Original Contributions

Dens evaginatus

Current treatment options

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ABSTRACT

Background. Teeth with dens evaginatus (DE) are more commonly observed in Western countries than previously. This is due to the increase in populations of patients of Asian origin, in whom DE is more common than in people of European origin. The interest in DE has also increased with the introduction of a procedure called regenerative endodontics.

Case Description. A narrative review of treatment options for teeth with DE is presented, based on pulpal conditions and maturity of the teeth.

Practical Implications. Early recognition of teeth with DE allows for treatment choices that generally lead to good outcomes and can aid in preserving developing teeth in young patients.

Key Words. Dens evaginatus; tubercle; supernumerary cusp; odontome; talon cusp; tooth development; regenerative endodontics.

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Dens evaginatus (DE) is a relatively rare developmental anomaly that occurs more often in people of Asian descent than European descent.[1-10] DE appears as a cusplike elevation of enamel, referred to as a tubercle, and is located in the central groove or on the buccal or lingual cusps of premolars or molars and the palatal or lingual surfaces of anterior teeth.[1,8,9,11,12] DE is now the most common term, but many other terms have been used such as interstitial cusp, central cusp, supernumerary cusp, occlusal enamel pearl, dilated composite odontome, odontome of the axial core, evaginated tooth, and Leong's premolar.[2,4]

There are 2 forms of DE: an occlusal tubercle on posterior teeth, primarily premolars (Figure 1A) and a lingual hornlike structure, often referred to as a talon cusp, on anterior teeth[3,4,7,8,11-13] (Figure 1B). Variations in locations for both forms of DE, such as proximal surfaces of posterior teeth and labial surfaces of anterior teeth (Figure 1C), have been reported.[14-18] Concomitant anomalies of DE and tooth development also occur, including unusual root formations.[19-22]

DE, while more prevalent in people of Asian descent (Japanese, Chinese, Thai, Malay, Filipino, and Indian) (range, 0.5%-4.3%), also occur in Alaska Natives and Inuit[5,8] and American Indians as well as prehistoric Amerindians.[23,24] In 1925, Leigh[25] was probably the first to report on teeth with extra cusps in Inuit. Owing to the increased global migration of people from Asia, Cho[26] urges dentists in Western countries to be aware of the existence of DE.

The etiology of DE is thought to involve a genetic component influencing a trait that occurs during the bell stage of tooth development; that is, abnormal proliferation and folding of a portion of the inner enamel epithelium and subjacent ectomesenchymal cells of the dental papilla into the stellate reticulum of the enamel organ occurs, leading to formation of a tubercle.[3,4,8,27] The genetic component may also explain the occasional association of DE with other developmental malformations.[14,16,17,21]

The DE tubercles on posterior teeth usually contain an extension of the pulp surrounded by dentin and enamel (Figure 1D).[2] The tubercles are about 2 millimeters in width and 3 mm in height on average,[2,3] whereas talon cusps on anterior teeth can be up to 6 mm in length.[28] Occlusal tubercles have been classified by means of their locations: the lingual cusp, the inclined plane of the lingual cusp, the buccal cusp, the inclined plane on the buccal cusp, and over the central groove.[7] They have also been described as smooth, grooved, terraced, or ridged.[8] Oehlers and colleagues[29] classified the tubercles on the basis of the pulpal contents and shapes.

