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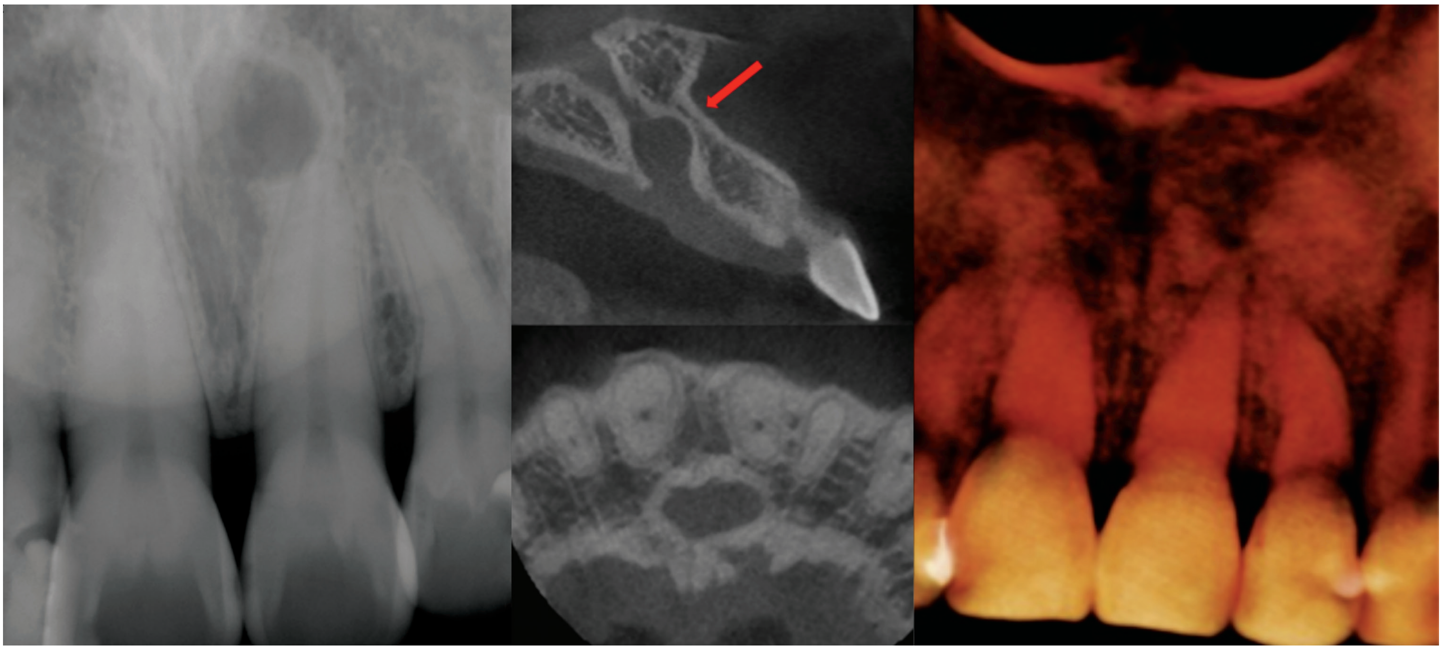

Official Journal of the Endodontic Society of the Philippines

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Root Canal Safety

The relationship of our teeth and mouth to overall good health is indisputable. Endodontics plays a critical role in maintaining good oral health by eliminating infection and pain, and preserving our natural dentition.

A key responsibility of any dentist is to reassure patients who are concerned about the safety of endodontic treatment that their overall well-being is a top priority. The American Association of Endodontists website *(www.aae.org)* is the best place for anxious patients to obtain comprehensive information on the safety and efficacy of endodontics and root canal treatment.

While plenty of good information is available online from the AAE and other reliable resources, patients sometimes arrive in the dental office with misinformation. This has occurred with the long-dispelled "focal infection theory" in endodontics, introduced in the early 1900s. In the 1920s, Dr. Weston A. Price presented research suggesting that bacteria trapped in dentinal tubules during root canal treatment could "leak" and cause almost any type of generative systemic disease (e.g., arthritis; diseases of the kidney, heart, nervous, gastroinestinal, endocrine and other systems). This was before medicine understood the causes of such disease.

Dr. Price advocated tooth extraction—the most traumatic dental procedure—over endodontic treatment. This theory resulted in a frightening era of tooth extraction both for treatment of systemic disease and as a prophylactic measure against future illness. Dr. Price's research techniques were criticized at the time they were published, and by the early 1930s, a number of well-designed studies using more modern research techniques discredited his findings.

Decades of research have contradicted Dr. Price's findings since then. In 1951, the *Journal of the American Dental Association* published a special edition reviewing the scientific literature and shifted the standard of practice back to endodontic treatment for teeth with non-vital pulp in instances where the tooth could be saved. The JADA reviewed Dr. Price's research techniques from the 1920s and noted that they **lacked many aspects of modern scientific research, including absence of proper control groups and induction of excessive doses of bacteria.**

More recent research continues to support the safety of dental treatment as it relates to overall systemic health. In 2007, the American Heart Association updated its guidelines on the prevention of infective endocarditis, drastically curbing the indications for premedication for dental procedures and excluding endodontic treatment from dental procedures requiring premedication. In April 2012, the AHA found no scientific evidence linking periodontal disease and heart disease, concluding that heart disease and periodontal disease often coincidentally occur in the same person due to common risk factors of smoking, age and diabetes mellitus.

Decades of research contradict the beliefs of "focal infection" proponents; **there is no valid, scientific evidence linking endodontically treated teeth and systemic disease.** Yet some patients still hear about this long-dispelled theory.

Dentists are asked to use the following guidelines to address patients who inquire about a connection between root canal treatment and illness:

- Acknowledge the patient's concerns; stress that optimum health is the goal for every dental patient.
- Provide the patient with written information about endodontic treatment, and discuss it. The AAE has a variety of patient education brochures available for purchase *(www.aae.org/onlinestore)*.
- Provide the patient with information from the AAE website about common root canal myths: *www.aae.org/patients/treatments-and-procedures/root-canals/myths-about-root-canals-and-root-canal-pain.aspx#2.*
- Indicate that the patient is in control of his/her own decision to move forward with any dental procedure, and reiterate a commitment to the highest quality dental care.

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The Recommended Guidelines of the American Association of Endodontists for The Treatment of Traumatic Dental Injuries

The Recommended Guidelines of the American Association of Endodontists for the Treatment of Traumatic Dental Injuries are intended to aid the practitioner in the management and treatment of dental injuries. Although it is impossible to guarantee permanent retention of a traumatized tooth, timely treatment of the tooth using recommended procedures can maximize the chances for success.

The guidelines are not fixed protocols. Variations in an individual patient's health, teeth, physical condition and personal preferences are important factors in an endodontist's treatment recommendation. Practitioners cannot guarantee treatment outcomes.

The AAE gratefully acknowledges the cooperation of the International Association of Dental Traumatology, which granted the AAE permission to use the *IADT Guidelines for the Evaluation and Management of Traumatic Dental Injuries* in the development of the AAE trauma guidelines. The AAE also endorses the IADT Guidelines, which can be accessed at *http://www.iadt-dentaltrauma.org/for-professionals.html.*

Table 1: Treatment Guidelines for Tooth Fractures and Alveolar Fractures in the Permanent Dentition

	CROWN FRACTURE		CROWN/ROOT FRACTURE	ROOT FRACTURE	ALVEOLAR FRACTURE
	UNCOMPLICATED	COMPLICATED			
DEFINITION AND DIAGNOSIS	Enamel and dentin fracture without pulp exposure.	Enamel and dentin fracture with pulp exposure.	A fracture involving enamel, dentin, and cementum with loss of tooth structure. Crown fracture extends below gingival margin. The pulp may or may not be exposed.	A fracture involving the root structure. It can be localized at the apical, middle or cervical third.	The bone segment containing the involved tooth/teeth is fractured and mobile.
CLINICAL ASSESMENT AND FINDINGS	Sensitivity tests and vitality tests are likely to give positive results. Normal mobility. Percussion test: not tender. If tenderness is observed, evaluate the tooth for possible luxation or root fracture.	Sensitivity tests and vitality tests are likely to give positive results. Exposed pulp sensitive to stimuli. Normal mobility. Percussion test: not tender. If tenderness is observed, evaluate the tooth for possible luxation or root fracture	Sensitivity tests and vitality tests are likely to give positive results. Tender to percussion. Coronal fragment is mobile.	The coronal fragment is usually mobile and sometimes displaced. The apical segment is usually not displaced. Tender to percussion. Sensitivity tests may be initially negative indicating transient pulpal damage.	Fracture lines may be located at any level, from the marginal bone to the root apex. Mobility of the teeth may be segmental if the fracture involves more than one alveolar socket. Occlusal interference is often present due to misalignment of the fractured alveolar segment. Displacement of an alveolar segment.
IMAGING AND RADIOGRAPHIC ASSESSMENT AND FINDINGS	One occlusal and two periapical radiographs from mesial and distal are recommended in order to rule out displacement or the possible presence of a root fracture. Radiograph of lip or cheek lacerations to search for tooth fragments or foreign material.	One occlusal and two periapical radiographs from mesial and distal are recommended in order to rule out displacement or the possible presence of a root fracture. Radiograph of lip or cheek lacerations to search for tooth fragments or foreign material.	One occlusal and two periapical radiographs from mesial and distal are recommended in order to rule out displacement or the possible presence of a root fracture. CBCT should be considered to reveal the extension and direction of the fracture.	One occlusal radiograph to determine the level of the root fracture at the apical and middle third. Two periapical radiographs with varying horizontal angles are needed to locate the fractures in the cervical third of the root. For a root fracture in the middle third, CBCT may rule out or confirm an oblique course of fracture involving the cervical third in the labiolingual dimension.	In addition to the three angulations and occlusal film, additional views such as a panoramic radiograph can be helpful in determining the course and position of the fracture lines. CBCT may be useful for diagnosis of alveolar fractures, especially when they involve the palatal or both cortical plates.
TREATMENT	If a tooth fragment is available, it can be bonded to the tooth. Otherwise perform a <u>provisional treatment</u> by covering the exposed dentin with glass ionomer or a permanent restoration using a bonding agent and composite resin. The <u>definitive treatment</u> for the fractured crown is restoration with accepted dental restorative materials.	In young patients with open apices, it is very important to preserve pulp vitality by pulp capping or partial pulpotomy in order to secure further root development. This treatment is also the treatment of choice in patients with closed apices. Calcium hydroxide compounds and MTA (white) are suitable materials for such procedures. If tooth fragment is available, it can be bonded to the tooth. Future treatment for the fractured crown may be restoration with other accepted dental restorative materials.	Without pulp exposure: fragment removal with or without gingivectomy and restore. With pulpal exposure and immature roots: Perform a partial pulpotomy to preserve pulp vitality. Pulp exposure with mature roots: Perform endodontic treatment then restore with a post-retained crown. Orthodontic or surgical extrusion of apical fragment may be indicated to expose the margins prior to permanent restoration. Extraction with immediate or delayed implant-retained crown restoration or a conventional bridge. Extraction is inevitable in crown root fractures with a severe apical extension, the extreme being a vertical fracture.	For root fractures where the coronal fragment has been avulsed out of the socket, please use the treatment guidelines for avulsion (Tables 6-8). Otherwise proceed as described below. Rinse exposed root surface with saline before repositioning. If displaced, reposition the coronal segment of the tooth as soon as possible. Check that correct position has been reached radiographically. Stabilize the tooth with a flexible splint for 4 weeks. If the root fracture is near the cervical area of the tooth, stabilization is beneficial for a longer period of time (up to 4 months). Monitor healing for at least 1 year to determine pulpal status. If pulp necrosis develops, then root canal treatment of the coronal tooth segment to the fracture line is indicated.	Reposition any displaced segment and then splint the involved teeth with a flexible splint for 4 weeks. Suture gingival laceration if present.
PATIENT INSTRUCTIONS	Soft diet, brush teeth with a soft toothbrush after each meal, follow-up as indicated in Table 7.				

Note: Pulp necrosis subsequent to trauma should be diagnosed by at least two signs or symptoms. In the noncompliant patient or one with limited access to care, with a tooth with a mature apex, a lack of response to pulp sensibility testing by 3 months is strongly indicative of pulp necrosis.

