

Endodontic Emergencies

Damascus University

Endodontic emergencies are a challenge for both diagnosis and management.

Incorrect diagnosis or incorrect treatment will fail to relieve pain and, in fact, may aggravate the situation.

The clinician must have knowledge of pain mechanisms, patient management, diagnosis, anesthesia, therapeutics, and appropriate treatment measures for both hard and soft tissues.

These emergencies are a matter of concern to patients, dentists, and staff, and may occur in patients before, during, and after root canal treatment.

Causes of such emergencies are a combination of irritants that induce severe inflammation in the pulp and/or periradicular tissues.

Bacteria are important causative agents of pathosis of the pulpal and periradicular tissues. Bacterial by-products (including collagenase, chondroitinase, and hyaluronidase) isolated from root canals have also been related to clinical symptoms.

Irritation of periradicular tissues results in inflammation and the release of a group of chemical mediators that initiate inflammation.

Chemical mediators cause pain either directly by lowering the response threshold of the sensory nerve fibers or indirectly by increasing vascular permeability and producing edema, which stimulates pain receptors also.

Definition

Endodontic emergencies are usually associated with pain and/or swelling and require immediate diagnosis and treatment.

These emergencies are caused by pathoses in the pulp or periradicular tissues.

They also include severe traumatic injuries that result in luxation, avulsion, or fractures of the hard tissues.

Categories

PRETREATMENT EMERGENCY

These are situations in which the patient is seen initially with severe pain and/or swelling.

Problems occur with both diagnosis and treatment.

INTERAPPOINTMENT AND POSTOBTURATION EMERGENCY

Also referred to as the "flare-up" this problem occurs after an endodontic appointment.

This is easier to manage because the offending tooth has already been identified and a diagnosis has been previously established.

The Challenge

it is satisfying and rewarding to successfully manage a distraught patient who has an emergency.

In contrast, how distressing it is to have a patient with a flare-up after root canal treatment in a previously asymptomatic tooth!

EMERGENCY AND URGENCY

It is important to differentiate between a *true emergency* and the less critical *urgency*.

A true emergency is a condition requiring an unscheduled office visit with diagnosis and treatment now!

Urgency indicates a less severe problem; a visit may be scheduled for mutual convenience of the patient and the dentist.

Key questions (that may be asked by telephone) to determine severity include the following:

1. Does the problem disturb your sleeping, eating, working, concentrating, or other daily activities?
2. How long has this problem been bothering you?
3. Have you taken any pain medication? Was the medication ineffective?

DEVELOPMENT OF A SYSTEM

Because a misdiagnosis will probably result in improper treatment and an exacerbation of the problem, a systematic approach is mandatory!

The emotional status of the patient, pressures of time, and stress on dentist and staff should not affect such an orderly approach.

Pain Perception and Pain Reaction

Pain is a complex physiologic and psychologic phenomenon.

Pain perception levels are not constant; pain thresholds as well as reactions to pain change significantly under various circumstances.

The pain reaction threshold is significantly altered by past experiences and by present anxiety levels and emotional status.

To reduce anxiety and obtain reliable information about the chief complaint and to receive cooperation during treatment, the clinician should :

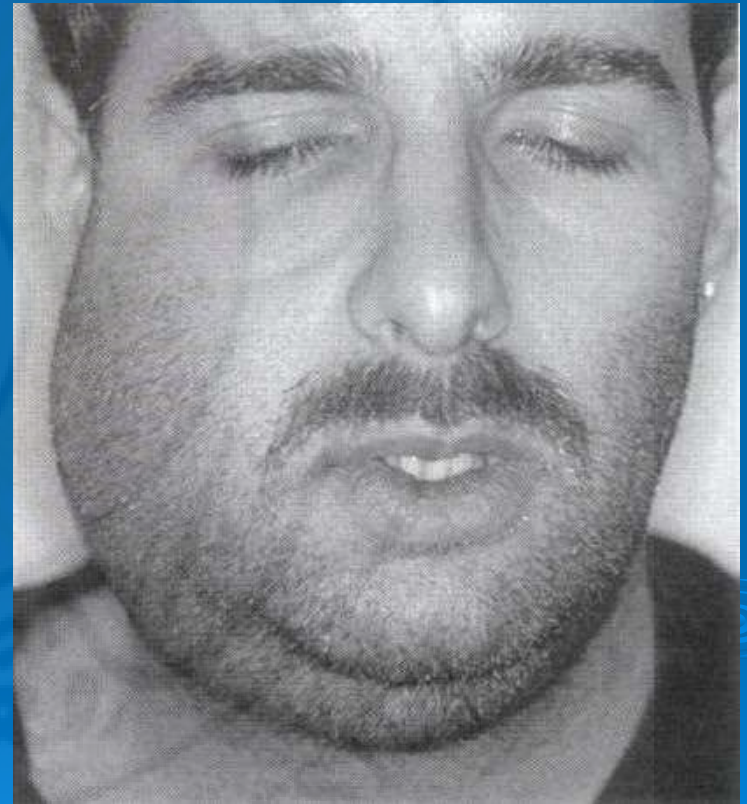
- (1) Establish and maintain control of the situation.
- (2) Gain the confidence of the patient.
- (3) Provide attention and sympathy.
- (4) Treat the patient as an important individual.

Physical Condition

Physical conditions induced as a result of these situations also contribute to the problems.

Pain or swelling may limit mouth opening,

In addition, hypersensitivity to thermal stimuli or pressure influences diagnosis and treatment.



System of Diagnosis

Patients in pain often provide information and responses that are exaggerated and inaccurate. After pertinent information regarding the medical and dental histories is obtained, both subjective questioning and an objective examination are performed carefully and completely.

A rule of the true emergency is **one tooth is the offender**, i.e., the source of pain.

In the excitement of the moment, the patient might believe that the severe pain is emanating from more than a single tooth.

The clinician may become convinced also, leading to overtreatment.

MEDICAL AND DENTAL HISTORIES

Medical and dental histories should be reviewed first, If the patient is the dentist's own, the medical history is briefly reviewed and updated, If the patient is new, a standard, complete history is taken.

This includes recalling of dental procedures, a chronology of symptoms.