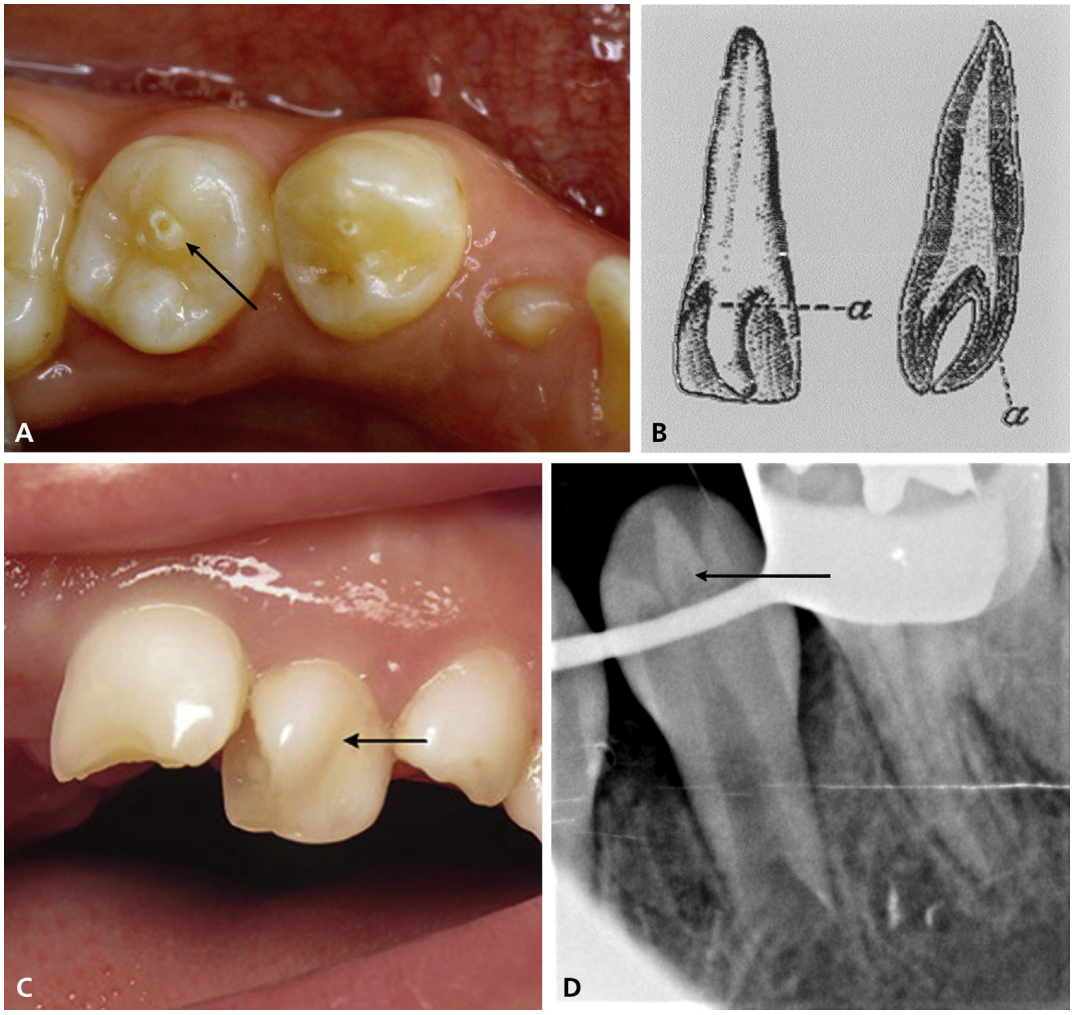

Figure 1. Types of dens evaginatus. **A.** Occlusal tubercle (arrow). **B.** Drawing of palatal talon cusp by Mitchell[11] in 1892. **C.** Labial talon cusp (arrow). **D.** Pulpal extension into occlusal tubercle (arrow).

Patients with DE risk experiencing many complications. Fracture of the fragile tubercles may lead to pulp exposure, followed by infection and pulp necrosis and apical abscess.[3,8,29] The presence of tubercles can result in malocclusion and loosening of the teeth.[3,8] Patients are usually young when teeth with tubercles are exposed to occlusal forces and the roots are not fully formed. If pulp necrosis occurs, such thin roots are prone to fracture.[19,30,31]

TREATMENT OPTIONS

Historically, treatment options for DE have included intermittent grinding of tubercles before any pulpal involvement, tubercle protection with composite resin, coronal pulpotomies, apexification combined with root canal filling, root canal therapy in teeth with mature roots, apical surgery, and extraction in cases of orthodontic treatment.[32-34] No treatment intervention is also an option, if the risk of experiencing tubercle fracture from occlusion is not a factor.[35]

Methods for treating teeth with DE are based on case reports. These provide reasonable information for making treatment recommendations on the basis of the teeth's pulpal conditions and root maturity. Levitan and Himel[8] developed 6 categories of such teeth:

- normal pulp, mature apex;
- normal pulp, immature apex;
- inflamed pulp, mature apex;
- inflamed pulp, immature apex;
- necrotic pulp, mature apex;
- necrotic pulp, immature apex.

ABBREVIATION KEY

CH: Calcium hydroxide.
DE: Dens evaginatus.
MTA: Mineral trioxide aggregate.
NaOCl: Sodium hypochlorite.
RE: Regenerative endodontics.