Table 2: Follow-Up Procedures for Fractured Permanent Teeth and Alveolar Fractures

TIME	CROWN FRACTURE		CROWN/ROOT FRACTURE		ROOT FRACTURE	ALVEOLAR FRACTURE
	UNCOMPLICATED	COMPLICATED	UNCOMPLICATED	COMPLICATED		
4 WEEKS					Splint removal*, clinical & radiographic control	Splint removal*, clinical & radiographic control
6-8 WEEKS	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control
4 MONTHS					Splint removal**, clinical & radiographic control	Clinical & radiographic control
6 MONTHS					Clinical & radiographic control	Clinical & radiographic control
1 YEAR	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control	Clinical & radiographic control
YEARLY FOR 5 YEARS					Clinical & radiographic control	Clinical & radiographic control

*Splint removal in apical third and mid-root fractures
**Splint removal with a root fracture near the cervical area

Table 3: Treatment Guidelines for Concussion, Subluxation and Luxation of Permanent Teeth

	CONCUSSION	SUBLUXATION	EXTRUSIVE LUXATION	LATERAL LUXATION	INTRUSIVE LUXATION
DEFINITION AND DIAGNOSIS	Tooth is tender to touch and/or percussion but without displacement or abnormal mobility.	Tooth is tender to touch and/or percussion and mobile, but not displaced.	Displacement of the tooth outward or incisally.	Displacement of the tooth in any lateral direction except axially; usually associated with a fracture of the facial cortical bone.	Displacement of the tooth inward and into the alveolar bone.
CLINICAL ASSESMENT AND FINDINGS	Sensitivity and vitality tests are likely to give positive results. Tender to percussion.	Sensitivity tests may be initially negative, indicating transient pulpal damage. Vitality tests are likely to give positive results. Tender to percussion.	The tooth appears elongated and is excessively mobile. Sensitivity and vitality tests are likely to give negative results Tender to percussion.	The tooth appears immobile or locked. Fracture of the alveolar process may be palpable. Sensitivity and vitality tests are likely to give negative results. Tender to percussion.	The tooth appears partially or totally infra-occluded, immobile and locked. Fracture of the alveolar process may be palpable. Sensitivity and vitality tests are likely to give negative results. Tender to percussion.
IMAGING AND RADIOGRAPHIC ASSESSMENT AND FINDINGS	Two periapical radiographs from mesial and distal to exclude displacement. No radiographic abnormalities are expected. CBCT should be considered if available and based on the severity of the injuries.	Two periapical radiographs from mesial and distal to exclude displacement. No radiographic abnormalities are expected. CBCT should be considered if available and based on the severity of the injuries.	One occlusal and two periapical radiographs from mesial and distal. PDL space appears enlarged. CBCT: evidence of increased PDL space and confirmation of the integrity of the socket, mainly on the sagittal and coronal planes.	One occlusal and two periapical radiographs from mesial and distal. PDL space appears enlarged. CBCT: evidence of increased PDL space and diagnosis of alveolar fracture, mainly on the sagittal and coronal planes.	One occlusal and two periapical radiographs from mesial and distal. The periodontal ligament space may be absent from all or part of the root. The cemento-enamel junction is located more apically than the adjacent, non-injured teeth. If the tooth is totally intruded, a lateral should be considered to evaluate the penetration into the nasal cavity. CBCT: PDL space may be absent, mainly on the sagittal and coronal planes

Note: Pulp necrosis subsequent to trauma should be diagnosed by at least two signs or symptoms. In the noncompliant patient or one with limited access to care, with a tooth with a mature apex, a lack of response to pulp sensibility testing by 3 months is strongly indicative of pulp necrosis.

***Table 3: Treatment Guidelines for Concussion, Subluxation and Luxation of Permanent Teeth** (continued)*

	CONCUSSION	SUBLUXATION	EXTRUSIVE LUXATION	LATERAL LUXATION	INTRUSIVE LUXATION
IMMEDIATE TREATMENT	No treatment.	If needed, stabilize the tooth for 2 weeks using a flexible splint (up to 0.016" or 0.4mm).	Rinse the affected area with saline. Reposition the tooth by gently reinserting it into the socket. Suture gingival laceration, especially in the cervical area. Stabilize the tooth for 2 weeks using a flexible splint (up to 0.016" or 0.4mm).	Rinse the affected area with saline. Reposition the tooth digitally or with forceps to disengage it from its bony lock and gently reposition it into its original location. Suture gingival laceration, especially in the cervical area. Stabilize the tooth. For 2 weeks using a flexible splint (up to 0.016" or 0.4mm). If displacement is extensive, splint for 4 weeks.	Teeth with incomplete root formation: - Up to 7mm intrusion, allow for re-eruption without intervention. If no movement, initiate orthodontic repositioning within 3 weeks. - In cases of >7mm, reposition surgically or orthodontically within 3 weeks. Teeth with complete root formation: - Up to 3mm intrusion and <17 years old, allow for re-eruption without intervention. If no movement after 2–3 weeks, reposition surgically or orthodontically before ankylosis develops. - Between 3-7mm intrusion, reposition surgically or orthodontically within 3 weeks. In cases of >7mm, reposition surgically. Splint for 2 weeks using a flexible splint. If displacement is extensive, splint for 4 weeks. - Suture gingival laceration, especially in the cervical area.
ENDODONTIC TREATMENT AND CONSIDERATIONS	Monitor pulpal response until a definitive pulpal diagnosis can be made.	Monitor pulpal response until a definitive pulpal diagnosis can be made.	Teeth with incomplete root formation: - Monitor closely for pulp vitality. - If the pulp becomes necrotic, pulp revascularization therapy or apexification should be considered. Teeth with complete root formation: Pulp necrosis is a common complication. If diagnosed, root canal treatment is indicated.	Teeth with incomplete root formation: - Monitor closely for pulp vitality. - If the pulp becomes necrotic, pulp revascularization therapy or apexification should be considered. Teeth with complete root formation: Pulp necrosis is a common complication. If diagnosed, root canal treatment is indicated.	Teeth with incomplete root formation: - Monitor closely for pulp vitality. - If the pulp becomes necrotic, pulp revascularization therapy or apexification should be considered. Teeth with complete root formation: - The pulp will likely become necrotic and root canal therapy should be initiated 2 weeks after the injury. - After cleaning and disinfection, a temporary dressing with calcium hydroxide is recommended for up to 4 weeks.
PATIENT INSTRUCTIONS	Soft food for 1 week. Maintain good oral hygiene. 0.12% chlorhexidine rinses bid for 2 weeks.	Soft food for 1 week. Maintain good oral hygiene. 0.12% chlorhexidine rinses bid for 2 weeks	Soft food for 1 week. Maintain good oral hygiene. 0.12% chlorhexidine rinses bid for 2 weeks.	Soft food for 1 week. Maintain good oral hygiene. 0.12% chlorhexidine rinses bid for 2 weeks.	Soft food for 1 week. Maintain good oral hygiene. 0.12% chlorhexidine rinses bid for 2 weeks.

Note: Pulp necrosis subsequent to trauma should be diagnosed by at least two signs or symptoms. In the noncompliant patient or one with limited access to care, with a tooth with a mature apex, a lack of response to pulp sensibility testing by 3 months is strongly indicative of pulp necrosis.

Table 4: Differential Diagnosis for Concussion, Subluxation and Luxation Injuries of Permanent Teeth

	CONCUSSION	SUBLUXATION	LUXATION EXTRUSIVE LATERAL INTRUSIVE
PERCUSSION	YES	YES	YES
MOBILITY	NO	YES	YES
DISPLACEMENT	NO	NO	YES

Table 5: Follow-up Procedures for Luxated Permanent Teeth

TIME	CONCUSSION/SUBLUXATION	EXTRUSION	LATERAL LUXATION	INTRUSION
2 WEEKS	Splint removal (if applied for subluxation) Clinical and radiographic examination	Splint removal Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination
4 WEEKS	Clinical and radiographic examination	Clinical and radiographic examination	Splint removal Clinical and radiographic examination	Splint removal Clinical and radiographic examination
6-8 WEEKS	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination
6 MONTHS	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination
1 YEAR	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination	Clinical and radiographic examination
2-5 YEARS	Yearly up to 5 years	Yearly up to 5 years	Yearly up to 5 years	Yearly up to 5 years

Note: Pulp necrosis subsequent to trauma should be diagnosed by at least two signs or symptoms. In the noncompliant patient or one with limited access to care, with a tooth with a mature apex, a lack of response to pulp sensibility testing by 3 months is strongly indicative of pulp necrosis.

Table 6: Treatment Guidelines for Avulsed Mature Permanent Teeth with Closed Apex

DIAGNOSIS & CLINICAL SITUATION	TOOTH HAS ALREADY BEEN REPLANTED	TOOTH HAS BEEN KEPT IN PHYSIOLOGIC STORAGE MEDIUM OR OSMOLALITY BALANCED MEDIUM (HBSS, SALINE, AND MILK) AND/OR STORED DRY FOR UP TO 60 MINUTES	EXTRA-ORAL DRY TIME > 60 MINUTES
IMMEDIATE TREATMENT	Leave tooth in place. Clean affected area with water, saline or 0.12% chlorhexidine. Suture gingival laceration, especially in the cervical area. Verify normal position of the replanted tooth radiographically. Apply a flexible splint for 1-2 weeks (up to 0.016" or 0.4mm). If an intracanal corticosteroid medication is chosen to be used as an anti-inflammatory, anticlastic medicament, it should be placed immediately or shortly following replantation and left for at least 2 weeks.**	Hold the tooth by the crown and clean the root surface and apical foramen with saline. Administer local anesthesia. Irrigate the socket with saline. Examine the socket for possible fracture and reposition if necessary. Replant the tooth slowly with slight digital pressure. Suture gingival laceration, especially in the cervical area. Verify normal position of the replanted tooth radiographically. Apply a flexible splint for 1-2 weeks (up to 0.016" or 0.4mm). If an intracanal corticosteroid medication is chosen to be used as an anti-inflammatory, anticlastic medicament, it should be placed immediately or shortly following replantation and left for at least 2 weeks.**	Carefully remove necrotic tissue attached to the root using gauze. To slow down osseous replacement of the tooth, treatment of the root surface with fluoride prior to replantation has been suggested (2% sodium fluoride solution for 20 min) but it should not be seen as an absolute recommendation. Administer local anesthesia. Irrigate the socket with saline. Examine the socket for possible fracture and reposition if necessary. Root canal treatment can be carried out prior to replantation or later. If an intracanal corticosteroid medication is chosen to be used as an anti-inflammatory, anticlastic medicament, it should be placed immediately or shortly following replantation and left for at least 2 weeks.** Replant the tooth slowly with slight digital pressure. Suture gingival laceration, especially in the cervical area. Verify normal position of the replanted tooth radiographically. Apply a flexible splint for 1-2 weeks (up to 0.016" or 0.4mm).
IMAGING AND RADIOGRAPHIC ASSESSMENT AND FINDINGS	Two periapical radiographs from mesial and distal. CBCT should be considered to confirm the reposition of the tooth and rule out alveolar bone fracture(s).		
ENDODONTIC TREATMENT AND CONSIDERATIONS	If endodontic treatment was not initiated immediately after replantation (read above), root canal treatment should be initiated 7-10 days after replantation and before splint removal. Calcium hydroxide is recommended as an intracanal medication for up to 4 weeks followed by root canal filling.		
ANTIBIOTICS	Prescribe systemic antibiotics: In patients <12 years old: amoxicillin for 7 days at appropriate dose for patient's age and weight. In patients >12 years old: doxycycline for 7 days, at appropriate dose for patient's age and weight. If the avulsed tooth has been in contact with soil, and if tetanus coverage is uncertain, refer to physician for a tetanus booster.		
PATIENT INSTRUCTIONS	Avoid participation in contact sports for at least 2 weeks. Soft diet for 2 weeks. Brush teeth with a soft toothbrush after each meal. Use a 0.12% chlorhexidine mouth rinse twice a day. Use a mouthguard for protection during contact sports.		
FOLLOW-UP	Splint removal and clinical and radiographic examination after 2 weeks. Clinical and radiographic examination at 4 weeks, 3 months, 6 months, 1 year and then yearly thereafter for 5 years.	Splint removal and clinical and radiographic examination after 2 weeks. Clinical and radiographic examination at 4 weeks, 3 months, 6 months, 1 year and then yearly thereafter for 5 years.	Splint removal and clinical and radiographic examination after 2 weeks. Clinical and radiographic examination at 4 weeks, 3 months, 6 months, 1 year and then yearly thereafter for 5 years. Ankylosis is unavoidable after delayed replantation and must be taken into consideration. In children and adolescents, ankylosis is frequently associated with infraposition. Careful follow-up is required and good communication is necessary to ensure the patient and guardian of this likely outcome. Decoronation may be necessary when infraposition (>1mm) is seen,

Note: Pulp necrosis subsequent to trauma should be diagnosed by at least two signs or symptoms. In the noncompliant patient or one with limited access to care, with a tooth with a mature apex, a lack of response to pulp sensibility testing by 3 months is strongly indicative of pulp necrosis.