SUBJECTIVE EXAMINATION

The subjective examination comprises careful questioning relate to the history, location, severity, duration, character, and eliciting stimuli of pain.

Questions relating to the cause or stimulus that elicits or relieves the pain help select appropriate objective tests to arrive at a final diagnosis.

Pain that is elicited by thermal stimuli and/or is referred is likely to originate from the pulp.

Pain that occurs on mastication or tooth contact and is well localized is probably periradicular.

The three important factors constituting the quality and quantity of pain are its spontaneity, intensity, and duration.

OBJECTIVE EXAMINATION

It is important in identifying the offending tooth to repeat tests that mimic what the patient reports subjectively.

The best test is to repeat the stimulus that reportedly causes the pain.

In addition, objective tests include extraoral and intraoral examination, observation for swelling as well as mirror and explorer examination, to note the presence of defective restorations, discolored crowns, recurrent caries, and fractures.

Periradicular tests include :(1) palpation over the apex, (2) digital pressure on teeth (3) light percussion with the end of the mirror handle, and (4) selective biting on a cotton swab

Pulp vitality tests are most useful to reproduce reported pain. Cold, heat, electricity, and direct dentin stimulation, usually indicate the pulp status (vital or necrotic).

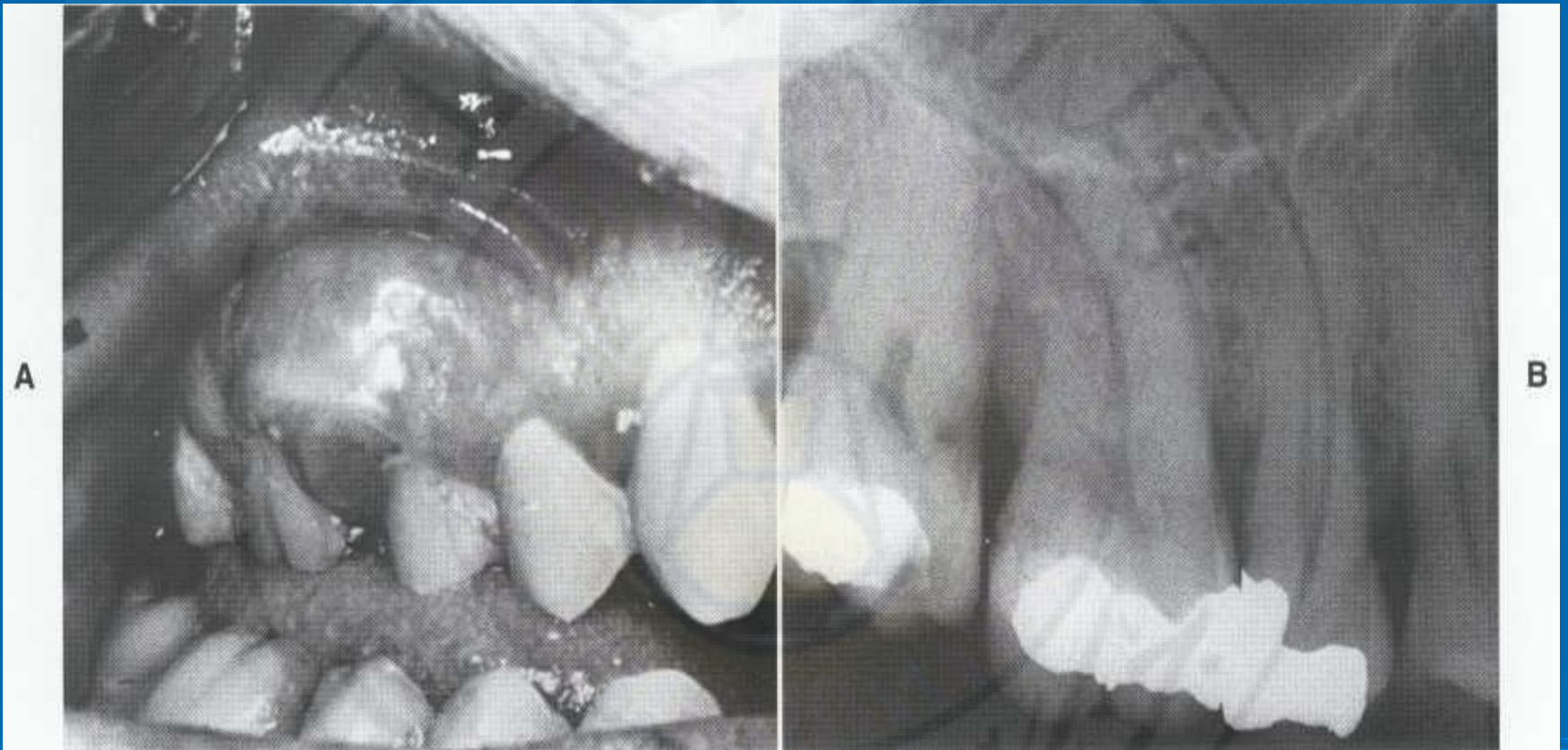
PERIODONTAL EXAMINATION

Probing helps in differentiating endodontic from periodontal disease.

A periodontal abscess can simulate an acute apical abscess, However, with a localized periodontal abscess, the pulp is usually vital.

In contrast, an acute apical abscess is related to an (necrotic) pulp.

These abscesses occasionally communicate with the sulcus and have a deep probing defect..



A, Periodontal abscess, B, Radiographic appearance. Positive responses to pulp testing differentiates this condition from an acute apical abscess.

RADIOGRAPHIC EXAMINATION

Radiographs are helpful, but have limitations. There is a tendency to over-rely on radiographs. Periapical and bitewing radiography may detect the presence of interproximal and recurrent caries, possible pulpal exposure, internal or external resorption, and periradicular pathosis, among other entities.

