CHAPTER 1
Diagnosis

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Dentistry has always been a fusion of science and art. Science provides the foundation for dentists to deliver optimal care. Evidence-based practice has successfully worked its way from medicine into dentistry. Every treatment decision that is made is at least partly influenced by the scientific support for its rationale. However, the science behind diagnosis relies on advancements in diagnostic equipment and armamentaria. The most consistent marker for an accurate diagnosis remains the clinician's ability to correctly process the diagnostic findings.

When patients are asked to grade the level of pain in an inflamed tooth after a painful stimulus is applied, it is foolish to assume a uniform and consistent response will be obtained from all patients. The International Association for the Study of Pain defines pain as an unpleasant sensory and/or emotional experience associated with actual or potential tissue damage [1]. Obviously, the physiologic condition of the tooth plays a major factor in pain perception, but the emotional aspect of this experience can modulate the pain levels among different patients. Factors such as past experiences, temperament, culture, gender, age, and overall pain tolerance can affect the responses. Recognizing this nuance is the trait of a good diagnostician. This is the *art* of diagnosis.

This chapter explores the various components that make up the examination process. A systematic approach to diagnosis is presented in order to gather the information thoroughly. A few clinical tips are offered to help clinicians with some of the confusing scenarios encountered during an examination.

Chief complaint

The chief complaint (CC) identifies the reason for the patient's visit. The information used to construct the CC is derived during the interview portion of the examination. This represents the very first interaction between the patient and the clinician. It is best to use the patient's own words when constructing the CC, rather than writing down a factual, objective sentence based on the initial interaction with a patient. For example, a chief complaint that reads *I have pain in my lower right back tooth after I bit down on an olive pit* is more complete than one that states *pain in the lower right tooth* or *evaluate lower right tooth*. Documenting the patient's own words often provides valuable information that can help steer the clinician toward an accurate diagnosis. It also allows the clinician to become familiar with the patient. Does the patient's demeanor suggest a high level of anxiety? Does the patient possess clarity of communication, or is the patient very vague and ambiguous when describing the purpose of his or her visit? Clinicians often overlook the significance of this last point. A patient lacking clarity of communication can make diagnosis more challenging for the clinician. Lastly, a well-documented CC allows the clinician to separate a coincidental finding or a coincidental diagnosis from the diagnosis that addresses the patient's CC.

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Medical history

Every patient who presents for evaluation or treatment should complete a thorough medical history form. The patient, or guardian if the patient is a minor, should sign and date the form. Prior to examining the patient, the clinician is responsible for reviewing the medical history with the patient, highlighting any medical conditions, a list of current medications, and any drug allergies. The clinician should initial the form to indicate that a review of the medical history has been completed. The medical history forms should be reviewed with the patient at every subsequent appointment and should be updated once a year to reflect any changes to the patient's medical history.

Many medical conditions require the clinician to modify a proposed dental treatment. Modifications to treatment can include shortening the appointment time, postponing elective treatment to a later date, or prescribing a course of antibiotics, just to name a few. Having a basic understanding of various medical conditions is paramount to providing appropriate care to patients with intricate medical conditions. The list of the medical conditions requiring a modification in dental treatment is vast. However, many textbooks and references are available to guide the clinician on how best to provide dental care for patients with medical conditions [2]. The clinician should also consult with the patient's primary health care provider if any aspect of the patient's medical history is not clear.

Recording the patient's blood pressure and pulse at the initial visit is an important step that provides the clinician with a broad snapshot of the patient's health status. Elevated blood pressure is associated with increased cardiovascular health problems. Even though hypertension is the most commonly diagnosed disease worldwide, undiagnosed hypertension is still prevalent in various patient populations. The findings of one study concluded that 20% of the sample patient population examined had undiagnosed hypertension [3]. Therefore, the clinician has an important role in screening for hypertension. Because the initial blood pressure readings can be elevated due to *white coat hypertension*, it is prudent for the clinician to obtain blood pressure readings at subsequent dental visits and compare the values.

If a patient presents with swelling or any other signs or symptoms of a dental infection, the patient's temperature should also be obtained and recorded. A febrile state justifies the use of antibiotics as part of a comprehensive dental treatment. The clinician should exercise caution when prescribing medications that may be contraindicated by the patient's medical history. Awareness of various drug–drug interactions that can adversely affect the patient's overall health is equally important. Online portals such as *HYPERLINK "http://www.pdr.net" www.pdr.net or lexicomp at HYPERLINK "http://www.wolterskluwercdi.com" www.wolterskluwercdi.com* are useful tools to aid clinicians in prescribing the appropriate pharmacological regimens for patients.