Table 7: Treatment Guidelines for Avulsed Permanent Teeth with Open Apex

DIAGNOSIS & CLINICAL SITUATION	TOOTH HAS ALREADY BEEN REPLANTED	TOOTH HAS BEEN KEPT IN PHYSIOLOGIC STORAGE MEDIUM OR OSMOLALITY BALANCED MEDIUM (HBSS, SALINE, AND MILK) AND/OR STORED DRY FOR UP TO 60 MINUTES	EXTRA-ORAL DRY TIME > 60 MINUTES
IMMEDIATE TREATMENT	Leave tooth in place. Clean affected area with water, saline or 0.12% chlorhexidine. Suture gingival laceration, especially in the cervical area. Verify normal position of the replanted tooth radiographically. Apply a flexible splint for 2 weeks (up to 0.016" or 0.4mm).	If contaminated, clean the root surface and apical foramen with a stream of saline. Do not handle the root. Soak the tooth in doxycycline or minocycline (1 mg per 20 ml of saline) for 5 minutes (if available). Administer local anesthesia. Irrigate the socket with saline. Examine the socket for possible fracture and reposition if necessary. Replant the tooth slowly with slight digital pressure. Suture gingival laceration, especially in the cervical area. Verify normal position of the replanted tooth radiographically. Apply a flexible splint for 2 weeks (up to 0.016" or 0.4mm).	Carefully remove necrotic tissue attached to the root using gauze. Administer local anesthesia. Irrigate the socket with saline. Examine the socket for possible fracture and reposition if necessary. Preferably, root canal treatment should be carried out prior to replantation Replant the tooth slowly with slight digital pressure. Suture gingival laceration, especially in the cervical area. Verify normal position of the replanted tooth radiographically. Apply a flexible splint for 4 weeks (up to 0.016" or 0.4mm).
IMAGING AND RADIOGRAPHIC ASSESSMENT AND FINDINGS	Two periapical radiographs from mesial and distal. CBCT should be considered to confirm the reposition of the tooth and rule out alveolar bone fractures.	Two periapical radiographs from mesial and distal. CBCT should be considered to confirm the reposition of the tooth and rule out alveolar bone fractures.	Two periapical radiographs from mesial and distal. CBCT should be considered to confirm the reposition of the tooth and rule out alveolar bone fractures.
ENDODONTIC TREATMENT AND CONSIDERATIONS	The goal for replanting developing and immature teeth in children is to allow for possible revascularization of the pulp space. For very immature teeth, root canal treatment should be avoided unless there is clinical or radiographic evidence of pulp necrosis. If pulp necrosis is diagnosed, pulp revascularization or root canal treatment (apexification) may be recommended.	The goal for replanting developing and immature teeth in children is to allow for possible revascularization of the pulp space. For very immature teeth, root canal treatment should be avoided unless there is clinical or radiographic evidence of pulp necrosis. If pulp necrosis is diagnosed, pulp revascularization or root canal treatment (apexification) may be recommended.	The root canal was completed prior to replantation. Delayed replantation has a poor long-term prognosis. The periodontal ligament will be necrotic and not expected to heal. The goal in delayed replantation is to temporarily restore the tooth to the dentition for aesthetic, functional and psychological reasons and to maintain alveolar contour. The eventual outcome will be ankylosis and resorption of the root. Decoronation may be necessary when infraposition (>1mm) is seen.
ANTIBIOTICS	Prescribe systemic antibiotics: In patients <12 years old: amoxicillin for 7 days at appropriate dose for patient's age and weight. In patients >12 years old: doxycycline for 7 days, at appropriate dose for patient's age and weight. If the avulsed tooth has been in contact with soil, and if tetanus coverage is uncertain, refer to physician for a tetanus booster.	Prescribe systemic antibiotics: In patients <12 years old: amoxicillin for 7 days at appropriate dose for patient's age and weight. In patients >12 years old: doxycycline for 7 days, at appropriate dose for patient's age and weight. If the avulsed tooth has been in contact with soil, and if tetanus coverage is uncertain, refer to physician for a tetanus booster.	Prescribe systemic antibiotics: In patients <12 years old: amoxicillin for 7 days at appropriate dose for patient's age and weight. In patients >12 years old: doxycycline for 7 days, at appropriate dose for patient's age and weight. If the avulsed tooth has been in contact with soil, and if tetanus coverage is uncertain, refer to physician for a tetanus booster.
PATIENT INSTRUCTIONS	Avoid participation in contact sports for at least 2 weeks. Soft diet for 2 weeks. Brush teeth with a soft toothbrush after each meal. Use a 0.12% chlorhexidine mouth rinse twice a day. Use a mouthguard for protection during contact sports.	Avoid participation in contact sports for at least 2 weeks. Soft diet for 2 weeks. Brush teeth with a soft toothbrush after each meal. Use a 0.12% chlorhexidine mouth rinse twice a day. Use a mouthguard for protection during contact sports.	Avoid participation in contact sports for at least 2 weeks. Soft diet for 2 weeks. Brush teeth with a soft toothbrush after each meal. Use a 0.12% chlorhexidine mouth rinse twice a day. Use a mouthguard for protection during contact sports.
FOLLOW-UP	Splint removal and clinical and radiographic examination after 2 weeks. Clinical and radiographic examination at 4 weeks, 3 months, 6 months, 1 year and then yearly thereafter for 5 years.	Splint removal and clinical and radiographic examination after 2 weeks. Weight and height measurements as a baseline for growth. This may become critical to determine the time of decoronation, if needed. Clinical and radiographic examination at 4 weeks, 3 months, 6 months, 1 year and then yearly thereafter for 5 years.	Splint removal and clinical and radiographic examination after 4 weeks. Clinical and radiographic examination at 2 and 4 weeks, 3 months, 6 months, 1 year and then yearly thereafter for 5 years. Ankylosis is unavoidable after delayed replantation and must be taken into consideration. In children and adolescents ankylosis is frequently associated with infraposition. Careful follow-up is required and good communication is necessary to ensure the patient and guardian of this likely outcome. Growth follow-up: weight and height measurements. Decoronation may be necessary when infraposition (>1mm) is seen.

Note: Pulp necrosis subsequent to trauma should be diagnosed by at least two signs or symptoms. In the noncompliant patient or one with limited access to care, with a tooth with a mature apex, a lack of response to pulp sensibility testing by 3 months is strongly indicative of pulp necrosis.

Table 8: Follow-Up Procedures for Avulsed Permanent Teeth with Closed & Open Apices

<table>
<tr><th>TIME</th><th>CLOSED APEX/EXTRAORAL DRY TIME <60 MINUTES</th><th>CLOSED APEX/EXTRAORAL DRY TIME >60 MINUTES</th><th>OPEN APEX/REGARDLESS OF EXTRAORAL DRY TIME</th></tr>
<tr><td>7-10 DAYS</td><td colspan="2">Root canal treatment & calcium hydroxide for up to 4 weeks.
Weight and height measurements as a baseline for growth. This may become critical to determine the time of decoronation, if needed.</td><td>No root canal treatment unless clinical or radiographic signs of pulp necrosis are evident.
Weight and height measurements as a baseline for growth. This may become critical to determine the time of decoronation, if needed.</td></tr>
<tr><td>2 WEEKS</td><td colspan="2">Splint removal.</td><td>Splint removal/clinical & radiographic examination.</td></tr>
<tr><td>4 WEEKS</td><td colspan="2">Clinical & radiographic examination.
Root canal filling.</td><td>Clinical & radiographic examination</td></tr>
<tr><td>3 MONTHS</td><td colspan="3">Clinical & radiographic examination.
Growth follow-up: weight and height measurements.</td></tr>
<tr><td>6 MONTHS</td><td colspan="3">Clinical & radiographic control.
Growth follow-up: weight and height measurements.</td></tr>
<tr><td>1 YEAR</td><td colspan="3">Clinical & radiographic control.
Growth follow-up: weight and height measurements.</td></tr>
<tr><td>YEARLY</td><td colspan="3">Clinical & radiographic control.
Growth follow-up: weight and height measurements.</td></tr>
</table>

Note: Pulp necrosis subsequent to trauma should be diagnosed by at least two signs or symptoms. In the noncompliant patient or one with limited access to care, with a tooth with a mature apex, a lack of response to pulp sensibility testing by 3 months is strongly indicative of pulp necrosis.

Antibiotic Prophylaxis

The American Heart Association recently revised its guidelines on antibiotic prophylaxis. The current practice of giving patients antibiotics prior to a dental procedure is no longer recommended **EXCEPT** for patients with the highest risk of adverse outcomes resulting from bacterial endocarditis. In response, the American Association of Endodontists has prepared a reference guide for applying the revisions to dental/endodontic procedures and patient care.

The new AHA guidelines for antibiotic prophylaxis are based on a comprehensive review of published studies that suggests infective endocarditis is more likely to occur as a result of daily activities such as brushing and flossing than from a dental procedure. For patients at risk of bacterial endocarditis, the AHA emphasizes the importance of good oral health and regular dental visits.

The new recommendations apply to many dental procedures, including teeth cleaning and extractions. Patients with congenital heart disease can have complicated circumstances. If there is any question at all as to the category that best fits their needs, these patients should check with their cardiologists before treatment.

BACTERIAL ENDOCARDITIS

Endocarditis Prophylaxis Recommended
Preventive antibiotics prior to a dental procedure are advised for patients with:

- Artificial heart valves
- Infective endocarditis history
- Certain specific, serious congenital (present from birth) heart conditions, including:
  - Unrepaired or incompletely repaired cyanotic congenital heart disease, as well as those with palliative shunts and conduits
  - Completely repaired congenital heart defect with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first six months after the procedure
  - Any repaired congenital heart defect with residual defect at the site or adjacent to the site of a prosthetic patch or a prosthetic device
- Cardiac transplant that develops a problem in a heart valve

Endocarditis Prophylaxis Not Recommended
Patients who have taken prophylactic antibiotics routinely in the past but no longer need them include people with:

- Mitral valve prolapse
- Rheumatic heart disease
- Bicuspid valve disease
- Calcified aortic stenosis
- Congenital heart conditions, such as ventricular septal defect, atrial septal defect and hypertrophic cardiomyopathy

***Regimens for a Dental Procedure*[1]**

		Regimen: Single Dose 30 to 60 min Before Procedure	
SITUATION	**AGENT**	**ADULTS**	**CHILDREN**
Oral	Amoxicillin	2 g	50 mg/kg
Unable to take oral medication	Ampicillin **OR** Cefazolin or ceftriaxone	2 g IM* or IV+ 1 g IM or IV	50 mg/kg IM or IV 50 mg/kg IM or IV
Allergic to penicillins or ampicillin—oral	Cephalexin ϕδ **OR** Clindamycin **OR** Azithromycin or clarithromycin	2 g 600 mg 500 mg	50 mg/kg 20 mg/kg 15 mg/kg
Allergic to penicillins or ampicillin and unable to take oral medication	Cefazolin or ceftriaxone δ **OR** Clindamycin	1 g IM or IV 600 mg IM or IV	50 mg/kg IM or IV 20 mg/kg IM or IV

* IM: Intramuscular
+ IV: Intravenous
ϕ Or other first- or second-generation oral cephalosporin in equivalent adult or pediatric dosage.
δ Cephalosporins should not be used in an individual with a history of anaphylaxis, angioedema, or urticaria with penicillins or ampicillin.

[1]American Dental Association Division of Legal Affairs. An Updated Legal Perspective of Antibiotic Prophylaxis. The Journal of the American Dental Association. 2008; 139:10-21S.

Patients With Joint Replacement

There have been no changes to the American Academy of Orthopaedic Surgeons recommendations. Please visit *www.aaos.org* for more information.

Cone Beam-Computed Tomography in Endodontic Practice: A Brief Review and Case Reports

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Abstract

Cone Beam-Computed Tomography (CBCT) provides superior advantage over conventional radiographs in many aspects of modern endodontic practice. However, clinicians who take advantage of this technology need to determine the ideal cases for a CBCT scan. The aim of this article is to discuss the background and uses of CBCT in endodontics. Five cases that utilized CBCT scans for diagnosis and treatment planning will be presented in the second part of the article.

Review of Literature

Conventional radiographs have been used in endodontics to diagnose, treatment plan and assess outcome. However, because of their two-dimensional nature, limited information can be interpreted from the images produced by radiographs (Patel et al., 2009b). Image distortion, regional anatomy as well as superimposition of both the teeth and surrounding dentoalveolar structures can further add to interpretation problems (Cotton et al., 2007; Patel et al., 2007).

Cone Beam-Computed Tomography (CBCT) (Figure 1) was developed in the late 1990's to produce three dimensions scans of the maxillofacial structures. This enables clinicians to visualize the dentition, the maxillofacial skeleton, and the relationship of anatomic structures in 3-D at a much lower radiation compared to a conventional computed tomography (Mozzo et al., 1998; Patel et al., 2015). It utilizes an extra-oral scanner to create images using effective doses ranging from 4-11 μSv for a limited field of view (FOV), which are comparable with digital periapical (PA) radiographs (Iwai et al., 2001).

When choosing which CBCT equipment to use, clinicians should keep in mind the extent of anatomy they regularly examine. In general, CBCT is categorized into large, medium and limited FOV, which describes the scan volume of the CBCT machine. The larger the CBCT volume is, the wider the area it scans. For most endodontic cases, the area of interest is almost always limited to a few teeth plus a slight extension into the surrounding structures. Therefore, a limited FOV CBCT is preferred to medium or larger FOV CBCT because there is less radiation dose to the patient, higher spatial resolution and shorter volumes to be interpreted (AAE and AAOMR, 2015). The technical details of this system can be read elsewhere (Pauwels et al., 2015).

Figure 1: A CBCT machine

There is overwhelming evidence that detection rate of apical periodontitis (AP) is higher when assessed with CBCT imaging than with PA radiography. In a meta-analysis report, PA radiographs (digital and conventional) reported good diagnostic accuracy on the discrimination of artificial AP from no lesions, whereas CBCT imaging showed excellent accuracy values (Leonardi Dutra et al., 2016). In comparing CBCT imaging with PA radiography, one study found that the detection of apical pathoses is higher when assessed with CBCT imaging (79% probability) than with PA radiography alone (57% probability) (Weissman et al., 2015). CBCT correctly identified 100% of periapical lesions compared with 24.8% for intraoral radiography (Patel et al., 2009a).

In a clinical study on patients with chronic intraoral pain of over six months, the diagnostic yield of CBCT examination over conventional radiographs to differentiate atypical odontalgia (AO) from symptomatic apical periodontitis (SAP) was tested. The study found that 60% of AO patients had no PA bone destruction (Pigg et al., 2011). The authors concluded that CBCT improved identification of patients without periapical bone destruction, which may facilitate differentiation between AO and SAP.

The use of CBCT is not limited to detection of AP alone. CBCT was effective and reliable in detecting the presence of resorption lesions, vertical root fractures (VRF) and root canals. Compared with intraoral radiography, CBCT had a significantly higher overall sensitivity, diagnostic accuracy and inter-examiner agreement when it was used to assess external and internal cervical resorption (Patel et al., 2009c). In-vivo vertical VRF that could not be visualized on PA radiographs were diagnosed with CBCT (Metska et al., 2012). Mesiolingual canals of maxillary molars (MB2) were detected with higher specificity and sensitivity using CBCT than PA radiograph (Vizzotto et al., 2013).