Diagnosis Sequence

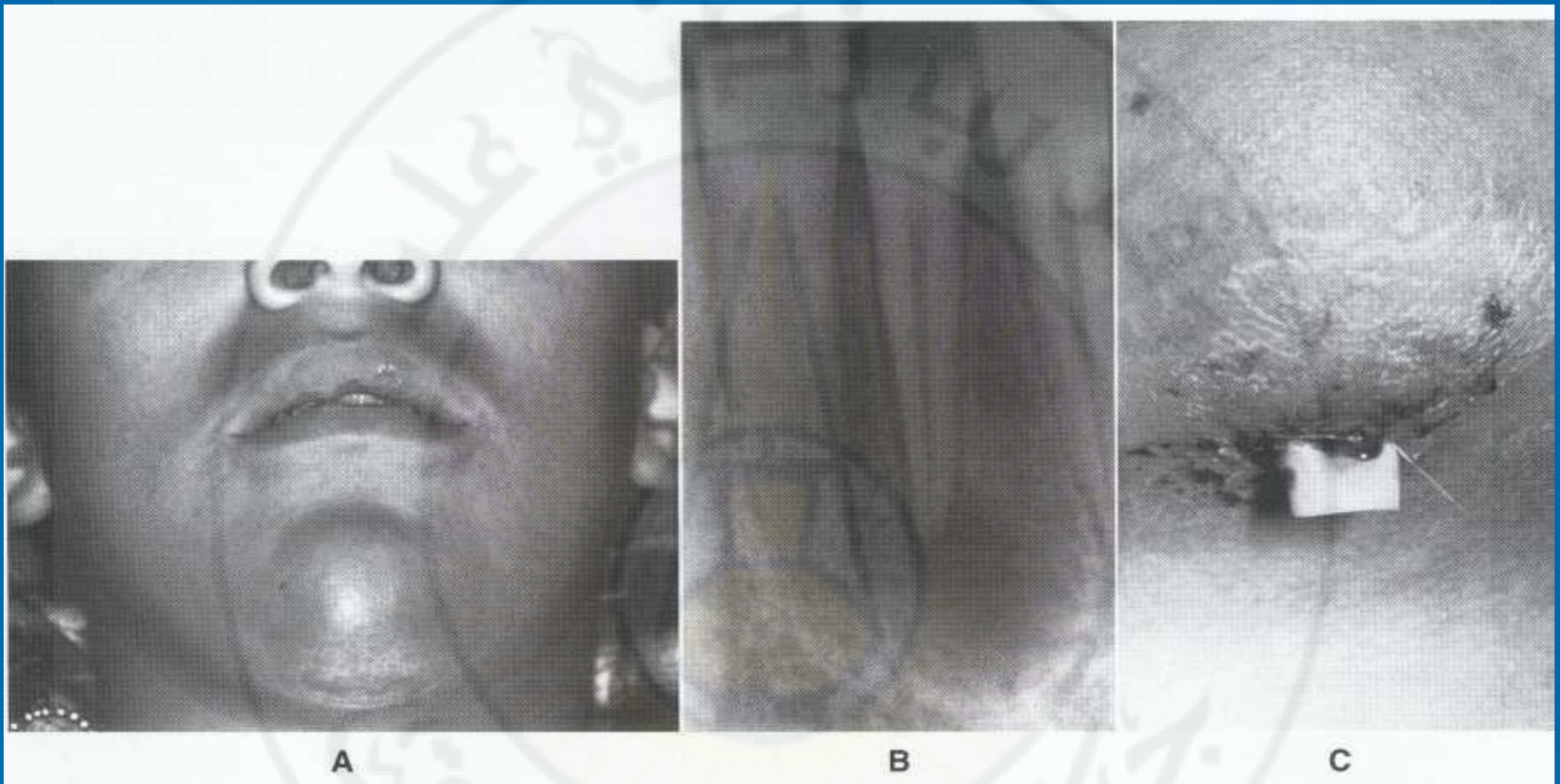
1. Obtain pertinent information about the patient's medical and dental histories.
2. Ask pointed subjective questions about the patient's pain: history, location, severity, duration, character, and eliciting stimuli.
3. Perform an extraoral examination.
4. Perform an intraoral examination.
5. Perform pulp testing as appropriate.
6. Use palpation and percussion sensitivity tests to determine periapical status.
7. Interpret appropriate radiographs.

DIAGNOSTIC OUTCOME

After working through the sequence just described, the clinician should have identified the offending tooth and the tissue.

For many reasons, these conclusions may not be clear, so this is not a true emergency, or the problem may be beyond the capability of the generalist and the patient should be referred .

If the diagnosis is clear, however, treatment planning follows.



This patient has a complex problem and should be considered for referral. A and B, Submental space swelling resulting from trauma followed by acute apical abscess. C, Removal of the necrotic tissue was followed by extraoral incision and placement of a drain.

Treatment Planning

Reducing the irritant, or reduction of pressure or removal of the inflamed pulp or periradicular tissue should be the immediate goal; this usually results in pain relief.

Pressure release is the most effective.

Pretreatment Emergencies

These emergencies require a diagnosis and treatment sequencing:

- (1) categorizing the problem.
- (2) taking a medical history.
- (3) identifying the source.
- (4) making the diagnosis.
- (5) planning the treatment.
- (6) treating the patient.

PATIENT MANAGEMENT

Patient management is always the most critical factor.

The frightened patient in pain must have confidence that his or her problem is being properly managed.

PROFOUND ANESTHESIA

Obtaining profound anesthesia of inflamed painful tissue is a challenge. Adequate anesthesia, however, will instill confidence and cooperation, and influence the patient's desire to save the offending tooth.

Although all "classic" signs of profound anesthesia are present, access into the dentin or pulp is painful.

Periodontal, intrapulpal, or intraosseous injection controls the remaining sensitivity in most cases. These supplemental injections are often given prophylactically, particularly with painful irreversible pulpitis.