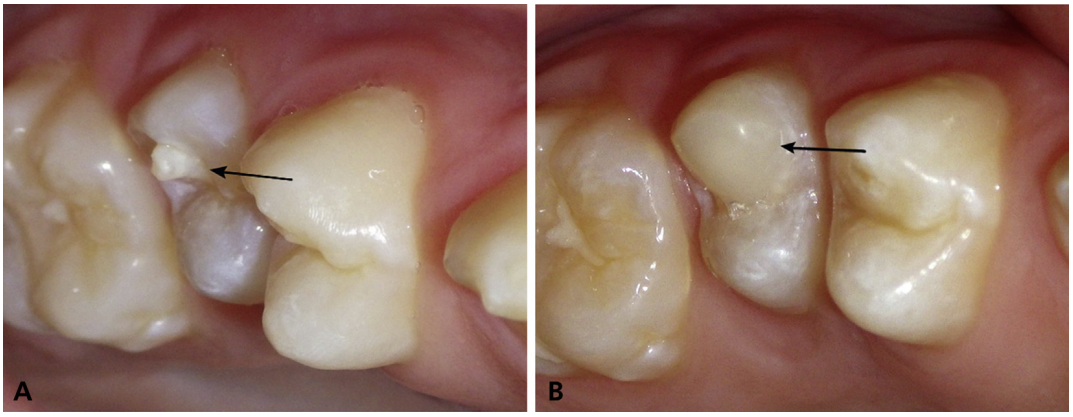

Figure 2. Protecting intact occlusal tubercle. **A.** The tubercle located on the buccal cusp (arrow). **B.** The tubercle protected by acrylic resin (arrow).

Using such a guide allows treatment to be tailored to each tooth's specific condition. For example, preserving vital pulp tissue in an immature tooth allows continued root development and reduces the risk of experiencing root fracture resulting from thin root walls.[31,36] The treatment options are tailored to the status of the tooth with respect to the occlusal position of the tubercle, the pulpal condition, and the root maturity.

Tubercle preservation

Protecting an occlusal tubercle from fracture, using composite resin, has been recommended.[35,37-40] This is accomplished by surrounding the tubercle with resin to reinforce it (Figures 2A and 2B). Monitoring such teeth may be done on a 6-month basis and when radiographic evidence indicates adequate pulpal recession, other treatment options such as those below should be considered.

Although tubercle preservation is probably the most conservative treatment approach, it may not be suitable if the protected tubercle will interfere with normal occlusion. The procedure may, however, be used as a temporary treatment or when the occlusion is such that interference is not likely.[35]

Gradual tubercle reduction

Conservative management of DE may also involve gradual grinding of the tubercle to stimulate tertiary reactionary dentin formation.[35,38] Grinding should be started after some recession of the pulp, as grinding too early reduces the protection of the pulp and can lead to pulpal inflammation and infection.[41] If this treatment option is selected, it is prudent to monitor frequently.[8] The treatment may, however, be successful only in tubercles with wide pulpal horns[37] or in tubercles with no pulpal extension.[42] In 1967, Oehlers and colleagues[29] cautioned that this procedure is unreliable, but that may have been because of the absence of a resin material to protect exposed dentin. Later, Rao and colleagues[40] found that progressive grinding of tubercles in adults was successful, and Segura-Egea and colleagues[39] reported that a talon cusp that was interfering with occlusion could also be managed by this procedure.

The following case illustrates the procedure of gradual tubercle reduction. A 10-year-old girl received treatment for a mandibular second premolar with DE (Figure 3A). The radiograph showed a tooth with a short root and an occlusal tubercle that appeared to have a recessed pulp within the tubercle (Figure 3B). The tooth was caries-free. Approximately 0.5 mm of the tubercle was reduced on the first visit, and the exposed dentin was treated with fluoride varnish (5% sodium fluoride varnish, 3M). Three months later the remaining structure of the tubercle was reduced, and the dentin was covered with a thin layer of composite resin (Adper single bond plus adhesive and Filtek Z250 composite resin, 3M ESPE) (Figure 3C). A follow-up radiograph was obtained 6 months later (Figure 3D); the tooth was asymptomatic and had normal interdigitation with its opposing tooth.

Vital pulp therapy

Preserving vital pulp tissue is important in all immature teeth. Interruption in root development has serious consequences for tooth survival. Because the occlusal tubercle can easily fracture, pulpal disease is a risk in teeth with DE.[8,37,42,43] Both direct and indirect pulp capping have been