Just like any emerging technology, CBCT does not come without its limitations. The presence of artefacts caused by root canal filling materials resulted in inaccuracies of VRF and MB2 detection by CBCT (Patel et al., 2013; Vizzotto et al., 2013). It is recommended that when endodontic retreatment is necessary, removal of the root filling prior to the CBCT examination eliminates artefacts, thereby permitting the use of the higher voxel protocol that has good diagnostic performance and lower radiation dose (Vizzotto et al., 2013). However, this recommendation may not be practical in instances when CBCT becomes the deciding factor whether retreatment should start or not. Patients may not want to spend additional time, effort and money for exploratory procedures just to remove artefacts for a better scan sensitivity.

In apical microsurgery, the use of intraoral PA radiography to assess complex and overlapping anatomy is limited specially in visualizing anatomical landmarks (e.g. mandibular canal, nasopalatine canal, sinuses) and their relationship to the tooth to be treated. CBCT is strongly recommended before performing apical microsurgery to localize root apices and to evaluate proximity to adjacent anatomical structures (AAE and AAOMR, 2015; Lauber et al., 2012). It is like working with a surgical GPS to aid the endodontist in performing apicoectomy. Having detailed knowledge of anatomy before a surgical procedure will help tremendously in treatment planning, in formulating pre-operative strategies and in navigating around critical landmarks, thus minimizing surgical complications.

Just last year, the American Association of Endodontists (AAE) issued an updated joint position statement with the American Association of Oral and Maxillofacial Radiologists (AAOMR) regarding the use of CBCT in endodontic treatment (AAE and AAOMR, 2015). Both associations discussed important considerations when deciding whether conventional PA radiographs or CBCT should be used in various endodontic procedures such as diagnosis, initial treatment and retreatment, management of complex cases and assessment of outcome. The general message of the joint position paper was to use CBCT only when the need for imaging cannot be met by lower-dose two-dimensional radiography. Furthermore, CBCT should not be used routinely for endodontic diagnosis or for screening purposes in the absence of clinical signs and symptoms.

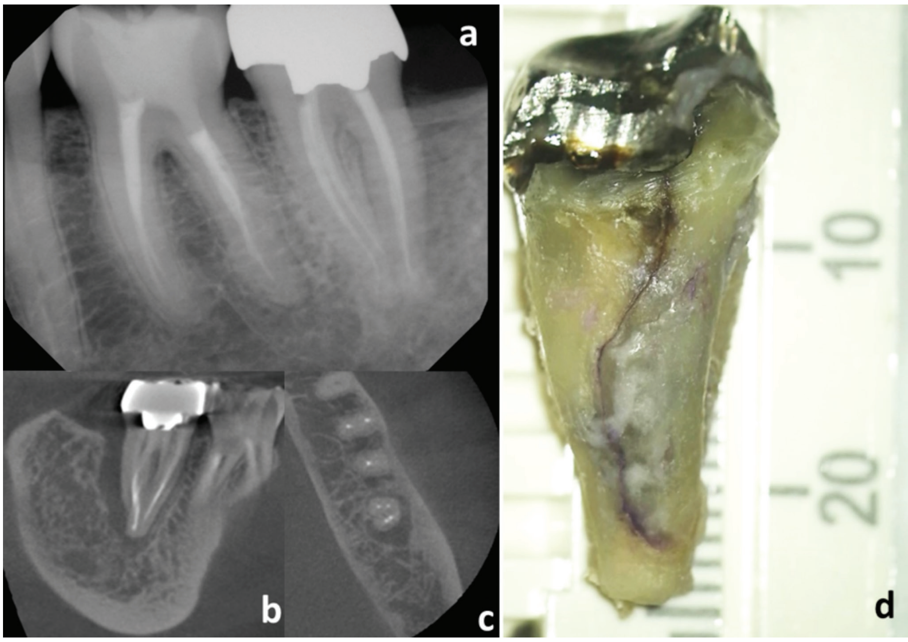

Figure 2: PA radiograph showing tooth 35-37 (a), sagittal and axial CBCT scans of 36 (b & c), distal view of 36 after extraction showing VRF (d). J-shaped radiolucency on distal of 37 was appreciated only on CBCT scans.

Case Reports

The following cases from my private practice or clinical teaching will highlight the importance of CBCT in modern endodontic practice. The FDI/Two-Digit System of tooth numbering will be used throughout.

Case 1

A 57-year old female was referred for re-treatment of tooth 36. Her chief complaint was continuous throbbing pain on the left lower quadrant. No significant medical history was noted except for well-controlled hypertension. Patient had good oral hygiene. The patient could not localize the pain and was visibly in distress. The referral letter stated that tooth 36's RCT "looked inadequate on PA radiograph". All teeth on the left upper and lower jaw were examined. No caries were noted, several teeth had composite filling with intact margins. Except for tooth 37 and 36, the rest of the teeth responded normally to cold. All teeth were negative to percussion and palpation. Probing depths were within 3-4 millimeters except in the distal aspect of 37 that had 6mm isolated probing depth. PA radiographs showed normal bone height and trabeculation. No periapical radiolucency was visualized on tooth 37 and 36 (Figure 2a). To further investigate the problem, a limited FOV CBCT of 37 and 36 was ordered.

The CBCT results showed no suggestion of periapical pathosis or root fracture on tooth 36. However, there was a well-defined, non-corticated low density J-shaped lesion on tooth 37. The lesion encompassed the entire distal root starting at the crest of the ridge (Figure 2b, 2c). This was not apparent on the PA radiograph. The CBCT findings were consistent with a VRF but an actual fracture could not be appreciated because of the scatter effect from the root canal filling material, among other reasons. No other abnormalities were detected. After a thorough discussion with the patient about treatment options, she chose to have the tooth extracted. A visual inspection of the extracted tooth revealed a VRF (Figure 2d). The patient's symptoms resolved after extraction.

Case 2

A healthy 48 year-old female was referred for evaluation and treatment due to periapical radiolucency (PARL) on tooth 21 (Figure 3a). Patient had no symptoms; however, the referring dentist noted a slight swelling on the alveolar mucosa of the tooth. The dentist's findings were confirmed upon clinical examination. Tooth 21 responded normally to thermal testing with no sensitivity to percussion or palpation. There was no history of trauma. A PA radiograph of the tooth showed a circumscribed radiolucency with well-corticated border. A clinical impression of nasopalatine canal cyst was made and a CBCT was ordered to support the clinical impression and to determine the extent of the lesion. No treatment was recommended for tooth 21.

The CBCT images showed anterior bowing of the nasopalatine canal (Figure 3b). The low density, well corticated lesion measured 5.23 mm in its greatest diameter and extended to the buccal cortical plate. There is no thinning, expansion or interruption of the buccal or palatal cortices (Figure 3b). The adjacent roots are not displaced or resorbed and are not connected to the lesion

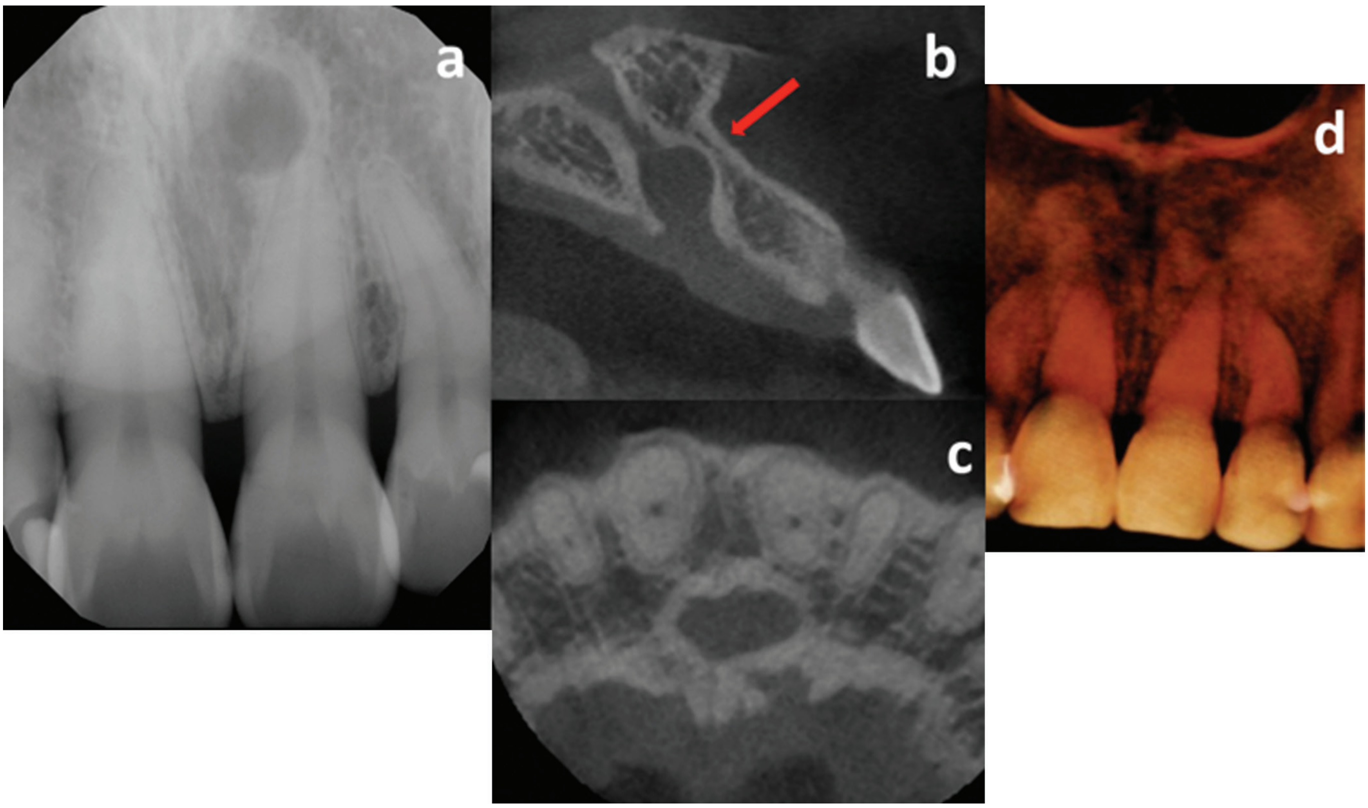

Figure 3: PA radiograph showing tooth 12-22 (a), sagittal (b), axial (c) and coronal (d) CBCT scans of anterior teeth. Arrow on (b) points to a nasopalatine canal cyst seen as PA radiolucency on (a). CBCT confirmed that the lesion was a non-odontogenic nasopalatine canal cyst.

(Figure 3c & 3d). With the CBCT results at hand, a consultation with an oral pathologist was made. Surgical excision of the nasopalatine canal cyst with biopsy was recommended.

Case 3

A 17 year-old male with well-controlled asthma presented for re-treatment of tooth 21. RCT was performed seven years prior due to trauma. From the PA radiograph, tooth 21 had an overextended root canal filling material with a large, circumscribed, low-density area at the periapex (Fig. 4a). The diagnosis was previously treated (PT) tooth with asymptomatic apical periodontitis (AAP). CBCT was requested for pre-operative apical microsurgery assessment.

Case 4

A female in her late forties with no significant health history was referred for evaluation and treatment of tooth 11. A circular radiolucency on the cervical area of the tooth presented as an incidental finding upon routine full mouth radiography (Figure 5a). The patient reported no spontaneous or provoked symptoms associated with the tooth. Upon clinical examination, no blushing, discoloration, probing defect or bleeding were noted. The tooth responded normally to sensibility testing, which led to the diagnosis of normal pulp (NP) with normal apical tissues (NAT). The clinical impression for the lesion was external root resorption, which was not seen on the PA radiograph of the same tooth from five years ago. To gather more information, a CBCT was ordered.

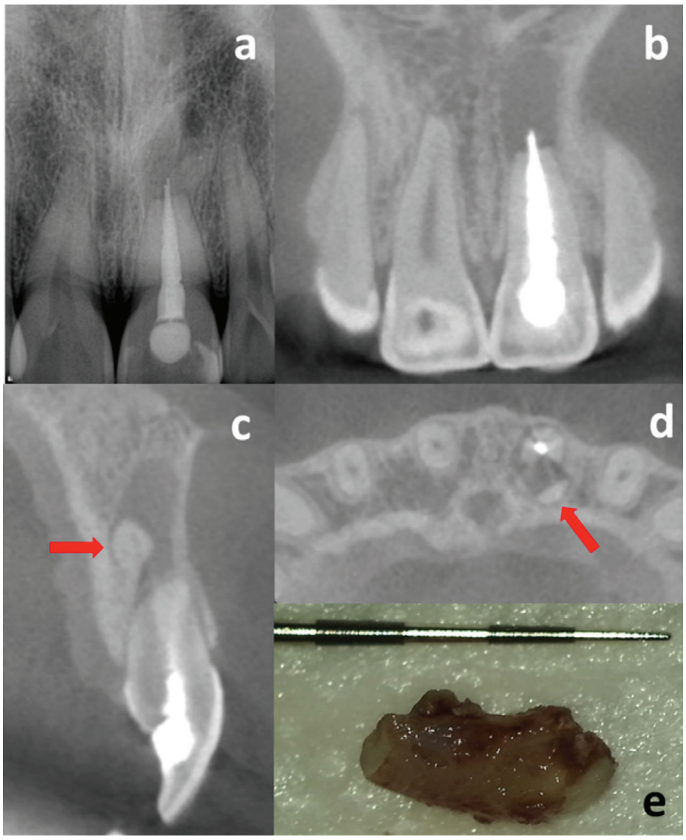

Figure 4: PA radiograph showing tooth 11-22 (a), coronal (b), sagittal (c) and axial (d) CBCT scans of anterior teeth. Fractured root fragment removed during apical microsurgery (e). Arrows on (c) and (d) point to the root fragment in (e) that was only visible on CBCT scan.