MANAGEMENT OF PAINFUL IRREVERSIBLE PULPITIS

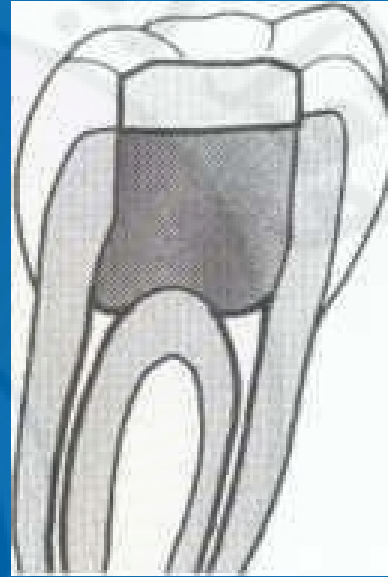
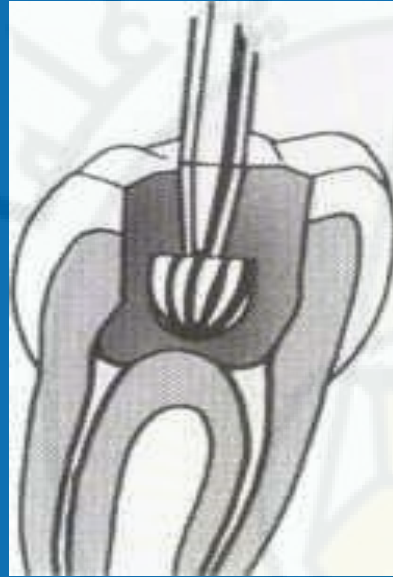
Because the pain is the result of inflammation, primarily in the coronal pulp, removal of the inflamed tissue will usually reduce the pain.

Without Acute Apical Periodontitis

Complete cleaning and shaping of the root canals is the preferred treatment if time permits.

With limited time, (partial pulpectomy) in single-rooted teeth, In molars, a partial pulpectomy is performed on the largest canals (palatal or distal root).

Pulpotomy is usually effective in molars when minimal time is available.



A dry cotton pellet alone is effective in relieving pain and sealed temporarily. A mild analgesic may be prescribed for patients with irreversible pulpitis.

Antibiotics, however, are definitely not indicated.

With Acute Apical Periodontitis

In patients with extreme tenderness on percussion, a partial or total pulpectomy is appropriate.

Reducing the occlusion to eliminate contact has been shown to aid in relief of symptoms.

Trephination (artificial fistulation) by creating an opening through mucosa and bone is not useful and is contraindicated.

MANAGEMENT OF PULP NECROSIS WITH APICAL PATHOSIS

Treatment now is biphasic:

- (1) remove or reduce the pulp irritants
- (2) relieve the apical fluid pressure (when possible)

The diagnosis may be acute apical periodontitis (no significant periradicular resorption) or acute apical abscess with or without swelling.

Therefore, with pain and pulp necrosis there may be: (1) no swelling, (2) localized swelling, or (3) diffuse, more extensive swelling.

Each is managed differently, of these three conditions, diffuse swelling is the least common.

1.Pulp Necrosis Without Swelling

These teeth may contain vital inflamed tissues in the apical canal and have inflamed painful periradicular tissues (acute apical periodontitis). Profound local anesthesia may be a problem, requiring a supplemental injection.

Alternatively, the lesion may have expanded and formed an abscess that is confined to bone.

These are often painful, because of fluid pressure.

The aim is to reduce the canal irritants and to try to encourage some drainage through the tooth.

Complete canal debridement, is the treatment of choice.

If time is limited, partial debridement at the estimated working length is performed with light instrumentation with a passive stepback or crown-down technique to remove irritating debris..

During cleaning, canals are flooded and flushed with copious amounts of sodium hypochlorite.

Finally, canals are dried with paper points, filled with calcium hydroxide paste, and sealed with a dry cotton pellet and a temporary filling.

Administering a long-acting anesthetic, reassuring the patient, removing (or reducing) the irritant, and prescribing an analgesic will usually reduce postoperative pain significantly.

Antibiotics are not indicated. The patient is told that there will still be some pain (the inflamed, sensitive tissues are still present), but should subside during 2 or 3 days, as the inflammation decreases.

2.Pulp Necrosis with Localized Swelling

The abscess has now invaded regional soft tissues and at times, there is purulence in the canal.

Radiographic findings range from no periapical change (rarely) to a large radiolucency.

Again, treatment is biphasic:

First and most important is debridement (complete cleaning and shaping if time permits) of the canal or canals, and second in urgency is drainage.

Localized swelling (whether fluctuant or nonfluctuant) should be incised.

A



B

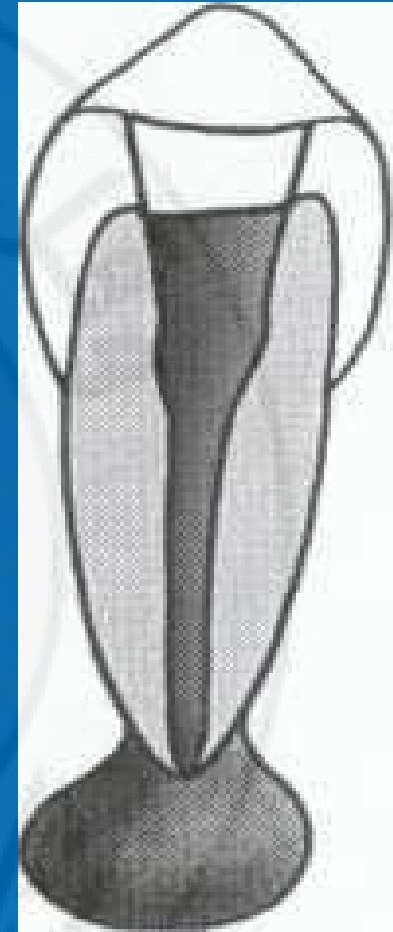
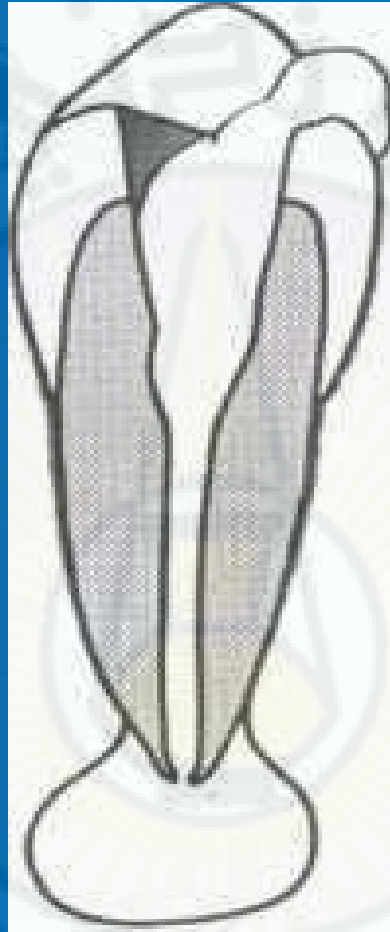
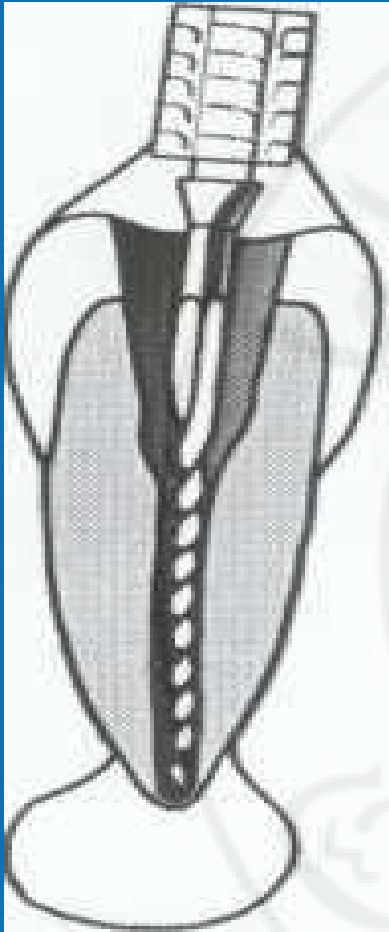