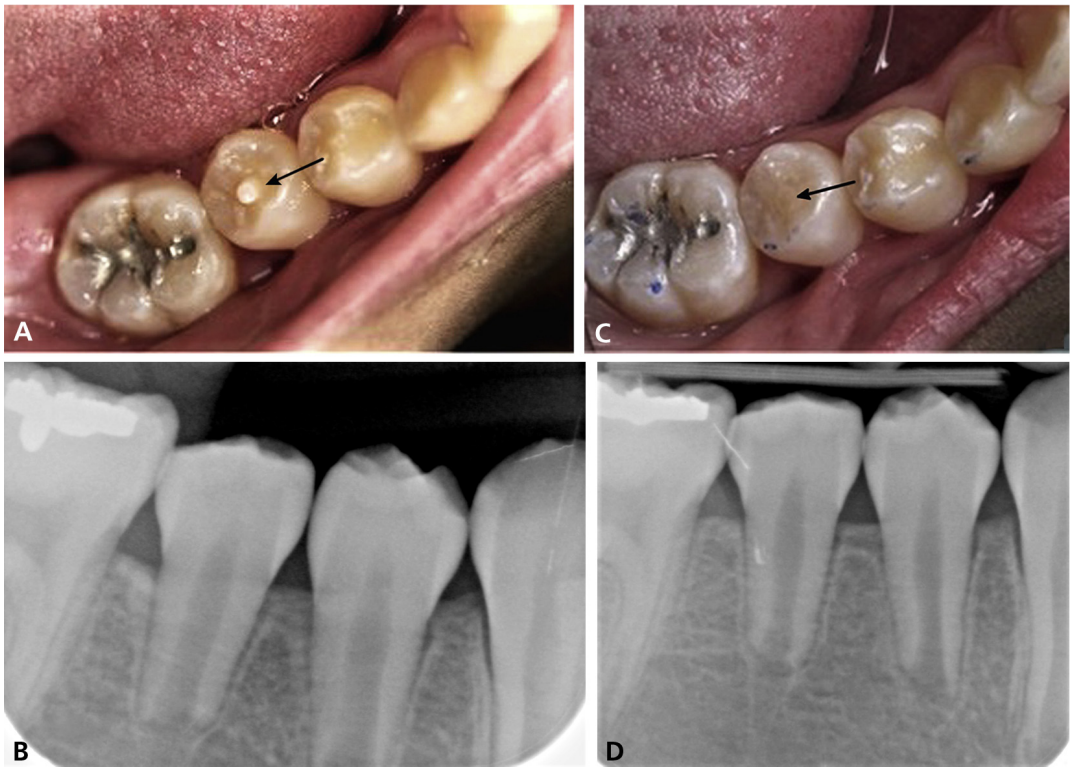

Figure 3. Tubercle reduction. **A.** Preoperative view of tubercle (arrow). **B.** Radiograph of the second premolar with occlusal tubercle. **C.** Three months after initial reduction, the remaining tubercle was reduced. **D.** Radiograph obtained 6 months after tubercle reduction.

recommended,[30,37,41,42,44,45] and vital pulp therapy procedures have good outcomes.[46] In a case report[47] on pulpotomy using mineral trioxide aggregate (MTA) in 2 premolars with DE that were scheduled for orthodontic extraction, a well-developed dentin bridge formation was observed after 6 months.

Apexification

Immature permanent teeth with pulpal necrosis and divergent apical canal walls were a difficult treatment problem until the calcium hydroxide (CH) apexification technique, as popularized by Frank,[48] became a common procedure. Apexification of teeth with DE, using CH, has also been reported.[8,36,49,50]

Figure 4 illustrates apexification in a 10-year-old patient with a mandibular right second premolar with DE (Figure 4A). The tooth was nonresponsive to pulp testing, and the preoperative radiograph showed that the tooth had an open apex and a periapical lesion (Figure 4B). After removal of the necrotic pulp tissue, the canal was filled with CH (Figure 4C). Six months later, an apical hard tissue barrier had developed and the CH was removed and a gutta-percha root canal filling was inserted (Figure 4D).

Another method for stimulating an apical hard tissue barrier was developed in the 1990s with the introduction of MTA.[51] Even though MTA stimulates hard tissue formation at the apical opening of the root canal, the physical presence of MTA apically allows gutta-percha to be inserted into the root canal without extruding it apically. The procedure can be done in fewer appointments and in less time than the CH technique. The use of bioceramic cements such as MTA is the recommended technique for managing immature teeth with pulp necrosis and open apexes.[52] It is reasonable to expect that placing a bioceramic apical plug in immature teeth with DE will also work, although we found no reports on such a procedure. However, with the possibility of using newly developed techniques of regenerative endodontics (RE) in teeth with DE and pulpal necrosis, apexification or apical plugs may be largely replaced by RE.