Relevant dental history

Clinicians often underestimate the importance of gathering an accurate account of the relevant dental history. Most clinicians transcribe the patient's description of the chronology of events as the dental history. Even though that is an important component, it is not the complete scope of the dental history. This chronology of events is better known as *history of present symptoms*. The other component of the dental history involves documenting any recent dental treatment in the offending area. If the patient is a new patient, the clinician should ask the patient about recent dental treatment. The information obtained can sometimes provide clues to guide the clinician toward an accurate diagnosis. For example, recent crown placement [4] or prior pulp capping [5] are positive findings that can lead to breakdown of pulp, even if the patient did not present with symptoms immediately after treatment was rendered.

Extraoral examination

Extraoral examination is the first opportunity for the clinician to examine the patient. This examination consists of a visual and a physical component. The clinician should look for any facial asymmetry. Asymmetry in the infraorbital, zygomatic, buccal, mandibular, or nasolabial regions may be an indication of facial swelling that has emerged from an intraoral source (Figure 1.1). If asymmetry is evident, the clinician should palpate the area to determine whether the swelling is firm or fluctuant, localized or diffuse.

Figure 1.1 Extraoral examination includes a visual assessment of facial asymmetry.

Swelling from an infection often includes localized lymphadenopathy as a concomitant finding. Therefore, palpation of the cervical and submandibular lymph nodes is an important part of every examination sequence, and a firm or tender lymph node should be recorded in the patient's chart.

Intraoral examination

The information obtained from the patient's chief complaint, the relevant dental history, and extraoral examination should direct the clinician to a more-specific area of the mouth for further examination. The intraoral examination is a focused examination of the internal structures in the suspected region of the mouth. For this examination to be thorough, it is prudent to implement a systematic approach to the examination process. A good examination sequence follows a pattern of *broad to narrow*.

The soft tissues are examined first. The tongue and the uvula should be positioned at the midline. The gingiva, mucosa, cheek, and tongue are dried using a dry gauze pad, and inspected for any abnormalities. The abnormality can be in color or texture. The presence of ulcerations is also an abnormality that must be noted. When recording an abnormality, a description of its color, texture, size, and location should be noted. The general rule is to reexamine the site in two weeks. If the abnormality is still present, the patient should be referred to an oral pathologist for further evaluation.

The clinician should then move to the quadrant of interest, to further examine the soft tissues. Intraoral swelling or the presence of a sinus tract should be noted. Swelling should also be palpated to determine if it is diffuse or localized and whether it is firm or fluctuant. This is an important point to emphasize, because a fluctuant swelling indicates whether a treatment of incision and drainage may be appropriate.

A sinus tract is defined as a pathway from an enclosed area of infection to an epithelial surface [6]. A sinus tract develops when a chronic infection drains to the surface and forms a nodule, known as a *parulis* (Figure 1.2). A sinus tract should be traced, when possible, because the location of the parulis may be distant to the source of the infection [7]. To trace a sinus tract, a thin gutta-percha point is placed through the tract until resistance is felt (Figure 1.3). A radiograph is exposed, allowing the clinician to see the path of infection to the source.

Figure 1.2 The presence of a sinus tract must be noted in the examination report.

Figure 1.3 A gutta-percha point is placed through the opening of the sinus tract until resistance is felt. A radiograph is obtained to identify the path of the sinus tract.

Palpation

The purpose of palpation is to assess the texture, rigidity, and tenderness of the tissues around the teeth. Palpation is performed using an index finger. This helps identify any areas of swelling that were not previously identified. Any tenderness to palpation, as compared to the contralateral side, should be recorded in the patient's chart.

Percussion

Percussion testing helps identify inflammation in the periodontal ligaments of a given tooth, termed *periradicular periodontitis*. If the patient's chief complaint includes pain when chewing or sensitivity to pressure, it can most likely be duplicated by performing a percussion test. The test is performed by gently tapping the occlusal surface using a blunt instrument, such as the back end of the mirror handle (Figure 1.4). It is prudent to test the contralateral side first so the patient can get accustomed to what a *normal* response feels like. The clinician should employ a simple system to record the values during percussion testing. Using one of three possible values of *normal*, *slight*, or + are sufficient to provide the necessary information for diagnostic purposes. Many clinicians assign multiple + values, such as +++, to emphasize the degree of sensitivity in a given tooth. This approach rarely adds any clinical significance, and it serves to complicate the diagnostic process by introducing an arbitrary component to the test. Having a simple value of *normal*, *slight*, *or* + is more than sufficient to underscore its importance.