A, Localized swelling. B, Incision for drainage after cleaning and shaping of offending incisor.

Drainage accomplishes two things:

- (1) relief of pressure and pain
- (2) removal of a very potent irritant-purulence.

In teeth that drain readily after opening, instrumentation should be confined to the root canal System.



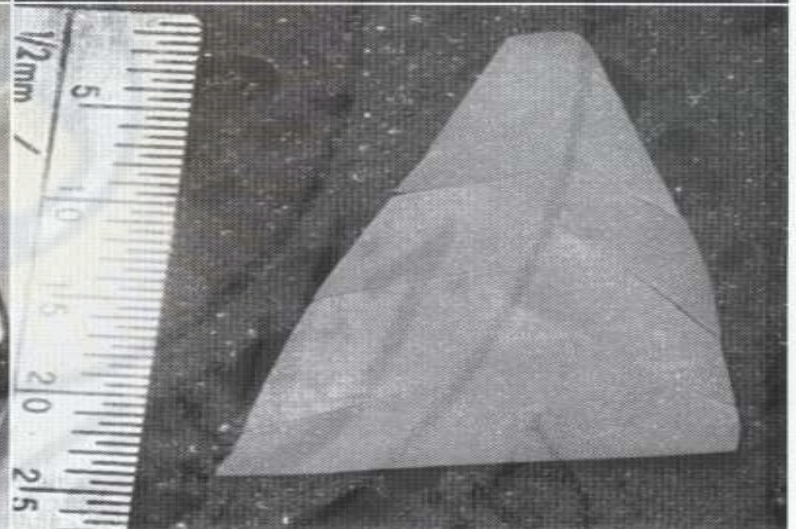
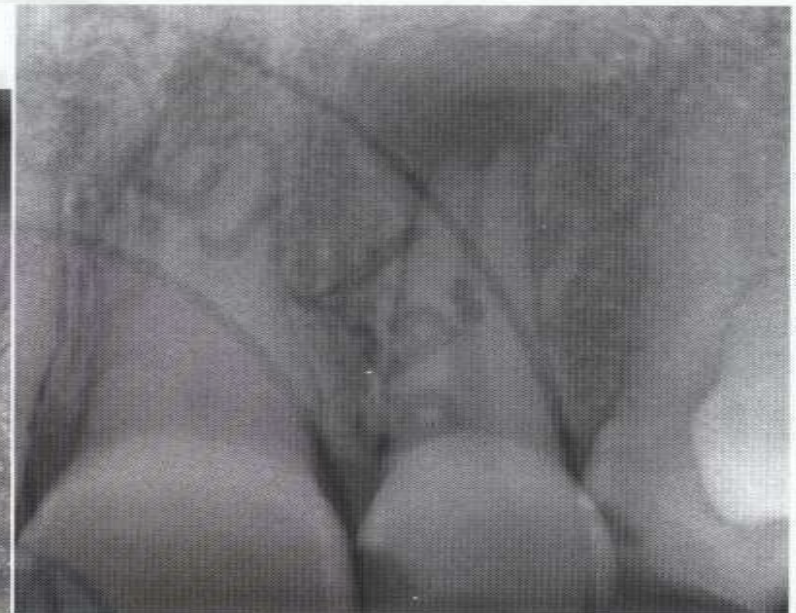
After opening into a root canal and establishment of drainage, instrumentation should be confined to the root canal system.

In patients with a periradicular abscess but no drainage through the canal, penetration of the apical foramen with small files (up to 25) may initiate drainage and release of pressure.

This release often does not occur because the abscess cavity does not communicate directly with the apical foramen.

Occasionally there may be more than one abscess one communicates with the apex and another separates.

Because they do not communicate, drainage must occur through both the tooth and a mucosal incision.



A, Localized fluctuant abscess as a result of periradicular pathosis after trauma. B, Radiographic appearance. C, Drainage was spontaneous when the tooth was opened. D, Christmas tree-shaped rubber drain placed after soft tissue incision.

Often, a drain is placed to permit continued drainage for 1 or 2 days or until debridement is complete.

Copious irrigation with sodium hypochlorite is performed throughout.

The canals are then dried and filled with calcium hydroxide paste, then the access is sealed temporarily.

These teeth should not be left open to drain, a canal exposed to the oral cavity is a potential home for introduced bacteria, food debris, and even viruses.

Occasionally, purulence will continue to fill the canal during the preparation (the so-called "weeping" canal).