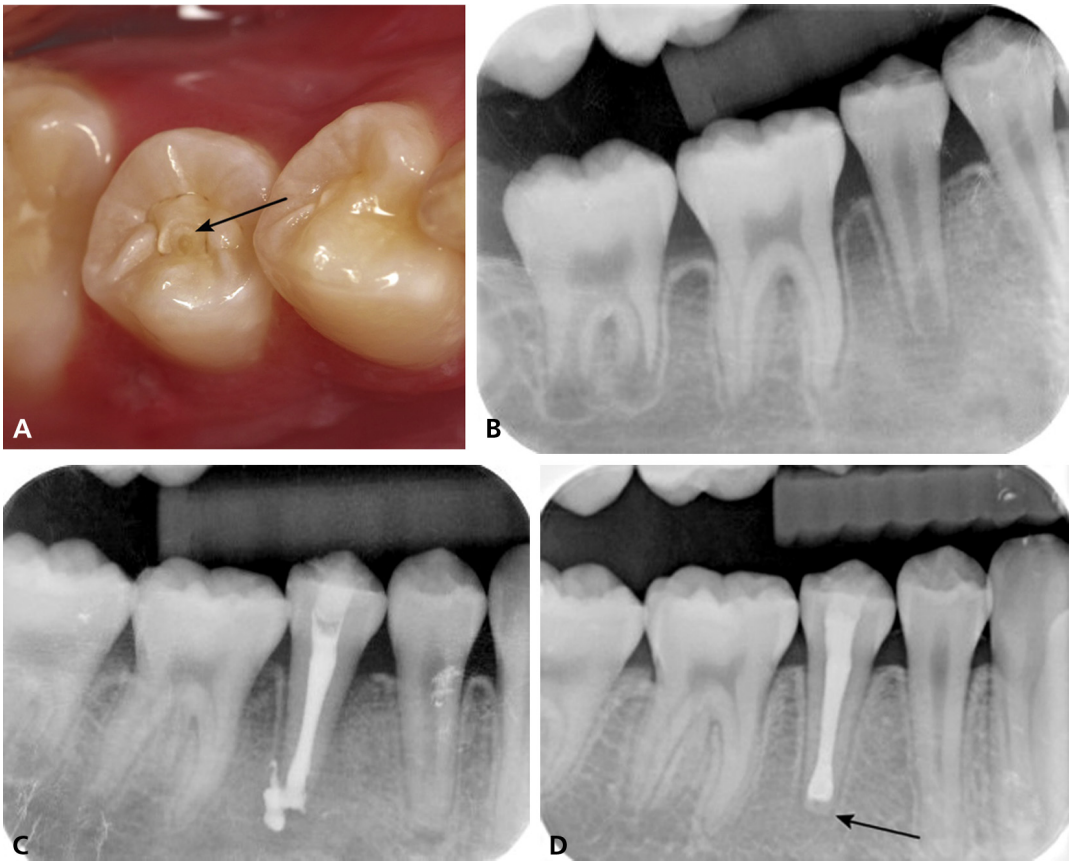

Figure 4. Apexification of tooth with DE. **A.** Photograph of fractured tubercle (arrow) on mandibular right second premolar. **B.** Preoperative radiograph showing the tooth with an open apex and the presence of a periapical lesion. **C.** Radiograph after apexification with calcium hydroxide. **D.** Radiograph obtained after replacement of the calcium hydroxide with gutta-percha. Note the resolution of the periapical lesion and the hard tissue apical closure (arrow).

Root canal filling

In mature teeth with DE and pulp necrosis, conventional root canal treatment is indicated.[8,33,36] Figure 5 shows the treatment of a 20-year-old patient with a mandibular right second premolar with DE. The tubercle had apparently not been subjected to occlusal trauma until the tooth was fully developed. After the tubercle fractured (Figure 5A), the patient developed acute apical periodontitis. The preoperative radiograph (Figure 5B) shows a fairly well-developed tooth and conventional root canal treatment was performed (Figure 5C). The tooth responded favorably. When root canals of immature teeth are filled with gutta-percha, it is prudent to use a flowable resin in the cervical area of the root to provide some additional resistance to fracture.[53]

RE

In 2001, Iwaya and colleagues[54] reported on a new treatment for immature teeth with DE. They published a case report about a 13-year-old patient with a mandibular premolar with DE, pulp necrosis, and apical abscess. They described a fractured central cusp, which is another term for DE. With permission from the authors radiographs from their case report show the mandibular right second premolar with an incompletely formed root apex and evidence of an apical lesion (Figure 6A).[54] The treatment procedure, which they referred to as revascularization, involved accessing the pulp space to evacuate purulent exudate and blood without using endodontic instruments on pulpal tissues. The goal was to preserve all vital tissue in the root canal. Over several visits, the pulp chamber and the coronal aspect of the canal were irrigated with sodium hypochlorite (NaOCl) and medicated with antimicrobial agents (metronidazole and ciprofloxacin). The symptoms subsided and vital tissue was observed in the canal. CH paste (Vitapex, Neo Dental Chemical Products) was placed on the soft tissue in the canal followed by restoration of the access cavity. The root continued to develop, and the apical area responded to the treatment as shown in the