Figure 1.4 Percussion testing is best performed by tapping a tooth using the back end of a mirror handle. The tapping force should be consistent when testing multiple teeth.

Figure 1.5 The Tooth Slooth is used to test for biting sensitivity in a given tooth.

The Tooth Slooth (Professional Results, Laguna Niguel, CA) can also be used to determine whether periradicular periodontitis is present. The plastic device is placed on the occlusal aspect of a given tooth, and the patient is asked to bite down on the stick (Figure 1.5). A painful response to biting down confirms inflammation in the periodontal ligaments of the tooth. Additionally, when the patient reports pain on release, this is usually

an indication of a cracked tooth. Refer to page 10 for more information on crack classifications.

Periodontal examination

The periodontal examination includes recording the probing depths of a given tooth, and mobility, if present. Grading the degree of mobility is rather arbitrary and ranges in increasing degree from +1 mobility to +3 mobility.

Probing depths should be measured in six areas of a tooth. The mesial, mid-root, and distal areas of the buccal and lingual aspects are measured. A probing depth greater than 4 mm signifies a possible periodontal attachment loss and may be a significant factor in the overall diagnosis.

Pulp testing

The patient's responses to pulp tests provide the requisite information that allows the clinician to formulate a pulpal diagnosis. Therefore, it is easy to see why pulp testing is one of the most important components of the diagnostic process. When diagnostic mistakes occur, they commonly result from misinterpretation of pulp test data, which can lead to an inconclusive diagnosis or misdiagnosis. Two common methods for pulp testing are electrical and thermal stimulations.

Electrical stimulation

Electrical stimulation is performed using a commercially available device, commonly referred to as the electrical pulp tester (EPT) (Figure 1.6). The tooth should be dried adequately and the probe from the device must be coated with toothpaste, which helps in the transfer of the current. Care must be taken to ensure the probe is placed over an area of natural tooth surface. Small probes are available that are suitable for placement under a crown margin, where tooth structure may be exposed. The patient needs to hold the probe in place to activate the current. Current is transferred to the tooth in increasing intensity until the patient feels a tingling sensation. The results of the EPT are usually interpreted as positive or negative (if no sensation is felt). The numerical reading is not usually of diagnostic importance, unless the value for one tooth is demonstrably higher than that for the other teeth. Even so, no definitive conclusions can be drawn from the disparity in values, only that test results may be questionable and further testing should be performed.

Figure 1.6 The Vitality Scanner 2006 from Kerr is a common electrical pulp testing device used in endodontic diagnosis. (Image courtesy of Kerr Endodontics.)

Thermal testing

Thermal testing is best performed using a refrigerant spray. The most effective refrigerant spray contains 1,1,1,2-tetrafluoroethane as its active ingredient and is commercially available as Endo-Ice (Hygenic Corp., Akron, Ohio) (Figure 1.7). Endo-Ice is easy to handle, easy to store, and environmentally safe. Endo-Ice has a low liquid temperature of −26.2 °C, which can decrease the intrapulpal temperature of a tooth effectively, thus making it useful for diagnostic testing [8].

Figure 1.7 Endo Ice has an effective working temperature to make it an ideal refrigerant for thermal testing.

Figure 1.8 Placing the pellet on the cervical third of the tooth ensures an accurate patient response.

Thermal testing should first be performed on a contralateral tooth to identify the *baseline* response for a given patient. The baseline response is the typical response of a normal tooth to thermal testing. This helps the clinician to identify a suspect tooth during testing, by identifying when a response deviates markedly from the baseline response. Endo-Ice, or any other suitable refrigerant, is sprayed liberally on a size #2 cotton pellet, and the pellet is placed immediately on the cervical third area of the tooth (Figure 1.8). The pellet is removed when the patient experiences a sensitive response. The patient is then asked about the onset, intensity, and duration of the sensitivity. The patient's response allows the clinician to formulate a pulpal diagnosis. For example, an immediate sensitive response that disappears rapidly on removal is generally accepted as a *normal* response. A hypersensitive response to thermal testing that disappears rapidly on removal is associated with *reversible pulpitis*. If the hypersensitive response is prolonged, or if sensitivity lingers after the stimulus is removed, then the pulp is in a state of *irreversible pulpitis*. Finally, a lack of response to the cold stimulus indicates *pulpal necrosis*.