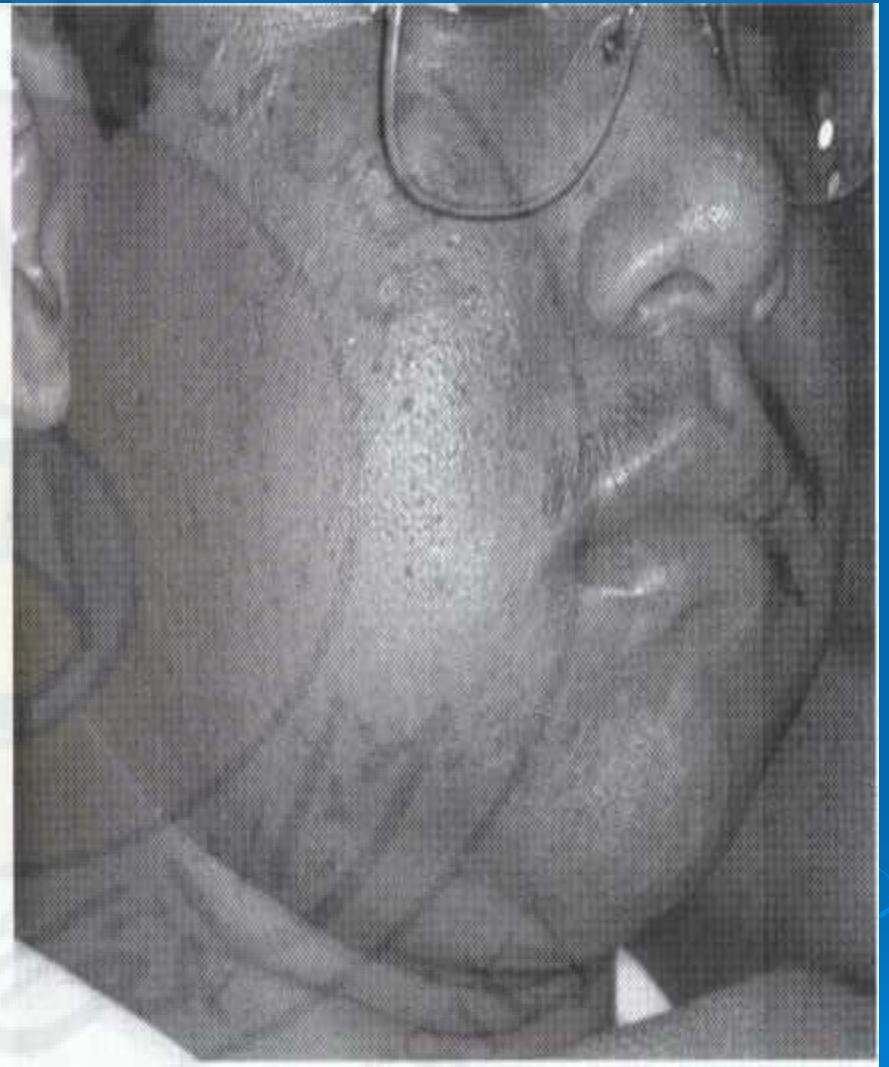
If this occurs, the patient should sit for a time, usually, the flow will cease and the access may be closed.

These patients seldom have elevated temperatures or other systemic signs. Therefore, in acute apical abscess with localized swelling, the use of systemic antibiotics is not necessary, having been shown to be of no benefit.

3.Pulp Necrosis with Diffuse Swelling

These rapidly progressive and spreading swellings are not localized and may have dissected into the fascial spaces .

These patients occasionally have elevated temperature or other systemic signs and usually should be referred to a specialist.

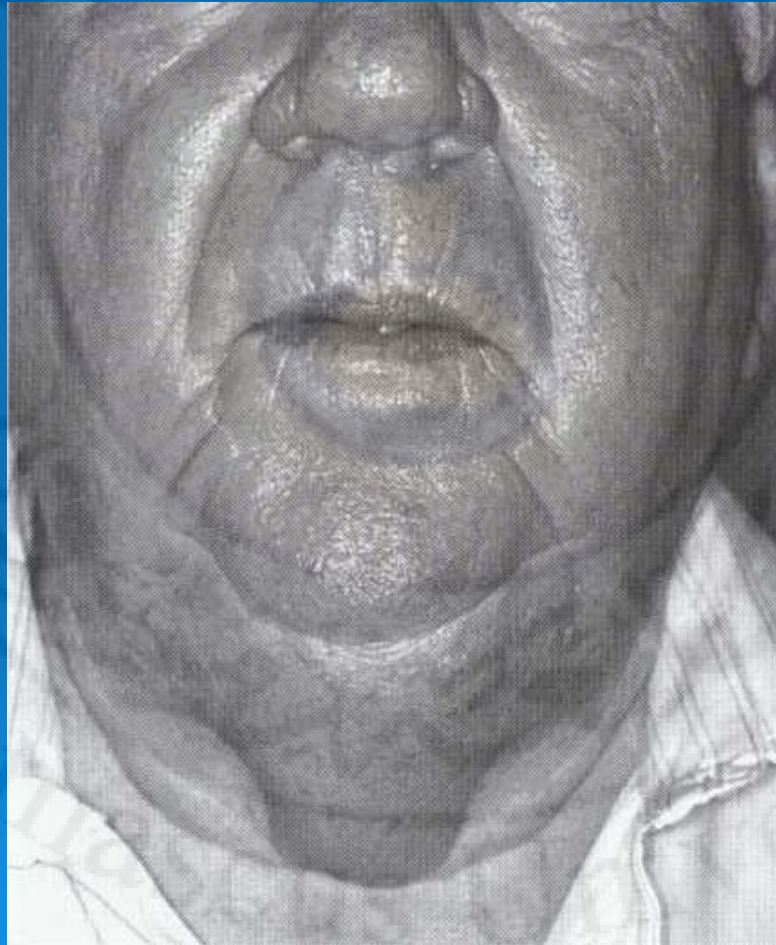


Most important is removal of the irritant by canal debridement or by extraction.

The apical foramen may then be gently penetrated with a file to hopefully permit a flow of exudate, although drainage often does not occur.

Also at this time, swelling may be incised and a rubber drain inserted for 1 or 2 days.