Figure 5. Root canal filling of mature tooth with dens evaginatus. **A.** Preoperative photograph showing fractured tubercle (arrow) on the mandibular right second premolar. **B.** Preoperative radiograph of mandibular right second premolar. **C.** Radiograph of completed root canal treatment.

radiograph obtained 5 months later (Figure 6B). A radiograph obtained 30 months after initial treatment (Figure 6C) shows continued root development and apical closure. Other reports followed[55-58] and the era of RE had begun. It now appears that teeth with DE have been a large component of reported case studies of RE.[59-66]

The American Association of Endodontists[67] has defined RE as "biologically-based procedures designed to physiologically replace damaged tooth structures, including dentin and root structures, as well as cells of the pulp-dentin complex." Regeneration of necrotic pulp tissue through revascularization has for many years been considered an option, in particular for replanted, avulsed immature teeth, absent pulp tissue infection.[55,68] In such replanted teeth with uninfected, coagulative pulp necrosis, the tissues that may migrate into the revascularized pulp space are cementum, periodontal ligament, bone, or a combination of any of these tissues.[69] The ingrowth of cementum will add thickness to the root canal walls, thus providing additional strength to thin immature roots.

The RE procedure for teeth with DE has been described by many authors.[54-58] RE usually takes 3 or 4 appointments, starting by accessing the coronal pulp space and removing visibly necrotic tissue, followed by irrigation with NaOCl. When bleeding from the pulp has stopped, CH is placed on the pulp tissue for further disinfection of the root canal walls, and the access is closed with a temporary cement restoration. The next visit also includes irrigation with NaOCl, and, if the tooth is still symptomatic, CH is again used as before and the access is closed as it was after the first visit. When the tooth is asymptomatic, the next step of the procedure is to stimulate bleeding in the radicular pulp tissue to attempt to create a blood clot proximate to the cervical level of the root. A bioceramic type of cement, such as MTA, is placed on the blood clot, and the rest of the access is partially filled with a glass ionomer cement and then with a composite resin.

Extraction

Extraction of teeth with DE has been chosen in cases of extensive alveolar abscesses associated with such teeth.[32,70] Other reasons have been treatment complications, recurrent infections, and root fractures.[31,36] If premolar extractions are part of an orthodontic plan, extraction of teeth with DE would be preferable,[8,34,71] but orthodontic movement of teeth with RE treatment is possible.[58] Extraction is recommended in cases of supernumerary premolars with DE.[16,22]

DISCUSSION

Awareness of the dental anomaly DE has taken on more importance. Increased migration of Asian people to Western countries including the United States[72] makes it likely that dentists unfamiliar with DE will begin to see more patients with such dental conditions.[26] Also, the interest in what has become known as RE brings case reports to the dental literature that describe RE treatment of teeth with DE.

Selecting a treatment option for a tooth with DE is guided by the maturity of the tooth, the condition of the pulp, and the overall dental treatment plan for the patient. Because DE is usually identified in young patients, the concern for management of immature roots prone to fracture is of high importance.[31] Procedures for pulp protection, such as tubercle protection, gradual tubercle reduction, and vital pulp therapy are conservative treatment approaches that benefit from early detection. When teeth with DE in young patients develop pulpitis and necrosis, the historical