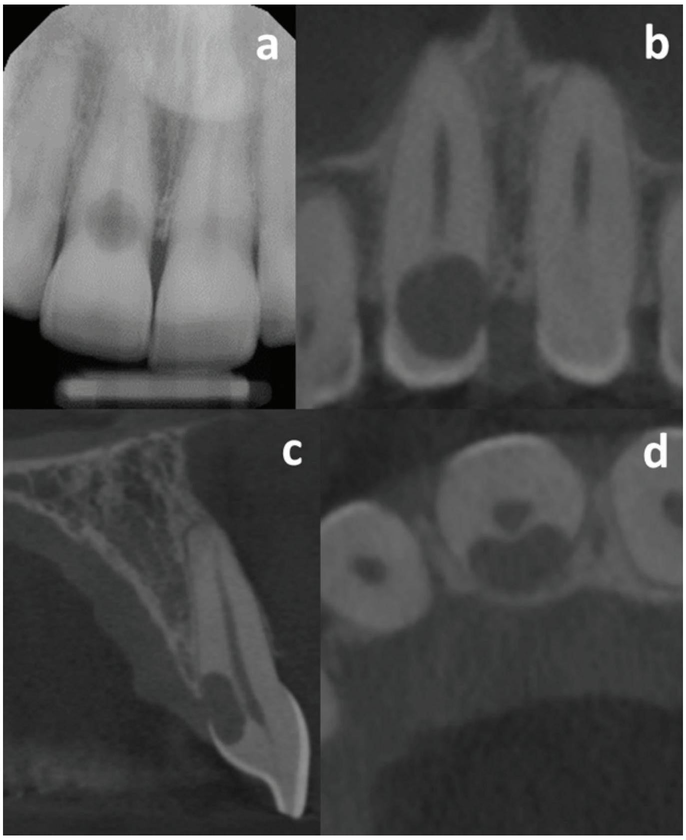

Figure 5: PA radiograph showing tooth 12-22 (a), coronal (b), sagittal (c) and axial (d) CBCT scan of anterior teeth. Detailed view of the external cervical root resorption on CBCT scans (b, c, d), showing no pulpal involvement at this point (c, d).

The coronal view of the CBCT images revealed a large radiolucency associated with tooth 21 (Figure 4b). The axial and sagittal sections, however, showed a clear, radiopaque structure disto-lingual to the tooth (Figure 4c & 4d). This could not have been possibly visualized using PA radiograph due to superimposition by the tooth and the overfilled root canal filling material over the structure. Periapical microsurgery was performed. The structure was removed and confirmed to be the fractured fragment of tooth 21 from the trauma (Figure 4e). The lesion healed well after the surgery.

There was a well-defined, low density oval area noted in tooth 11 (Figure 5b). It extended 1.65 mm apical to the crestal bone on the palate to the midheight of the cingulum and from the periodontal ligament space with no pulpal involvement (Figure 5c & 5d). The lamina dura is intact and the periodontal ligament space is uniform. Based on the CBCT findings, the resorptive defect was classified as Heithersay Class 3 with no osseous pathosis (Heithersay, 1999). The corresponding treatment options and prognosis were discussed with the patient who opted to wait and see at this point.

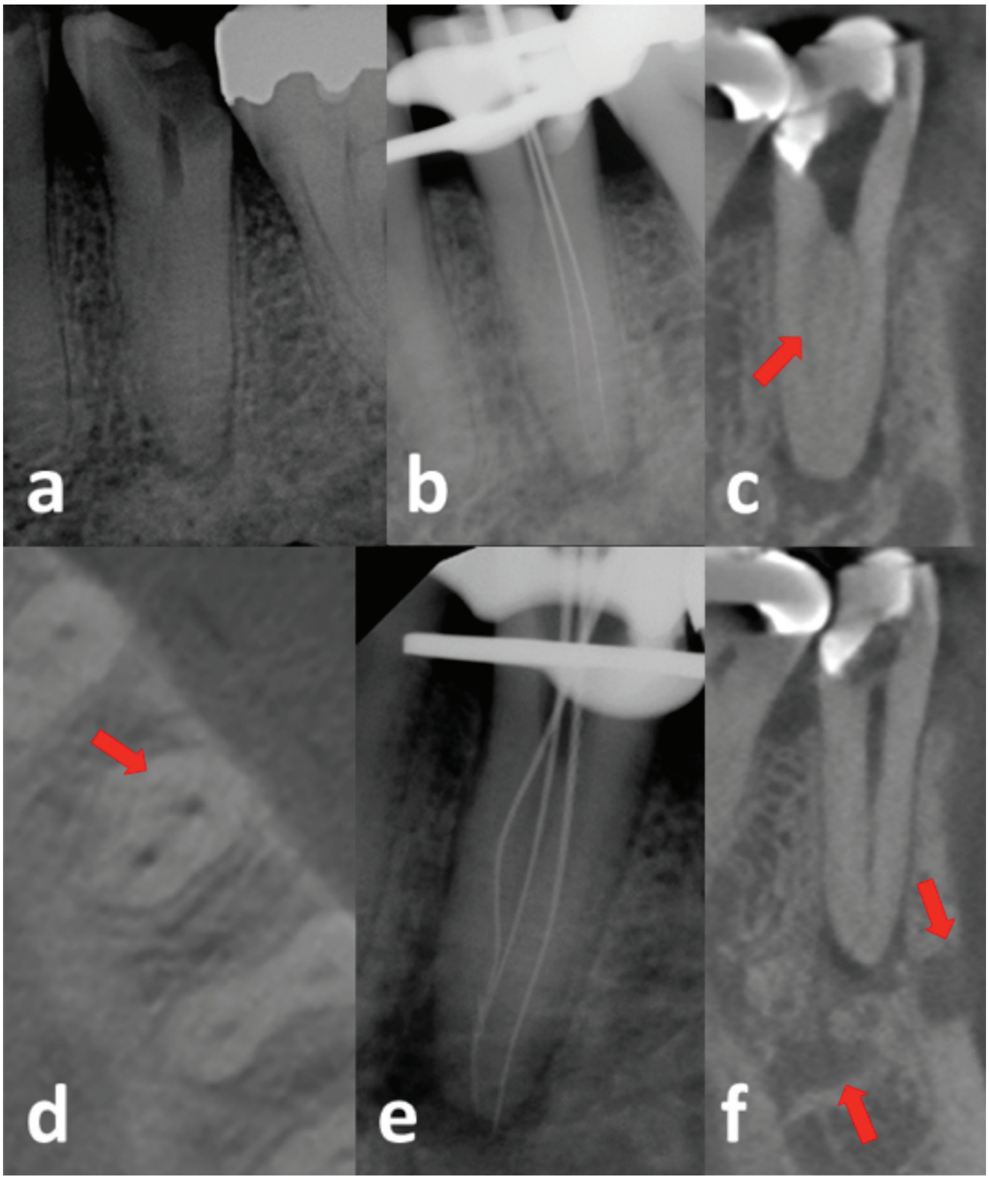

Figure 6: PA radiograph showing full view of tooth 35 exhibiting a fastbreak (a), file shot suggesting a missed third canal (b), sagittal (c) and axial (d) CBCT scan of 35 showing a third canal (arrows), third canal located clinically (e), mental foramen (upper arrow) and IAN (lower arrow (f).

Case 5

A healthy 35-year old male was referred for RCT on tooth 35. His general dentist started the treatment, but difficulty in instrumenting the canals was encountered during the procedure so the patient was referred. The referral form described the tooth as possibly having more than two canals. PA radiographs before and during the initial treatment were received from the dentist. The pre-op radiograph showed a "fast break" appearance, wherein the canal disappeared on the radiograph as it continued apically (Figure 6a). Fast break occurs when the main canal splits into several small canals that cannot be discernable on a conventional radiograph. The working length radiograph from the dentist appeared to have endodontic files in an asymmetrical distribution inside the tooth, strongly suggesting a missed third canal (Figure 6b). A CBCT scan before continuing with the previously initiated root canal treatment was ordered.

As suspected, a third canal on the mesial aspect of the buccal canal was identified in the sagittal (Figure 6c) and axial (Figure 6d) CBCT scans. These findings facilitated locating and instrumenting the third canal that merged with the mesial canal (Figure 6e). The exact location and relationship of the mental foramen and the mandibular canal with the tooth were also determined (Figure 6f). In instances when treatment issues due to anatomical variations or uncertainties occur, the use of CBCT proves to be an invaluable service to both the endodontist and the patient.

Conclusion

The preceding cases demonstrate the importance of CBCT in endodontic diagnosis and treatment planning. With limited FOV scans having similar radiation dose as a PA radiograph, clinicians should take advantage of this technology to better serve their patients. However, prudence and good clinical judgment must still be exercised when deciding to utilize CBCT or when translating CBCT interpretation to actual treatment. Weighing potential risks and proven benefits must come hand in hand with excellent diagnostic skills.

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Endodontic Microsurgery of an Abutment of a Long Span Bridge: A Case Report

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Introduction

Outcome of endodontic therapy is generally good with 60 – 100% success rate based on loose criteria (Ng et al, 2007). When the treatment fails, generally the preferred approach to save the tooth is to undertake a non-surgical root canal retreatment. But when a patient is presented with a long span bridge together with failed endodontic treatment, the clinician is always faced with the challenge of selecting the best type of treatment to manage the periradicular lesion. With non-surgical retreatment, access into the root canal system could only be made by either drilling through the bridge itself or removing the bridge. When there is a presence of a long metal post in the canal, removal of the post and the bridge itself with unknown cement can be very challenging and risky. The bridge removal process is often by destructive means and post removal carries the risk of root fracture and perforation. Even if the bridge is not completely destroyed, reconstruction of a new bridge will be needed as refitting the old bridge may affect coronal seal. On top of that, the non-surgical retreatment especially with the presence of apical periodontitis has a reduced success rate of 60% (Sjogren et al 1990). Therefore, in this case endodontic surgery could be considered as the best option to manage the persistent infection at the periradicular area especially when condition of the bridge is good sound margin with no evidence of secondary caries.

In recent years, endodontic surgery has evolved to become endodontic microsurgery. This approach can produce predictable outcomes in the healing of lesions of endodontic origin. State-of-the-art equipment, instruments and materials that match biological concepts with clinical practice have improved a lot is the way in which surgery is performed (Kim & Kratchman, 2006). When the surgery is concentrated at the anterior part of the mouth, the highly esthetically critical zone must be considered as well as to treat the disease. For example, it is necessary, to preserve the interdental papilla as well as minimizing gingival recession at the anterior maxillary region (Velvart, 2005).

This case report describes the surgical management of tooth 23, diagnosed with symptomatic apical periodontitis, which was an abutment of a long span bridge.

Case Report

A 57-year old female Malay patient with a non-contributory medical history was referred to the Endodontic Specialist Clinic, Faculty of Dentistry, Universiti Kebangsaan Malaysia (UKM) due to pain on palpation at the buccal mucosa in relation to the upper left canine region. The patient graded the pain 3/10 on visual analogue scale (VAS). The patient reported that she had root canal treatment in the year 2003, followed by the bridge construction two years later. She was asymptomatic until recently.

Figure 1: Site of complaint, which was the maxillary left canine.

Clinical Examination

Extraorally, patient's smile line was moderate (Camara 2010). Upon intraoral inspection and evaluation of the patient's oral condition, she had generalized gingivitis of both the upper and lower jaws. Her dentition was heavily restored with fixed dental prostheses and generalized attrition was noted. There was a bridge to replace the missing 12, 11, 21 and 22 with tooth 13 and tooth 23 crowned as the abutments (Figure 1). The condition of the bridge was aesthetically satisfactory with sound crown margin on both abutments. However, tooth 23 was tender on percussion and the buccal mucosa was tender on palpation at the sulcus.

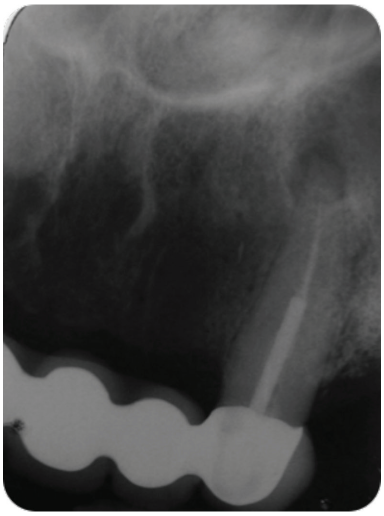

Figure 2: Intraoral radiograph of maxillary upper canine.

Sulcular periodontal probing depths were less than 3 mm with 1mm gingival recession and with adequate keratinized gingiva (measuring around 4 mm). There was no pathological mobility of the tooth. A periapical radiograph showed presence of a parallel-sided post inside 2/3rd of the root length with root canal filling 3mm short of the radiographic apex (Figure 2). Periradicular radiolucency was noted measuring about 3x3mm.

Cone beam computed tomography (CBCT) imaging revealed 3x3mm radiolucency with penetration of the buccal bone in relation to the affected tooth. The palatal bone was intact however there was a possible communication of the lesion with the maxillary sinus (Figure 3).

Diagnosis and Treatment Plan

Tooth 23 was diagnosed with previously treated, symptomatic apical periodontitis. It was decided that the endodontic microsurgery would be carried out as the best approach considering the condition of the bridge and the presence of a long post in the canal. The patient strongly wished to save the tooth and consented to the treatment after being informed about the treatment plan, the procedures and prognosis of the tooth.