Occasionally the abscess localizes extraorally and subcutaneously, requiring extraoral incision for drainage.



Speed of recovery (whether the swelling is localized or diffuse) depends primarily on canal debridement and drainage.

Because edema has spread through the tissues, diffuse swelling decreases slowly, over a period of perhaps 3 to 4 days.

After placing calcium hydroxide paste and a dry pellet, the access is closed with a temporary filling.

Systemic antibiotics are indicated for the diffuse, rapidly spreading swelling.

The preferred and first choice is penicillin; the causative microorganisms are likely to be streptococci.

An alternative for penicillin-allergic patients is clindamycin.

Systemic steroids, advocated by some, are probably of no benefit.

Analgesics for moderate to severe pain should be prescribed.

POSTOPERATIVE INSTRUCTIONS

Patients must be informed of what to expect.

The pain and swelling will take time to resolve.

Medications must be taken as prescribed, the problem may recur or worsen (flare-up), equiring another emergency visit.

Communication after the visit is very important, calling the patient the day after the appointment is important.

Interappointment Emergencies

flare-up is a true emergency, and is so **severe that an unscheduled patient visit and treatment** are required.

Despite careful treatment procedures, complications such as pain, swelling, or both may occur.

Regional temporary paresthesia has even been reported .

These emergencies should be resolved quickly..

INCIDENCE

Studies, which are well controlled, report an overall incidence of flare-ups of 1.4% to 3%.

Therefore, overall the occurrence is low, but it varies in certain situations. Most postoperative discomfort is in the mild range.

CAUSATIVE FACTORS

These factors can be categorized as related to the patient, to pulpal or periapical diagnosis, or to treatment procedures.

A history of preoperative pain or swelling is the best predictor of interappointment emergencies.

In other words, a patient who has a painful acute apical abscess that requires emergency treatment, is much more likely to experience a flare-up.

PREVENTION

Procedures

Use of long-acting anesthetic solutions, complete cleaning and shaping of the root canal system, analgesics, and psychologic preparation of patients will decrease interappointment symptoms in the mild to moderate levels .

Verbal Instructions

Most important is the preparation of patients for what to expect after the appointment.

They should be told that discomfort is likely; and should subside within a day or two.

An increase in pain, noticeable swelling, or other adverse signs necessitate a call and sometimes a visit.

This explanation reduces the number of calls from unnecessarily concerned patients.

Therapeutic Prophylaxis

A popular preventive approach has been the prescribing of antibiotics to minimize postoperative symptoms.

This has been demonstrated to be not useful

In contrast, certain analgesics and anti-inflammatory agents will reduce post-treatment symptoms

DIAGNOSIS

A step-by-step approach to diagnose the existing condition reduces confusion and error; most important, it calms a patient who has been shaken by the episode of pain or swelling.

After the underlying complications are identified, treatment is initiated.

TREATMENT OF FLARE-UPS

Reassurance is the most important aspect of treatment. The patient is generally frightened and upset.

The explanation is that the flare-up is not unusual and will be managed.

Next in importance is restoring the patient's comfort and breaking the pain cycle.

For extended anesthesia or analgesia, administration of ropivacaine, etidocaine, is recommended.

Interappointment emergencies are divided into patients with an initial diagnosis of a vital or a necrotic pulp, and with or without swelling.

Previously Vital Pulps with Complete Debridement

patient reassurance and the prescription of a mild to moderate analgesic often will suffice. Generally, nothing is to be gained by opening these teeth; the pain will usually regress spontaneously.

Flare-ups, have not been shown to be prevented by steroids, whether administered intracanal or systemically.

Previously Vital Pulps with Incomplete Debridement

It is likely that tissue remnants have become in-flamed and are now a major irritant.

The working length should be rechecked, and the canal(s) should be carefully cleaned with copious irrigation of sodium hypochlorite.

A dry cotton pellet is then placed followed by a temporary filling, and a mild to moderate analgesic is prescribed.

Occasionally, a previously vital pulp (with or without complete debridement) will develop into an acute apical abscess.

This will occur some time after the appointment and indicates that pulpal remnants have become necrotic and are invaded by bacteria.

Previously Necrotic Pulps with No Swelling

Occasionally these teeth develop an acute apical abscess (flare-up) after the appointment.

The abscess is confined to bone and can be very painful.

The tooth is opened and the canal is gently recleaned and irrigated with sodium hypochlorite.

Drainage should be established if possible.

If there is active drainage from the tooth after opening, the canal should be recleaned (or debridement completed) and irrigated with sodium hypochlorite.

The rubber dam is left in place; the patient is allowed to rest pain-free for at least 30 minutes or until drainage stops.

Then, the canals are dried, calcium hydroxide paste is placed, and the access is sealed.

The tooth should not be left open! If there is no drainage, the tooth should also be lightly instrumented and gently irrigated, medicated with calcium hydroxide paste, and then closed. The symptoms usually subside, but do so more slowly than if drainage was present.

A long-acting anesthetic and a strong analgesic are helpful; antibiotics are not indicated

Previously Necrotic Pulps with Swelling

These cases are best managed with incision and drainage .

In addition, it is most important that the canals have been debrided, If not, they should be opened and debrided, medicated with calcium hydroxide paste, and closed.

Then incision and drainage with placement of a drain are completed.

Follow-up Care

With flare-ups, the patient should be contacted daily until the symptoms abate.

Patients with more serious problems should return to the dentist for treatment, depending on findings.

When symptoms recur or cannot be controlled, these patients should be considered for referral. Ultimate treatment by a specialist may include extra measures, such as apical surgery, or even hospitalization.

MEDICATIONS

Intracanal

Both local and systemic medications are part of the treatment regimen used for flare-ups.

Phenolic intracanal medications include formocresol, CMCP, Cresatin, and eugenol.

Other medications used in canals are steroid combinations and calcium hydroxide.

None of these has been shown to prevent flare-ups; none helps in relieving flare-up symptoms.

Systemic

Systemic drugs are usually limited to analgesics and antibiotics, Nonsteroidal anti-inflammatory agents are indicated if an analgesic effect is desired.