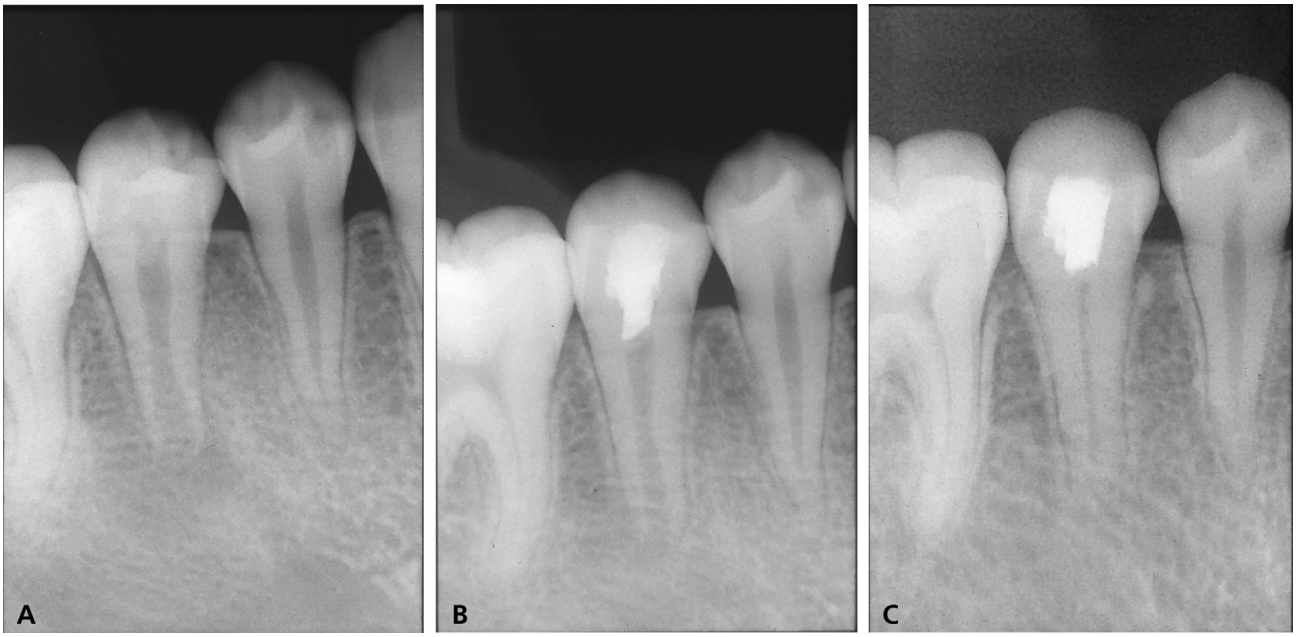

Figure 6. Clinical case of revascularization reported by Iwaya and colleagues.[54] **A.** Preoperative radiograph of a second mandibular premolar with apical radiolucency. **B.** Radiograph obtained 5 months after placement of calcium hydroxide. Note the dentin bridge subjacent to the coronal treatment filling. **C.** Thirty months after initial treatment, the radiograph shows maturation of the root. *Reprinted with permission of the publisher from Iwaya and colleagues.*[54]

approach has been to treat them by apexification and root canal filling. Such immature teeth risk root fracture owing to the thin root walls. RE can be of great value for such teeth.

A common observation in successful RE case reports is that they usually include teeth with immature apexes and often are premolars with DE.[59-66] It is possible that teeth with DE respond differently to infection than other teeth, owing to their unique pulpal anatomy[73] (Figure 7). The bacterial invasion occurs through a small opening in a fractured occlusal tubercle into the coronal pulp. The large volume of tooth pulp and the good blood supply lead to a strong immune response involving both the pulp and the periapical tissues. This immune reaction also causes pulpal and apical tissue destruction. Along with the continuous invasion of microbes, a pathway of infection extends to the apical tissues. Along that pathway, inflammatory cells generate a defensive wall, preserving some vital pulp tissue, especially in the apical one-third of the root canal where the blood supply is rich. The surviving pulp tissue may resume its root-forming function after an RE procedure by which necrotic tissue and bacteria are removed from the pulpal space. Such a unique response to RE was reported in a histologic analysis comparing the different pulpal responses in 1 tooth with DE and another tooth with a history of traumatic injury in the same patient.[74]

Common features of RE procedures in immature teeth with pulpal necrosis include minimal or no instrumentation of the root canal walls, irrigation with NaOCl, use of an intracanal medicament, stimulation of bleeding into the canal to generate a blood clot, capping with a bioceramic material, and placing a coronal seal.[75] There is a difference, however, both in concept and procedure between teeth with DE and teeth that have developed pulpal necrosis from traumatic dental injuries. In the former, pulp tissue that is not obviously necrotic is left undisturbed,[54] whereas all pulp tissue in traumatized teeth is usually removed to reduce the volume of bacteria from the root canals.[76] Furthermore, disinfecting canals in traumatized teeth is difficult because bacteria may remain in the dentinal tubules even after disinfection of the canal space.[76] Case reports on outcomes of RE include a large number of patients with DE,[59-66] disproportionate to the incidence of DE even in Asian countries.[2,6,17,33,36,44] Because of this difference, RE case series reports should make a distinction between patients with DE and patients with trauma-related pulpal necrosis.