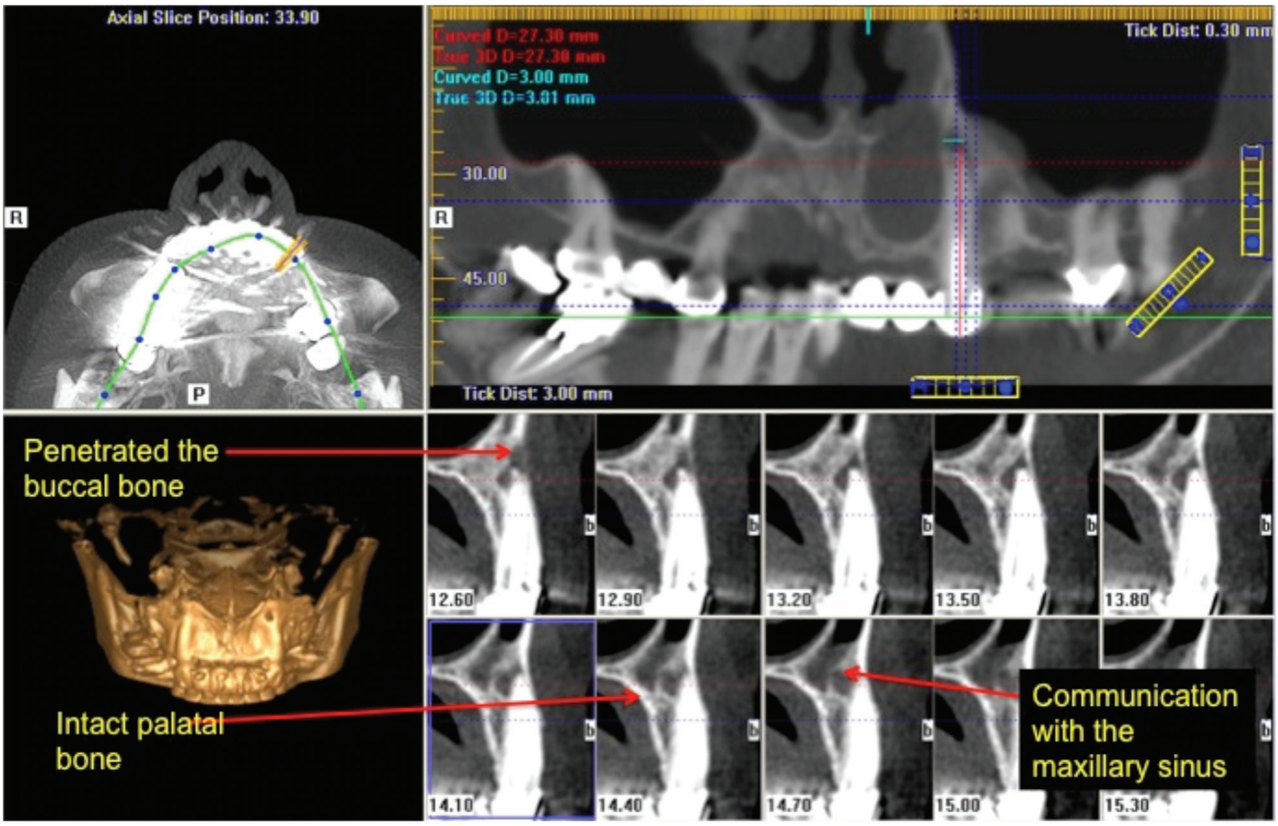

Figure 3: Cone beam computed tomography of tooth 23.

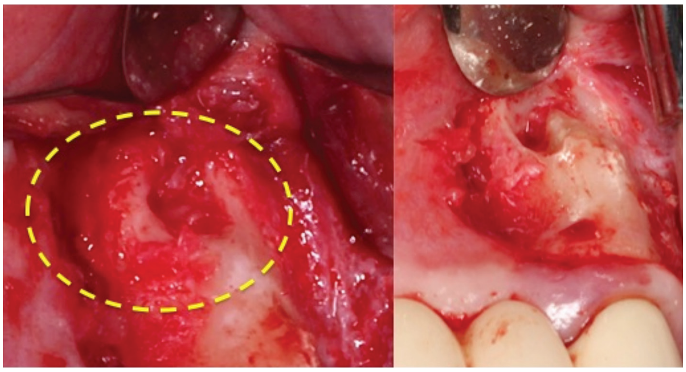

Figure 4: Detection of the lesion and osteotomy performed.

Surgical Procedure

After a thorough assessment of patient's soft and hard tissue condition, endodontic microsurgery was planned for the patient and submarginal/ Luebke-Oschenbein flap design was chosen. All procedures were done with the aid of surgical microscope (OPMI Pico, Zeiss, USA). The surgical area was anaesthetized (4% Mepivacaine containing 1:80,000 adrenaline) using nasopalatine nerve block as well as infraorbital nerve block technique to achieve a profound anaesthesia of the anterior maxillary region. The tissue was incised using blade 15C. A full mucoperiosteal submarginal flap was elevated. Due to the bone penestration, the lesion was automatically located and osteotomy around 4mm was performed (Figure 4). The inflamed and infected granulation tissues were removed and the area was washed with saline. The root end was resected 3mm from the anatomical apex using a tapered diamond bur and Impact Air 45 handpiece (Palisades Dental, USA) . The surface of the resected root was stained with methylene blue dye to detect presence of crack lines and it was inspected under the highest magnification. Preparation was made 3mm into the canal using retro-prep ultrasonic tip (SybronEndo Europe, Netherlands). TotalFill Bioceramic (FKG, Switzerland) was used as root end filling material (Figure 5). The surgical area was washed with saline and flap was re-approximated and sutured. A post-operative radiograph was taken and post-operative instruction for oral hygiene care of the surgical site was given to the patient (Figure 6 and Figure 7).

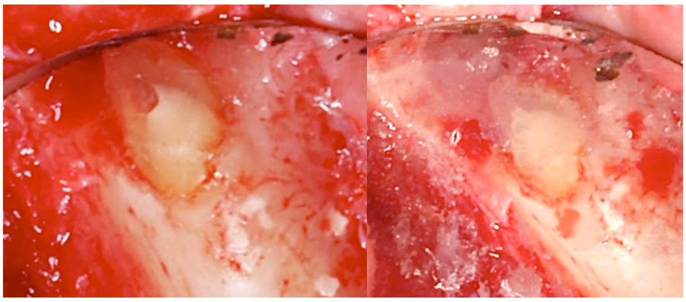

Figure 5: Root-end resection, root-end preparation and root-end restoration.

Review

At the 6-month follow-up examination, the tooth was clinically asymptomatic, not tender to percussion, with no abnormal mobility and periodontal probing depths were within normal limits. Soft tissue healing was noted with minimal scarring and minimal gingival recession. Radiographic examination revealed healing of the periapical tissue with reduction of the radiolucency area and deposition of bone noted (Figure 6 and Figure 7).

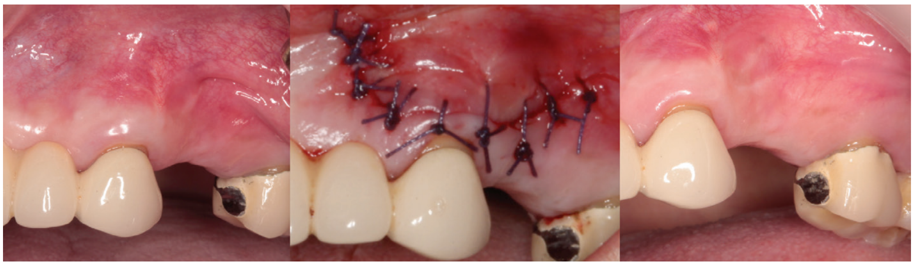

Figure 6: Pre-operative, post-operative and 6-months review of the surgical site.

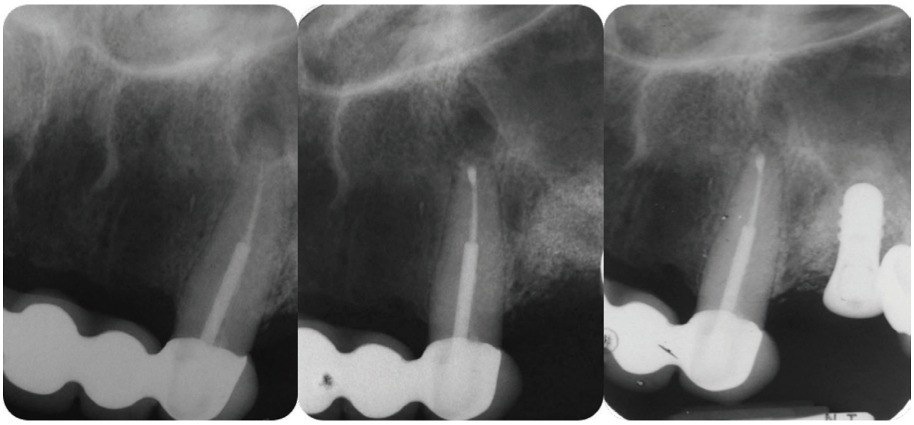

Figure 7: Pre-operative, post-operative and 6-months periapical radiograph.

Discussion

Endodontic surgery has been practiced for years and has often been considered as an alternative to root canal treatment. One of the indication of endodontic surgery is when the apical part of the root is inaccessible by a coronal approach due to posts, calcifications or procedural accidents (Molven et al, 1991). In this case, the surgery gives the benefit of preserving the existing prothesis as well. Years ago, success rates for endodontic surgery was very low leaving doubt to the value of the treatment (Frank et al 1996). More recent studies have shown that these failures were due to the persistent infection from the root canal indicating insufficient canal cleaning and the root fillings placed at the end of the root often do not provide the apical seal (Frank et al 1996). In a recent systematic analysis of literatures on endodontic treatment outcome, success rate for endodontic surgery at 2–4 years (77.8%) was found to be significantly higher compared with nonsurgical retreatment for the same follow-up period (70.9%). At 4–6 years, however, this relationship was reversed, with nonsurgical retreatment showing a higher success rate of 83.0% compared with 71.8% for endodontic surgery. From this analysis, it appears that endodontic surgery offers more favorable initial success, with nonsurgical retreatment offers a more favorable long-term outcome (Torabinejad et al, 2009).

With the advances of the surgical microscope, root end filling materials and root end preparation tools, the outcome of the surgery is more predictable. Surgical microscope provides magnification and illumination to enable visualisation of minute details of the root end, such presence of cracks and resorption. It also facilitates precise preparation of root end keeping the size minimal. Impact Air handpiece was used to resect the root end. This handpiece has a small and unique head design. The head is angulated 45° to the body of the handpiece which gives better access and visibility to the surgical site, especially in areas of the mouth that is difficult to reach. The rear air exhaust drives air away from the surgical site and provides patient safety in preventing air emphysema. The waterline inside the handpiece produces pure jet of water instead of water spray/mist therefore eliminating forced air into the surgical area.

Root bevelling has been found to expose more dentinal tubules and this causes an adverse effect to the healing process. Therefore it is no longer practiced. The use of small ultrasonic tip with angled design allows better access into the bony crater to enable the root end to be prepared sufficiently. The preparation of the root end is still necessary to clean the canal and it should extend deep to well-condensed gutta percha or to the apical end of a post.

It is important to choose the most biocompatible and anti-bacterial material that can seal and fill the apical canal space. Total Fill Bioceramics (FKG, Switzerland) is a premixed putty ready-to-use cement developed for permanent root canal repair and filling applications. The advantages of bioceramic material are its high pH (pH >12.5), high resistance to washout, not affected by the presence of blood, no-shrinkage during setting and excellent biocompatibility. Its compressive strength of 50-70 MPa, similar to that of Mineral Trioxide Aggregate (MTA) (Koch et al, 2013). As with MTA, it has the ability to promote tissue regeneration during healing.

Flap design could influence the success of an endodontic microsurgery (Grandi and Pacifici, 2009). In this case, anterior and posterior to the surgical site were an edentulous span, so we could not perform a papilla preservation flap design. Therefore, we opted for a submarginal/Luebke-Oshenbein flap design. This flap design consisted of two vertical incisions and one horizontal/scalloped incision. It needs at least 2mm of attached gingiva and is commonly indicated in teeth with existing fixed restorations and in cases where aesthetics are a major concern, usually in the anterior maxillary area. The advantages of this type of flap include leaving the marginal and interdental gingiva intact, minimal gingival recession and lesser bone resorption as the crestal bone was left unexposed (Ahmed et al, 2013). Post-surgical hygiene is also feasible.

During surgery, it is important to keep the patient comfortable and pain free throughout the procedure. In this case, the infraorbital nerve block was employed to achieve profound anesthetic effect. Advantages of using this technique include the use of a smaller amount of local anesthetic to achieve anesthesia than is required for local infiltration and it can also provide anesthesia without causing tissue distortion. A successful infraorbital nerve block will provide anesthesia for the area between the lower eyelid and the upper lip. After application of topical anaesthesia, the upper lip was retracted outward and the mucolabial sulcus was examined at the second premolar region. The needle was introduced around 1.5-2.5 cm upward into the mucosa opposite the upper second premolar, keeping the needle parallel with the long axis of the second premolar (needdle is approximately 0.5 cm from the buccal surface) until it is palpated near the infraorbital foramen. Before injecting the local anaesthesia, the syringe was aspirated to ensure the needle was not in the blood vessel.

Newer study suggests that the success rate of surgical endodontic treatment in a 1-year follow-up was up to 89% (Tsesis et al, 2013). Surgical endodontic treatment resulted in a better short-term healing, however when the follow up was extended to 4 years the outcome for the both non-surgical and surgical procedures became similar (Del Fabro et al, 2007).

Conclusion

Endodontic microsurgery is indicated in cases where performing root canal retreatment is difficult. With proper use of equipments and materials, the surgical procedure can be carried out without much of a hassle and the outcome of treatment will be favourable.