Comparison of methods

A number of studies that conclude cold testing is more reliable than electrical testing [9] [10], and conventional wisdom supports this conclusion. For example, cold testing can enable the clinician to distinguish among the different stages of a vital pulp (normal, reversible pulpitis, and irreversible pulpitis), whereas EPT is usually interpreted as all or none (vital or necrotic).

The future

Laser Doppler flowmetry (LDF) is based on a technology that objectively measures the vitality of the pulp by way of assessing the blood supply rather than the sensory function. An infrared light beam is projected through the crown of the tooth. Based on the Doppler principle, if the frequency or the wave of the light beam is shifted, then there are moving red blood cells in the pulp. If the light remains unshifted, the pulp tissue is deemed necrotic. Many studies have found LDF to be accurate, reliable, and reproducible in assessing the pulp status [11]. However, the technology has not yet reached a point where the testing mechanisms or the equipment are practical and cost effective for everyday clinical use [11–13].

Pulse oximetry is an oxygen saturation monitoring technique that has been widely used in medical practice for years. A probe is placed over a tooth; the probe contains two light-emitting diodes: red light and infrared light. Some of the light is absorbed as it passes through the pulp tissue. A sensor on the other end of the tooth detects the amount of absorbed light. Since oxygenated and deoxygenated hemoglobin absorb different amounts of red and infrared lights, this ratio is used by the oximeter to calculate pulse rate and the oxygen concentration in the blood [14]. Like LDF, the pulse oximeter is an *objective* test, eliminating some of the bias challenges seen in thermal and electrical testing. However, much like LDF, the available pulse oximetry machines are not suitable for private dental offices because they are very expensive [15].

Box 1.1 lists other experimental diagnostic testing mechanisms that have been in research since the 1990s [17–19].

Interpreting Radiographs

Dental radiography is the most objective tool available to the clinician. The decision to expose radiographs (and if so, how many) is based on the information gathered from the previous portions of the diagnostic process. The chief complaint, extraoral and intraoral examinations, and pulp testing should provide the clinician with a preliminary impression of the type of dental problem the patient is presenting with. Many

Box 1.1 Experimental Diagnostic Testing Modalities

Photoplethysmography

Photoplethysmography is an optical measurement technique that can be used to detect blood volume changes in the microvasculature using a light with a shorter wavelength [16].

Transillumination

Transillumination uses a strong light source that identifies color changes that can indicate pulpal pathology [17].

Ultraviolet light photography

Ultraviolet light photography detects the different fluorescence patterns that can allow additional contrast of visible change that are otherwise more difficult to observe [18].

Cholesteric liquid crystals

The use of cholesteric liquid crystals in detecting pulp vitality is based on the principle that teeth with an intact pulp blood supply have a higher tooth-surface temperature compared with teeth that have no blood supply.

Optical reflection vitalometer

The optical reflection vitalometer is a system based on pulse oximetry. The difference from conventional oximetry is that adsorption is measured from reflected light instead of transmitted light. One can see the pulse of the pulp or the oral mucosa. This device may be used in cases of partially erupted or fractured teeth.

Thermographic imaging (Hughes Probeye Camera)

Thermographic imaging is another noninvasive method of recording the surface temperature of the body [19]. It is a highly sensitive method.

clinicians make the mistake of formulating a diagnosis solely on whether a lesion is present or absent on a radiograph. In many instances, an endodontic lesion is present but is not noticeable in a radiograph [20].

Because endodontic diagnosis is a focused examination, the number of radiographs exposed should be limited. In general, two or three periapical radiographs, exposed from different angles, allow adequate visualization of anatomical structures. In addition, at least one vertical bitewing should be exposed. The proximity of caries or a restoration to the pulp of a tooth is best determined with a bitewing radiograph. A vertical bitewing has an added benefit of providing the clinician with an impression of the alveolar crest and the furcation areas of a tooth.

When interpreting radiographs, clinicians often focus on the most obvious findings and overlook other, subtle findings that may be clinically significant. This can have deleterious consequences for both the clinician and the patient. Therefore, it is best to employ a systematic approach to interpreting radiographs. This ensures that radiographs are interpreted thoroughly and consistently every time. Once again, a pattern of broad to narrow, or general to specific, ensures that radiographs are thoroughly interpreted. Table 1.1 outlines the common structures that should be interpreted when evaluating a radiograph.