The tissues that develop in pulp spaces after RE procedures in teeth without DE have been described as fibrous connective tissue, of which some resembles periodontal ligament, and mineralized tissue resembling cementum and bone; dentin, however, has not been observed.[69,77-80] A frequent finding in more than 70% of such cases is canal space obliteration by calcification.[81] One

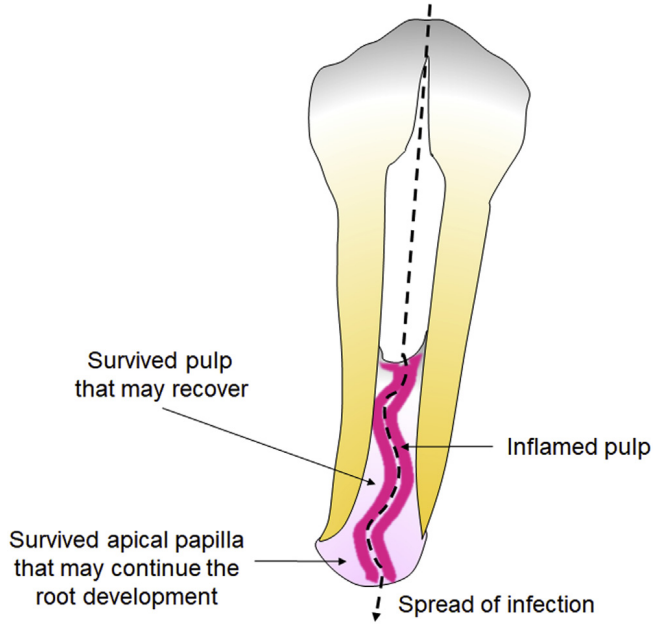

Figure 7. Hypothetical infection process and pathway to the periapical area of teeth with dens evaginatus. The coronal tubercle is fractured, exposing the pulp to the oral environment. The infection spreads coronal-apically. When the infection reaches the large pulp volume in the middle and apical one-thirds of the canal, the immune defense is greatly aided by a rich blood supply such that a wall of defense, in the form of inflammation (dark pink band), is created to protect the remaining uninfected pulp. The pathway of infection advances apically until reaching the periapical area.

case report presented 8-year follow-ups of 2 mandibular premolars in which extensive canal calcification was noted as early as 2 years after treatment.[82]

A variation in tissues observed in a tooth without DE was a histologic report that found pulplike tissues with a well-aligned odontoblast layer that formed in the canal of an immature permanent maxillary lateral incisor after an RE procedure.[83] The tooth had been diagnosed clinically with irreversible pulpitis, and, therefore, the presence of pulplike tissue regeneration is likely the result of surviving nonnecrotic pulpal tissue. The tooth's pulpal condition probably resembled that of teeth with DE.[74]

The procedure that is now referred to, particularly in the United States, as RE[67] has also been referred to as revascularization,[54,55] pulpal regeneration,[59] and revitalization.[84] Huang and Lin[85] prefer the term revitalization, which is also the preference of the European Society of Endodontology.[84] Revascularization should be reserved for trauma cases in which pulp tissues that have lost blood supply because of severance of vasculature (such as avulsion and luxation) later experience a return of blood supply to the sterile necrotic pulp tissue (coagulative necrosis).

Huang and Garcia-Godoy[86] have discussed the criteria for pulpal regenerative procedures. The regenerated pulp should have

- formation of new odontoblasts lining against the existing dentin wall;
- newly formed and complete vascularity and reinnervation;
- regenerated dentin deposited onto the existing dentin with dentinal tubules resembling natural dentin.

So far, stem cell–mediated pulp regeneration tested in various animal models including ectopic, semiorthotopic, and orthotopic regeneration has shown the complete pulplike regeneration and formation of newly deposited dentinlike structure on dentin walls, albeit lacking tubular structures.[87] A pilot clinical study by Nakashima and colleagues[88] and a phase 1 clinical trial in humans conducted by Xuan and colleagues[89] have shown promising results. There was no safety concern regarding autologous dental stem cells implanted into the canal space of the patients. One tooth sample, after receiving pulp regeneration, underwent trauma and was extracted for histologic and immunostaining analysis. The data showed good quality of the regenerated pulp with complete vascularization.

CONCLUSIONS

The treatment of teeth with DE and pulp necrosis during the past 2 decades has shown a favorable outcome of RE procedures.[57] With such good outcomes in mind, it is reasonable to suggest that

procedures such as CH apexification and apical plugs of bioceramic cements can, for the most part, be replaced by RE procedures tailored for teeth with DE and pulp necrosis. In the future, stem cells may also be included in such treatment. ■

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