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Write the Right Word

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Language is our major communication tool. We use words to convey our thoughts and intentions to others. The use of an incorrect word paves the way towards misunderstandings. In precise areas, such as medicine and dentistry, it is absolutely imperative to use exact words to avoid misunderstandings. Words such as mesial, osteoclast, and gram-negative anaerobes may not mean much to the average person, but contain a world of information to the endodontist. When one learns a new topic it also includes learning a new nomenclature in order to understand and to be understood. Obviously, the nomenclature must be correct. However, in the endodontic nomenclature there are presently three highly misused terms: obturation, three dimensional filling, and biomechanical instrumentation.

In 1985, the late endodontist and linguist Dr. Murray Cantor, published an article entitled "Suit the word to the action". The article dealt with the increasing misuse of words, especially the misuse of the word "obturation" in endodontics. Dr. Cantor pointed out that to obturate means to close or to obstruct. It definitely does not, in any way, mean to fill. As Dr. Cantor so elegantly explained it to his students: "If you fill a bottle with water and place your thumb at the opening, you can turn the bottle upside down without losing a drop. The thumb has obturated the opening, but it has of course not filled the bottle. A retrograde filling is placed to obturate the apical end of the canal. A root filling is placed to fill the canal." Unfortunately, Dr. Cantor's article apparently became one of the most ignored texts in our field. The word obturate is used constantly and incorrectly in endodontic textbooks, articles, and on a daily basis. For the sake of our patients, I hope we fill the root canals and not just obturate them.

Some years ago an article was published which emphasized that canals should be filled not just in the two dimensions of the radiographic image, but in all dimensions (Schilder 1967). The author intentionally used the term "three dimensional filling" to stress this point. Unfortunately, in proceeding years the term has been made into a "root filling standard" which is a misuse of the term. If you look at it from a physics perspective, all fillings are three-dimensional even the poor ones. It is not possible to make a two-dimensional filling in our three dimensional world.

Every now and then you find in endodontic literature the expression "biomechanical instrumentation" as a description of the use of endodontic instruments in the root canal. Biomechanics is the branch of science which deals with muscles and bones and their interactions during movement. There is a vast literature on Biomechanics (for information, please see the website of the American Society of Biomechanics). So, to be precise, the only thing that is biomechanical during "biomechanical instrumentation" is the movement of the clinician's hands and fingers.

Some may say that this is just a matter of semantics and they will be absolutely right. It is a matter of understanding the words we use. It is a matter of understanding what we do.

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Restorative Considerations for Endodontically Treated Teeth

Armin Segarra, DMD

Introduction

After the work of the endodontist is done, it is up to the restoring dentist to make the root canal treatment worthwhile. Successful root canal treatment is a result also of the successful restoration of the root treated tooth. Although restorative procedures are done after root canal treatment, it is wise to assess the restorability of the tooth in question beforehand.

This article will present several cases on restoration of endodontically treated teeth and will thoroughly discuss the reasons for such choice of restoration as well as explain some biomechanical principles that were considered during the restoration of these teeth. Such principles and factors include: 1) the amount of remaining tooth structure, 2) the ferrule principle, 3) cuspal protection, and 4) post space diameter.

Assessment of Remaining Tooth Structure

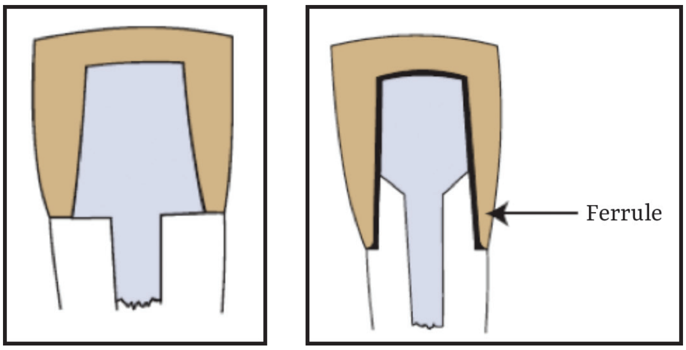
In restoring endodontically treated teeth, the restorative dentist needs to assess the remaining tooth structure after the root canal treatment is done. The amount of remaining tooth structure after endodontic treatment usually dictates the type of restoration and restorative material (Assif and Gorfil, 1994). It is common misconception that root canal treated teeth are best restored with post-core and crown. This however, is not true as there are more conservative restorations available. Restorations can be as conservative as a composite resin to close the access opening, an onlay made with either direct composite resin or ceramic, post-core and composite or just simply core build-up and crown. The more tooth structure remaining, the more conservative will be the restoration.

Amount of Remaining Coronal Tooth Structure

Most endodontically treated teeth are structurally weak as externally, they had been destroyed by caries or trauma, and internally by root canal preparation. These teeth usually have weakened walls especially the proximal walls. There are varying opinions regarding adequate thickness of remaining coronal tooth structure. Many researchers opine that the minimum thickness of dentin between the inside of the canal wall and the outside surface of the ferrule should be at least 1 mm (Caputo et al, 1976; Tjan and Whang, 1985; Sorensen and Engelman, 1990). Furthermore, a study by Hunter et al in 1989 found that thicker coronal dentin reduces chances of failure by tooth fracture. These principles regarding thickness of remaining coronal tooth structure still hold true despite advances in restorative materials.

The Ferrule Principle

A ferrule is a band of metal or restorative material which totally encircles the tooth, extending 1 – 2 mm onto sound tooth tissue to guard against longitudinal fracture (Figures 1 and 2). The availability of 2.0 mm of coronal tooth structure between the shoulder of the crown preparation and the tooth/core junction has been shown to provide a ferrule effect enhancing fracture



Figures 1 and 2: Left figure: A crown placed without ferrule. Right figure. Illustration of proper ferrule.
(Illustration adapted from Gegauff AG. J Prosthet Dent 2000)

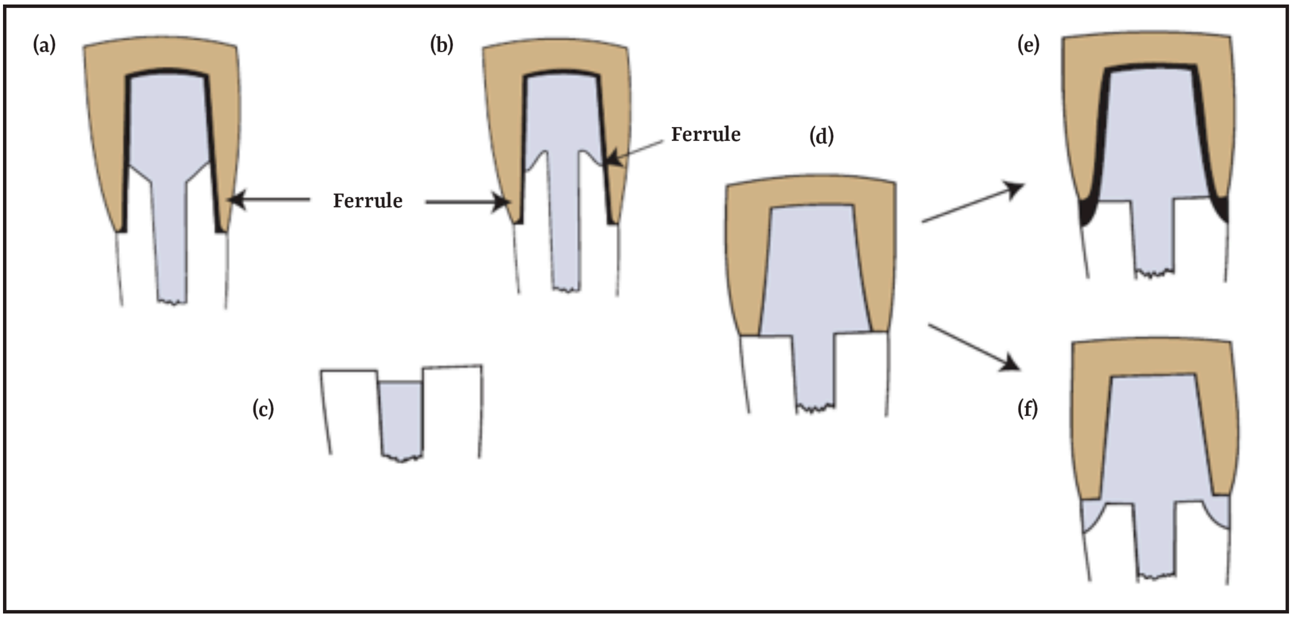


Figure 3: Ways to obtain ferrule in severely decoronated teeth. *(Illustration adapted from Gegauff AG. J Prosthet Dent 2000)*

resistance and preventing fracture and dislodgement of the post (Gegauff, 1990). In a severely decoronated tooth, the ferrule may be difficult to obtain. Figure 3 shows how a ferrule can still be obtained in such situations.

Not incorporating a ferrule in post and core situations will weaken the tooth up to 100% thus leaving it more susceptible to fracture in service (Dikbas et al, 2007). However, there are some instances when a 360° circumferential ferrule is impossible to achieve. In these instances, the location of the remaining coronal tooth structure becomes of primary importance (Ng et al, 2006; Muangamphan et al, 2005). In both studies of Ng et al, 2006 and Muangamphan et al, 2005, a ferrule on the palatal only has significantly similar fracture loads as a completely circumferential ferrule. Muangamphan also found that ferrules on 3 walls, that is, labial, palatal and mesial increases fracture resistance.

Cuspal Protection

A premolar or molar that has undergone root canal treatment is best restored with full cuspal coverage, because usually the root canal treatment renders the remaining walls weak to withstand excursive and laterally directed forces. The access preparation results in greater cuspal flexure and increases the probability of fracture (Varlan, et al 2009). Several studies including those of Cheung et al, 2003 and Aquilino et al, 2002 show that endodontically treated teeth with cuspal coverage have higher survival rate than those without. However, contradictory findings have also been reported such as the one by Mannocci et al, 2002 which states that there is no significant difference in survival rates between root canal treated teeth with or without full cuspal coverage. It was mentioned that other factors such as tooth function, occlusal loading and tooth position in the arch, also play important roles in the survival of endodontically treated teeth. If ever some cusps are to be preserved, the operator must make sure there is adequate thickness of the remaining axial walls to withstand occlusal forces (Trope et al, 1985).

Post Space Diameter

There are claims that even if the post occupies up to 50 percent or half of the tooth diameter, it is still deemed capable of withstanding fracture forces in the mouth. However, from the perspective of conserving tooth structure and decreasing the risk of root fracture, it is recommended that the post width should not exceed one-third of the root width at its narrowest dimension (Morgano, 1996; Cheung, 2005) and there should be a minimum of 1 mm of sound dentin surrounding the post especially in the apical area where it is narrowest and the stresses are greatest (Caputo and Standlee, 1976; Cheung, 2005). Greater than 50 percent post space makes the root already very weak and thus prone to fracture (Standlee et al, 1978).

Increase in the post space diameter occurs with endodontic re-treatment which may happen several times. With a bigger post space, it is recommended to fill the space with composite which will be cured through a light transmitting fiber post. The end result is a big post and core made of composite. A casted post is not recommended in this case because it will definitely fracture the remaining root structure while in function (Assif et al, 1993).

Clinical Examples

Restoration of Anterior Teeth

Case 1: Restoration with composite resin

After endodontic treatment, most of the tooth structure is deemed intact. Coronal tooth structure lost was limited to the access opening. No heavy occlusal contact was observed on the tooth. There was no discoloration that will affect esthetics, hence non-vital bleaching was not necessary. For this case, the recommended restoration was merely to seal the access opening with composite.

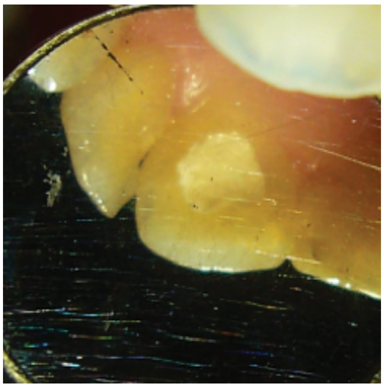


Figure 5.1: Tooth 11 after endodontic treatment. Note that the tooth is relatively intact except for the access opening.

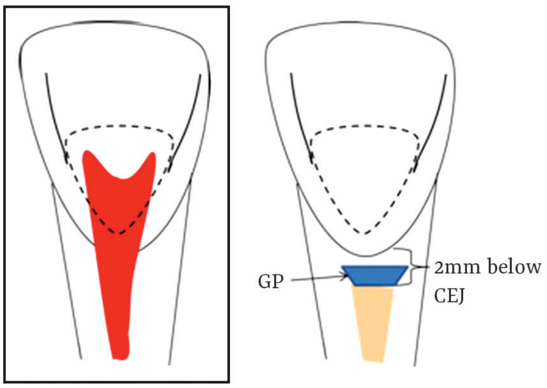


Figure 5.2: Gutta percha is cut 2mm below CEJ as gutta percha beyond the CEJ may disintegrate and later on cause discoloration. A periodontal probe is used to measure the level of gutta percha remaining in the canal. A layer of glass ionomer with a thickness of at least 0.5 mm was placed over the gutta percha bed.

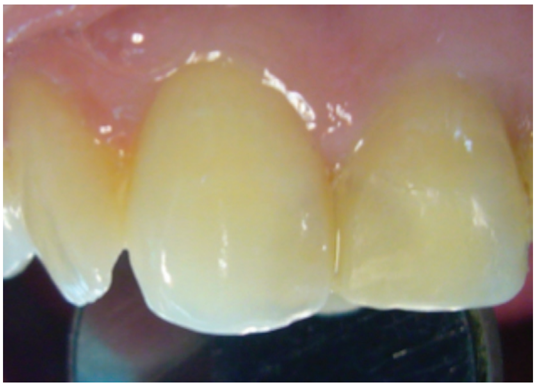


Figure 5.3: The tooth showing no signs of discoloration on the labial, hence there is no need for non-vital tooth bleaching. The small proximal cavities were then filled with direct composite resin (picture not shown).