Tips for an accurate diagnosis

The components that make up the diagnostic data consist of objective and subjective findings. Objective findings are clinician derived and include radiographic interpretations or clinical observations, such as swelling and fever. Subjective findings are patient derived, such as the chief complaint and patient responses to various pulp tests. An accurate diagnosis is made when the clinician correctly interprets and processes these findings. Because the subjective findings are patient derived,

Table 1.1 Interpreting the dental radiograph.

Structure	Interpretation
Caries and quality of existing restoration	Proximity to the pulp
Osseous levels, including the alveolar crest	Bone loss
	Inconsistency in trabeculation
Lamina dura	Intact or missing
Radiolucency or radiopacity	Location
Widening of the periodontal ligament	Location
Root appearance	Normal or resorbed
Pulp canal space	Normal, calcified, or enlarged
	Traceable or not

the information obtained can be confusing at times and can mislead the clinician. Different patients perceive pain differently; therefore, responses can appear atypical or unorthodox at times. The following tips are provided to help minimize errors in interpreting test results.

- During testing for percussion sensitivity, it may be difficult for some patients to communicate the level of sensitivity clearly. If typical responses from a patient include "they all hurt" or "none of them hurt," it may be better to perform tests on pairs of teeth at a time, similar to an eye exam with the optometrist. Some patients can provide a clearer response when asked to compare sensations between two teeth, as opposed to responding about sensitivity on one tooth.
- In general, it is best not to inform the patient about which tooth is being tested. This ensures there is no bias in responses.
- Correctly interpreting a patient's response during cold testing can be challenging, especially when testing a necrotic tooth. One solution may be to approach this test differently. Before testing, the clinician should inform the patient that the purpose of the test is to assess the *maximum threshold* to cold. So, rather than placing a cold pellet on the tooth and asking the patient if it is sensitive, the focus should be on the maximum length of time the patient can tolerate the cold pellet. This approach minimizes the possibility of obtaining a false positive response from a necrotic tooth.
- During thermal testing, patients should be asked to rate their levels of sensitivity using a numerical scale. A scale of 1 to 10 works best, where 1 represents no sensation and 10 represents the worst pain. The clinician should first establish a numerical value for the *baseline* response, thereby calibrating the scale for each patient.
- Even though endodontic diagnosis sometimes involve multiple teeth, it is best to perform treatment one tooth at a time. In employing this modular approach to treatment, where the most obvious tooth is treated first, and the other teeth are reevaluated after a short interval, the clinician minimizes the risk of misdiagnosing or overtreating a patient.

Diagnostic terms

When making an endodontic diagnosis, it is important to provide both a *pulpal* and *periradicular* status for the tooth in consideration. The information gathered from the examinations, clinical testing, and radiographic findings is what is required to make an endodontic diagnosis. Tables 1.2 and 1.3 illustrate the classification states that are routinely associated with symptoms.

Since the 1950s, various diagnostic terms have been used to describe, essentially, the same clinical scenario. At a consensus meeting in 2008, the American Association of Endodontists sought to standardize the terminology used for pulpal and periradicular classifications. This was done in the interest of providing a uniform classification system to be used by clinicians, researchers, authors, and educators. The following are the various classification terms approved by the American Association of Endodontists and the American Board of Endodontics to describe different pulpal and periradicular conditions.

Table 1.2 Pulpal classifications.

Condition	Symptoms*		
	Yes	No	Maybe
Normal pulp		¶	
Reversible pulpitis	¶		
Symptomatic irreversible pulpitis	¶		
Asymptomatic irreversible pulpitis		¶	
Pulpal necrosis		¶*	
Previously treated		¶*	
Previously initiated treatment		¶*	

*Symptoms are exhibited when the periodontal ligament is inflamed. Necrotic pulps or pulpless teeth do not exhibit symptoms in the absence of periodontal ligament inflammation.

Table 1.3 Periradicular classifications.

Condition	Symptoms		
	Yes	No	Maybe
Normal		¶	
Symptomatic apical periodontitis	¶		
Asymptomatic apical periodontitis		¶	
Acute alveolar abscess	¶		
Chronic apical abscess			¶

Classification of pulp

Normal pulp

A diagnosis of normal pulp (NP) is made when a tooth does not exhibit any atypical symptoms during testing. The tooth responds positively to pulp testing; however, the sensation is transient and disappears in seconds. When identifying a tooth as a control tooth during pulp testing, that tooth is intended to have a diagnosis of NP.

