presented by the C-shaped variant.

Conclusions

Familiarization with dental anomalies, specifically those pertaining to endodontic treatment will enable the provider to prevent inaccurate diagnosis that can potentially lead to inappropriate treatment or procedural errors.

Some anomalies such as dens evaginatus and the subsequent pathosis seen with early pulp necrosis will more likely be seen in children. As the Asian and Pacific Islander population grows in the western states, and as those populations migrate throughout the United States, all health care providers should be aware of diagnostic and treatment technique modifications required to overcome the clinical challenges posed by various anatomical anomalies. ■■■■

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