As long as the pulp chamber is cleaned of remaining debris and caries and the gutta percha is below the CEJ, there will be no discoloration. One common cause of discoloration after root canal treatment is the remaining pulp horn due to inadequate access preparation. Access preparation for the maxillary central incisor should be triangular and not ovoid to include the pulp horns (Figure 5.2).

Case 2: Large Class IV lesion restored with composite resin only

The retention of large composite restorations has been greatly improved with recent advancements in dental adhesive systems. In some cases, large composite restorations can be retained without the use of posts or pins resulting to more conservative restorations that preserve much of the remaining tooth structures. The clinician should always remember that the use of post in endodontically treated teeth does not in any way increase the resistance of the tooth to fracture but instead, preparation for the post space might even weaken it due to removal of remaining tooth structure.

Figure 6.1: Tooth 11 was endodontically treated and upon removal of the temporary restoration, a large Class IV cavity on the mesial surface was revealed.

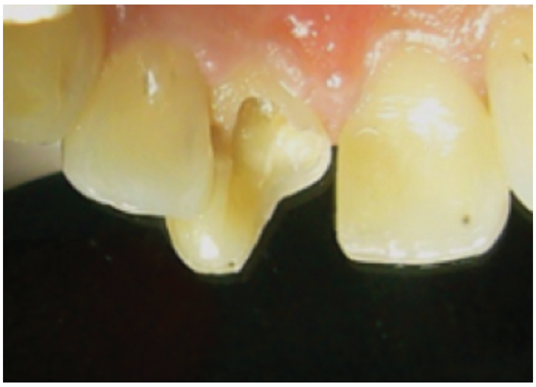


Figure 6.2: Upon careful analysis of the remaining tooth structure and of the occlusion, sufficient bulk of tooth structure was still present and no heavy occlusal load is exerted on this tooth. With these considerations, the restoration of choice was merely to seal the access preparation and restore the Class IV cavity with Composite resin.

As in the previous case, the gutta percha root filling was removed 2 mm below the CEJ and covered with at least 0.5 mm base of glass ionomer cement.

Case 3: Cuspid restored with a post and core - crown

The next case is an endodontically treated canine, 13 (Figure 7.1). Although it has the same amount of remaining tooth as in the previous case, this canine will be used as an abutment for an RPD, thus much load is expected to be exerted on it. Restoring the missing portion with composite will not be adequate. In this case, a post core and crown is the restoration indicated.

Figure 7.1: Endodontically treated canine

Post selection

Different types of posts are available. In general, tapered posts do not exert stress on the remaining dentin, but is not retentive. Parallel posts are more retentive but may cause weakening of the root the closer it gets to the tapered apical area. Metal posts have good mechanical properties but are not esthetically acceptable when show-through occurs as in all-porcelain crowns. Fiber posts are more esthetically acceptable, but need additional procedures (bonding procedures of the internal root surfaces and the tooth structure) are needed to make it retentive.

This author's preference is screw metal posts because of its retentiveness as it engages the dentin during placement. Caution should be exercised though, because it exerts stress on the root dentin, and excessive force might fracture the root.

In this case, the tooth being a canine, the obturated canal is long. Cutting the gutta percha for the post space may be done up to the length of the crown to be restored, that is, a 1:1 post length to crown ratio is sufficient (McLean, 1998). By doing so, one need not cut the gutta percha up to the recommended 4-5 mm apical seal, leaving a longer apical seal which is more advantageous (Figure 7.2).

Figure 7.2: Gutta percha cut to have a 1:1 ratio of post to crown length, thus leaving more than minimum gutta percha length at apical canal area.

Figure 7.3: Two posts selected. Note the temporary crown with paper clip wire at the left.

Figure 7.4: The first post fitted tightly but only a small portion of the post head is exposed.

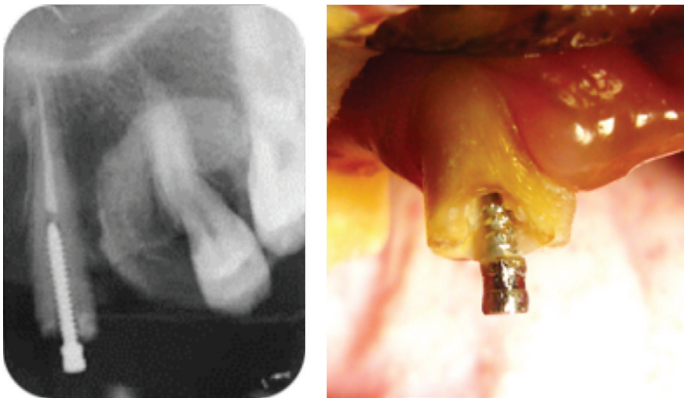


Figure 7.5: The second post fits better because a good portion of the post head is exposed to support the core.

For post selection, the post should fulfill two criteria (Figures 7.3 to 7.5): 1) post should have enough post head jutting out from the canal to be able to hold and support the core, and 2) there should be a snug fit.

Core Build-up

There are several materials available for core build-up which includes composite resins, glass ionomers and amalgam. Composite has good bonding and mechanical properties. Glass Ionomers are not recommended for core build-up because of its weak mechanical properties. Amalgam may be used as well, with its superior mechanical properties (McLean, 1998). However, mercury issues, and the need for an additional appointment to let the amalgam fully set, are some of its disadvantages as a build-up material.

For this particular case, composite was used for the core build-up. The final restoration was porcelain fused to metal crown.

Figure 7.6: Composite core build-up on 13.

Figure 7.7: PFM as final restoration. Tooth 13 is ready to be used as abutment for an RPD

Case 4: Excessive removal of gutta percha filling

This next case is another post-core-crown restoration because there is almost no coronal tooth structure remaining (Figure 8.1).

Figure 8.1: Radiograph of completed RCT on 21.

A common error in removing gutta percha filling when creating post space is the misconception that one should stick to the 4-5 mm gutta percha seal regardless of the length of the root and the required post-crown ratio. This case is a classic example of such misconception (Figure 8.2).

Figure 8.2: Excessively cut gutta percha.

Gutta percha is cut excessively, leaving only 4 mm of gutta percha at apical area. The post fitted should have been adequate, that is a 1:1 ratio of canal length and crown length and with 9 mm of gutta percha remaining. However, the clinician thought that leaving 4-5 mm of gutta percha apical seal is the rule of thumb, too much gutta percha was removed leaving a big space present between the gutta percha and a post that fulfills the 1:1 post to crown length ratio. This is unacceptable because the void may cause reinfection of the canal (Figure 8.2).

Fortunately, a fiber post was obtained that filled the canal length (Figure 8.3) eliminating the need for re-obturation which would have been too tedious.

Figure 8.3: A fiber post with a good fit within the canal.

Figure 8.4: The case after post placement and composite build-up. Take note of the attempt to follow the ferrule principle. At the mesial area, there is little tooth structure remaining.

Figure 8.5: The restored tooth 21 after PFM crown placement.

Restoration of Posterior Teeth

For posterior teeth that have undergone RCT, of primary importance is the remaining tooth structure after the RCT is completed. Generally, a restoration with full cuspal coverage is recommended, because the forces exerted on the remaining cusps may fracture the tooth more easily.

For a molar tooth which has undergone RCT, the recommended final restoration is full coverage crown or a full coverage onlay. When, after crown preparation, the axial walls will have 2mm or more of thickness, a full crown restoration is possible. If at least 2 mm of coronal height, is available throughout the whole circumference of the tooth, a post is no longer necessary, because the ferrule provided will be enough to hold the crown restoration. It should be remembered that a post does not strengthen a tooth. It merely retains a core build-up. In addition, most molar roots are small and thin, a post for posterior teeth is usually not necessary.

When the remaining tooth structure on the axial walls is thin (1mm or less), a viable option to preserve the remaining intact tooth structure is an Endocrown restoration (Pissis, 1995). The Endocrown covers the whole occlusal surface and 2 mm of occlusal reduction is usually necessary. Some dentists refer to Endocrowns as “onlays”. The pulp chamber is filled by the “onlay” material and serves as the post-core to help in retention. This will preserve the remaining intact tooth structure at the axial walls. As the pulp chamber is filled with the onlay material, the more accurate term for this kind of restoration is thus, “Endocrown.” Lander and Dietschi (2008) described Endocrowns made of ceramic as a “promising and conservative alternative to full crowns for the treatment of posterior non-vital teeth that require long-term protection and stability.” However, Magne and Knezevic (2009) support the use of composite resins as resins increased fatigue resistance of the overlay (onlay) in root canal treated molars and noted that 40% of tooth fractures below the CEJ occurred with ceramics while only 25% occurred with composite resins. Their study also revealed a 73% survival rate for composite resin overlays.

Case 5: Posterior case restored with a direct composite Endocrown (onlay/overlay)

Figure 9.1: Tooth 36 temporized after RCT. The axial walls at mesial, distal, buccal and lingual are thin with 1 mm or less tooth structure. Normal occlusal forces are exerted on it. This case is indicated for an Endocrown restoration.

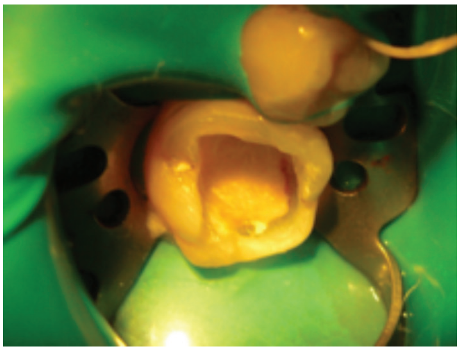


Figure 9.2: The preparation for a direct onlay is done by cutting cusps 2 mm occlusally. Orifices are covered with Glass ionomer base and bonding procedures done on the remaining tooth surfaces.

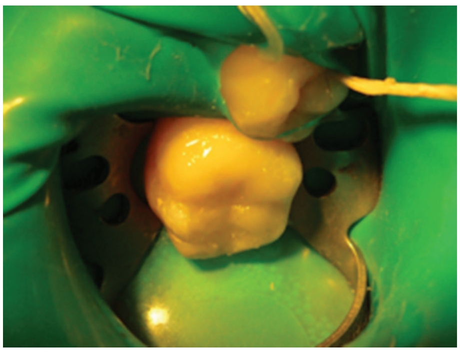


Figure 9.3: The finished composite build-up, with cusps and grooves. Minimum adjustments needed.

Figure 9.4: Polishing procedures.

Figure 9.5: Completed direct composite Endocrown restoration on tooth 36.

Case 6: Restoration of a root canal treated molar with direct composite Endocrown

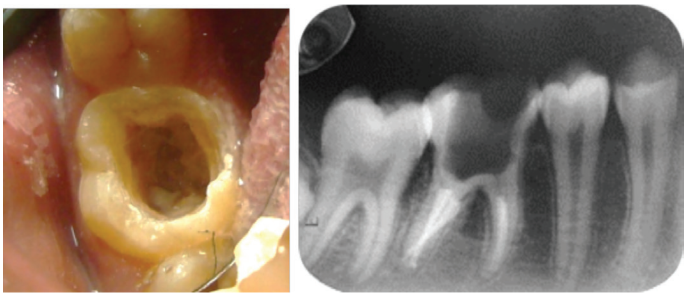


Figure 10.1: Tooth 46 after RCT. Much of the pulp chamber is hollowed out. Remaining walls are thin. This tooth is definitely not indicated for a full coverage crown restoration as reduction for crown will leave no coronal tooth structure remaining.

Figure 10.2: A layer of GIass ionomer base is placed over the orifices.

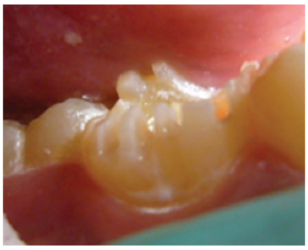


Figure 10.3: Depth cuts placed on the walls to ensure a 2 mm. reduction.

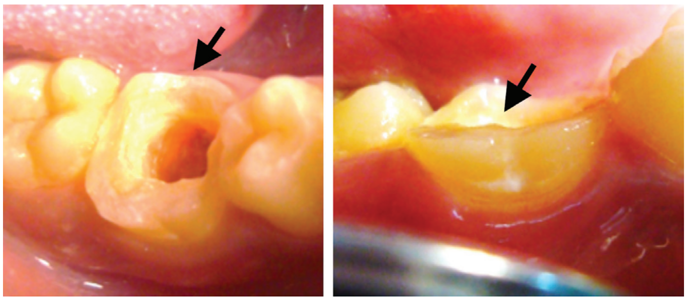


Figure 10.4: The tooth after cuspal reduction. Note the butt joint margins or so-called "cervical sidewalk."

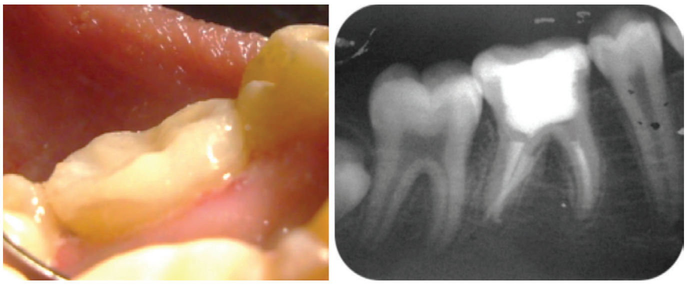


Figure 10.5: The final Endocrown restoration.

Conclusion

There are many ways of restoring the esthetics and function of endodontically treated teeth and the most appropriate restoration will be dependent upon the remaining tooth structure after the root canal treatment. The clinician must keep in mind to conserve tooth structure whenever possible, and restore the function by applying sound biomechanical principles.

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