Reversible pulpitis

Two findings differentiate reversible pulpitis (RP) from a normal pulp: In RP, the suspect tooth is hypersensitive to thermal testing, as compared to a control tooth. In RP, a clinical finding such as caries, deep restoration, failing restoration, or exposed dentin is commonly seen during examination.

Symptomatic irreversible pulpitis

The pulps of these teeth generally have spontaneous pain. The pain may be sharp or dull, of short duration or long, and localized or diffuse. When pulp testing, the pain from testing lingers well after the stimulus is removed. Radiographs might show a finding such as deep caries or a deep restoration. When reviewing the dental history, it is not uncommon to find recent treatment involving a deep restoration, pulp exposure, or a pulp-capping procedure. However, this diagnosis is mainly a symptom-based diagnosis.

Asymptomatic irreversible pulpitis

In asymptomatic irreversible pulpitis, the tooth is not symptomatic; however, the suspect tooth usually shows caries that has extended into the pulp. The tooth may respond normally to thermal testing. Whereas symptomatic irreversible pulpitis is mainly a diagnosis derived from symptoms, asymptomatic irreversible pulpitis is a diagnosis derived from clinical or radiographic findings. Some examples include a tooth that has radiographic evidence of caries extending into the pulp or an asymptomatic tooth that has had a carious pulp exposure.

Pulpal necrosis

In pulpal necrosis, the pulp of a given tooth does not respond to pulp testing. No other associated findings need to be present in order to make this diagnosis.

Previously treated

The classification of a previously treated tooth is different from the others described above because the diagnosis is made by the dental history and radiographic confirmation that the tooth has had endodontic treatment (Figure 1.9).

Previously initiated treatment

Teeth with previously initiated treatment have had endodontic treatment initiated but not completed. Similar to the *previously treated* classification, pulp testing is not needed in order to make this diagnostic. There needs to be a recent dental history that pulpotomy or pulpectomy was performed or a radiographic verification that the pulp of the tooth has been partially treated. The difference between this classification and *previously treated* is that endodontic treatment has not been completed.

Classification of the periradicular area

Normal

The tooth responds normally to percussion and palpation testing. Radiographically, the lamina dura is intact, and the periodontal ligament space is uniform with no indication of periradicular rarefaction.

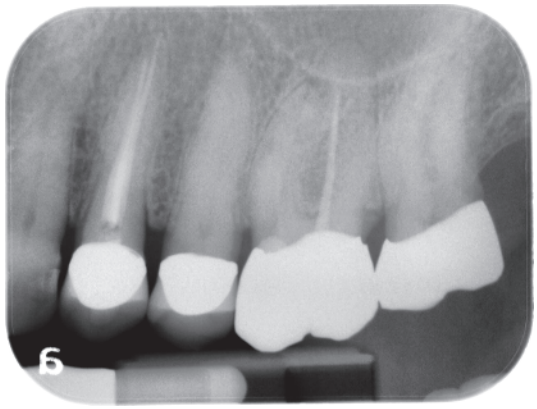


Figure 1.9 Even though endodontic treatment on tooth #14 is incomplete, the pulpal diagnosis would still be previously treated.

Symptomatic periradicular periodontitis

This is perhaps the easiest classification to make for clinicians. The diagnosis is made if the tooth is sensitive to biting pressure, percussion testing, or palpation. However, there is no swelling. Radiographic findings may or may not be present. However, this diagnosis is based solely on the presence of symptoms during testing.

Asymptomatic periradicular periodontitis

In asymptomatic periradicular periodontitis, the tooth responds normally to percussion and palpation testing, but there is radiographic evidence of radiolucency in the periradicular region of a tooth. The radiographic evidence can be subtle, such as widening of the periodontal ligament space, or it can be obvious, such as periradicular lucency. It must be emphasized that the patient does not present with any pain to percussion or palpation testing.

Acute apical abscess

Acute apical abscess is an inflammatory reaction to a pulpal infection, characterized by swelling of the tissues, spontaneous pain, and tenderness of the tooth to pressure and percussion. The patient also often presents with fever, lymphadenopathy, or a general feeling of malaise. The presence of swelling and the other systemic signs of an infection distinguish this stage from *symptomatic periradicular periodontitis*. Radiographic findings may or may not be present; the hallmark finding in this classification is intraoral swelling.

Chronic apical abscess

Chronic apical abscess is an inflammatory reaction to pulpal necrosis or a previously treated tooth, often characterized by slight or no discomfort and an intermittent discharge through a sinus tract. The release of pressure by drainage through a sinus tract is the reason there is little or no discomfort. Radiographically, periradicular radiolucency is seen. The presence of a sinus tract is what separates this classification from asymptomatic apical periodontitis.

Classification of cracks in teeth

The mouth is a dynamic environment that subjects teeth to various destructive forces throughout one's

lifetime. Functional and parafunctional forces contribute the most to this destruction and often lead to the development of cracks in teeth. The presence of cracks can lead to changes in the pulp–dentin complex, which can in turn affect pulpal diagnosis. Cracks in teeth are *findings;* to diagnose a tooth as a *cracked tooth* is incomplete within the context of an endodontic diagnosis. There are five distinct types of cracks seen in teeth: craze lines, fractured cusp, cracked tooth, split tooth, and vertical root fracture.

Craze lines

Craze lines are superficial breaks in the crystalline structure of the tooth and are limited to only the enamel layer. Because there is no extension into the dentin, the tooth is completely asymptomatic. Treating a craze line is only necessary where esthetics is the primary concern. To differentiate a craze line from other types of cracks in teeth, transillumination is performed. A craze line allows the light to transmit through completely, whereas a deeper crack blocks the transmission of light in that segment, thus highlighting the location of the crack.

Fractured cusp

As the name implies, fractured cusp involves cracks that are initiated from the cusp of the tooth. It may be a complete or incomplete fracture (Figure 1.10), and it is directed mesiodistally and buccolingually along a buccal or lingual groove. The crack may extend subgingivally.

Figure 1.10 After the restoration is removed, inspection of the underlying tooth surfaces reveal an incomplete fracture of the mesiobuccal cusp, extending mesiodistally and buccolingually along a buccal groove.

Treatment involves removing the fractured cusp and placing a suitable restoration. Endodontic treatment is only warranted if the crack is seen extending into the pulp space or if a diagnosis of symptomatic irreversible pulpitis or pulp necrosis is made.

Cracked tooth

A cracked tooth is an incomplete fracture. Clinically, a cracked tooth advances in a mesiodistal direction, extending into one or both marginal ridges (Figure 1.11). A cracked tooth extends more apically than a fractured tooth and therefore has a higher chance of resulting in pulpal or periapical pathology. Treatment can range from restoring the tooth with a full-coverage restoration to extraction, depending on the extent and location of the crack. Root canal treatment is only indicated if the diagnosis confirms a need for it. If the decision is made to keep the tooth and root canal treatment is indicated, the patient should be made aware that the long-term prognosis of a cracked tooth is questionable.

Split tooth

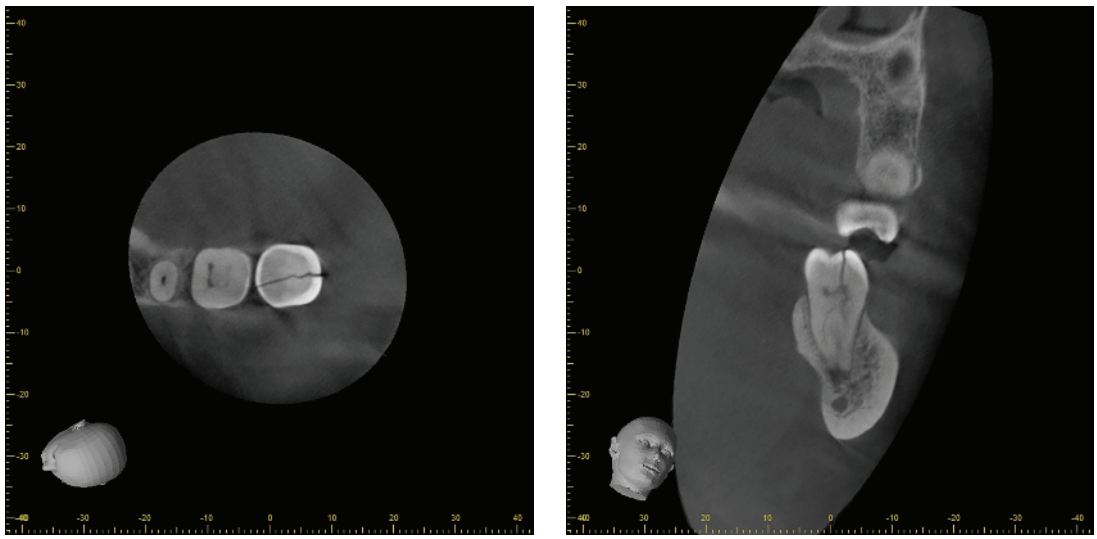
If a cracked tooth is left untreated, it eventually results in a complete fracture, forming two entirely separate segments. This is known as split tooth (Figure 1.12) A split tooth shows mobility. Treatment involves removing the smaller (or more mobile) segment and assessing the structural integrity of the remaining segment for restorability.

Vertical root fracture

Vertical root fracture (VRF) is defined as a complete or incomplete fracture initiated in the root of a given tooth. A VRF occurs exclusively after the tooth has had endodontic treatment (Figure 1.13). The fracture is usually located on one or both proximal surfaces (buccal or lingual) and can extend coronally. Radiographic verification of a VRF can be challenging, because the appearance can mimic that of a failed endodontically treated tooth. However, cone beam computed tomography (CBCT) imaging provides a greater degree of accuracy in identifying VRFs. Clinically, the presence of a sinus tract, along with a narrow, deep periodontal pocket associated with a tooth that has had endodontic treatment usually indicates a VRF. The only predictable treatment of a VRF is extraction of the tooth.

(a) (b)

Figure 1.11 A crack is seen advancing in the mesiodistal direction. *A,* With the restoration in place. *B,* With the restoration removed.



(a) (b)

Figure 1.12 A coronal and axial slice from a conebeam volume reveals a crack that has extended apically and formed two separate segments. This is known as a *split tooth*.

Conclusion

The importance of correct diagnosis must not be underestimated. A treatment plan can only be drawn up when a correct and accurate diagnosis has been made. Newer techniques and devices in endodontic diagnosis are ever evolving. Careful attention to these new diagnostic aids and tools combined with an understanding of their usefulness and limitations is necessary if they are to be employed most effectively in clinical dentistry.

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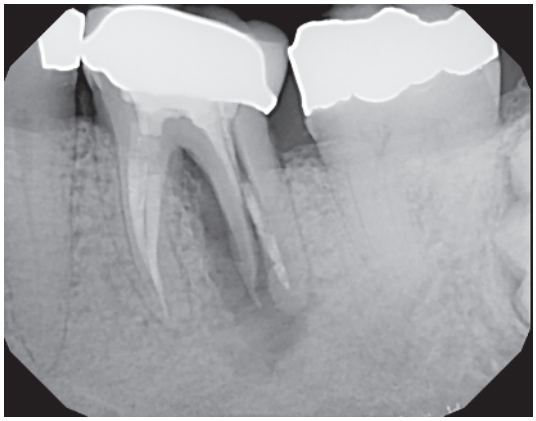

Figure 1.13 This is a more obvious example of a vertical root fracture. In most cases, identifying a vertical root fracture can be challenging without the aid of advanced imaging modalities.

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Questions

1 What is the best way to verify thermal sensitivity on a tooth?

A Use an ice cube.
B Use a cold refrigerant spray, such as Endo-Ice.
C Ask the patient to breathe in air through his or her mouth.
D Take the patient's word for it.

2 A given tooth with irreversible pulpitis always has an associated lingering response to cold.

A True
B False

3 Which of the following statements is or are true?

i. A necrotic pulp does not respond to cold testing.
ii. A necrotic pulp always shows periapical radiolucency.
iii. It is possible for a tooth exhibiting irreversible pulpitis to also show acute alveolar abscess.

A Both i and ii are correct.
B Only i is correct.
C Only ii is correct.
D All of the statements are correct.
E None of the statements are correct.

4 If a clinician is certain of a diagnosis based on clinical findings alone, it is acceptable to forgo exposing a radiograph.

A True
B False

5 Electric pulp testing is more accurate than thermal testing in assessing pulp vitality.
- **A** True
- **B** False

6 Which of the following findings is always associated with a diagnosis of asymptomatic irreversible pulpitis?
- **A** Spontaneous pain
- **B** Swelling
- **C** Recent pulpectomy procedure
- **D** Radiographic evidence of caries extending into the pulp chamber

7 Antibiotics should be prescribed to a patient who presents with swelling, fever, and lymphadenopathy.
- **A** True
- **B** False

8 Which of the following findings negatively affects the prognosis of a tooth?
- **A** A crack
- **B** Swelling
- **C** Presence of a sinus tract
- **D** Lingering pain to hot fluids

9 Percussion testing is done to identify inflammation in the periodontal ligaments of a given tooth.
- **A** True
- **B** False

10 Teeth with the following pulpal diagnosis do not respond to thermal testing:
- **A** Pulpal necrosis
- **B** Previously treated
- **C** Normal pulp
- **D** All of the above
- **E** Only a and b