Narcotics are useful to provide analgesia and sedation. Combinations of an opioid (codeine, oxycodone, pentazocine,) and a non-steroidal agent are most effective for more severe pain.

Antibiotics are indicated only if there is a diffuse, rapidly spreading cellulitis into the fascial spaces.

Localized swelling does not indicate a need for antibiotic administration; surgical or canal Drainage, and complete canal debridement are necessary.

Occasionally, but rarely, a flare-up or a presenting acute apical abscess may be serious or even life-threatening ,these situations may require hospitalization and aggressive therapy with the cooperation of an oral surgeon.

A



B



C



Postobturation Emergencies

True emergencies postobturation are infrequent ,although pain at the mild level is common.

Therefore, active intervention is seldom necessary; usually symptoms will resolve spontaneously.

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CAUSATIVE FACTORS

Approximately, one-third of endodontic patients experience some pain after obturation.

There is a correlation between the level of obturation and pain incidence, overextension associated with the highest incidence of discomfort.

Postobturation pain also relates to preobturation pain.

TREATMENT

Information about possible discomfort, reassurance about the availability of emergency services, and administration of mild analgesics significantly control the patient's anxiety, this in turn decreases the incidence of postobturation frantic telephone calls or "emergency" visits.

Some patients, however, do develop serious complications and require follow-up treatment.

Retreatment is indicated when prior treatment obviously has been inadequate.

Apical surgery is often required when an acute apical abscess develops, and there is uncorrectable, inadequate root canal treatment.

If root canal treatment was acceptable, excision and drainage of swelling after obturation should be performed, usually the swelling resolves without further treatment.

If there is no evidence of acute apical abscess, and the root canal treatment has been well done, these patients are treated with reassurance and analgesics.

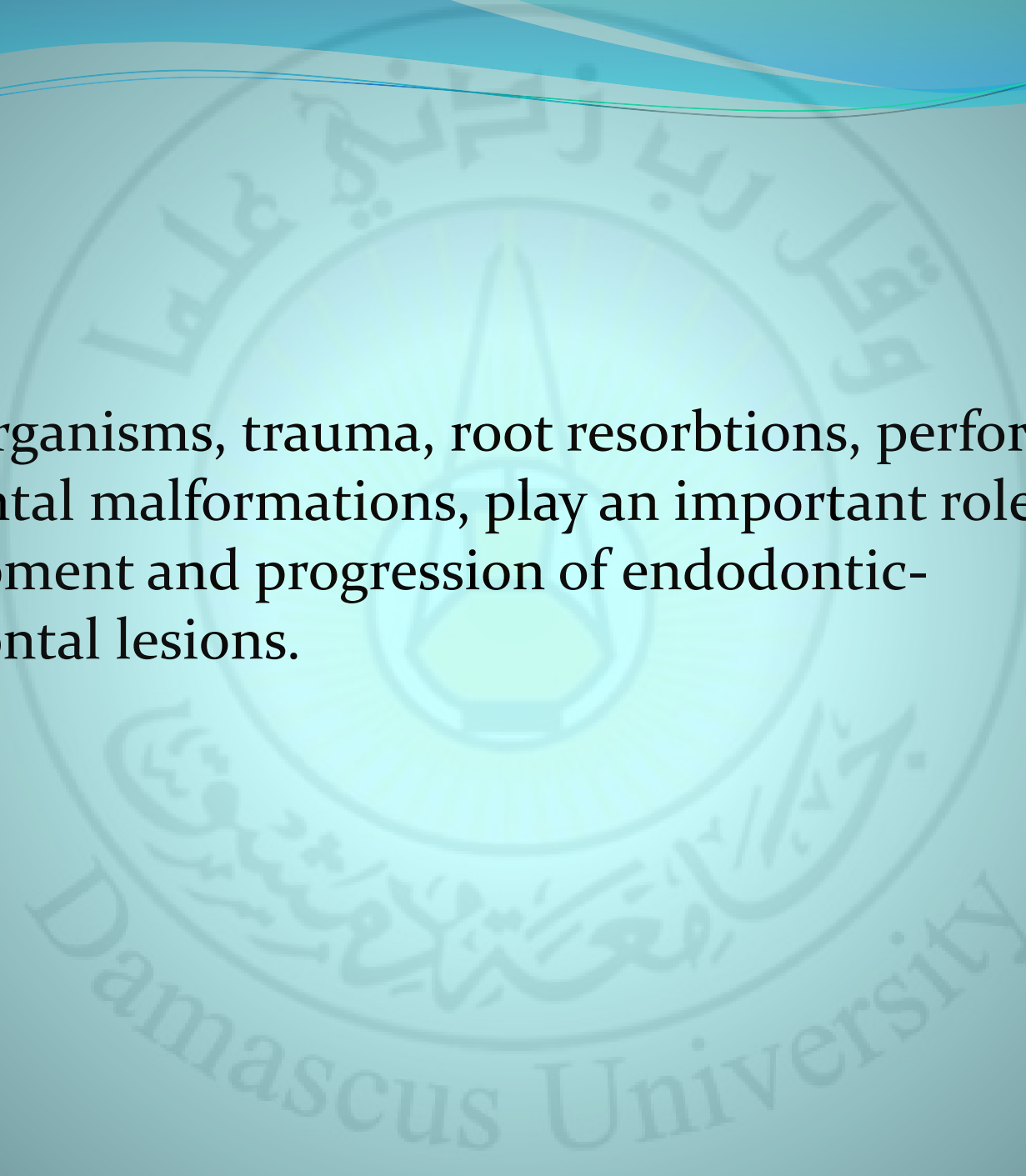
Patients with postobturation emergencies that do not respond to therapy should be referred to an endodontist.

Endodontic and Periodontal Interrelationship



Treatment and prognosis of endodontic-periodontal diseases depend on the etiology and correct diagnosis.

Diagnosis presents a challenge in interpretation of the origin of a defect as reflected In the integrity of the periodontal ligament.

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Microorganisms, trauma, root resorbtions, perforations, and dental malformations, play an important role in the development and progression of endodontic-periodontal lesions.

PATHWAYS OF COMMUNICATION BETWEEN THE DENTAL PULP AND THE PERIODONTIUM

The dental pulp and periodontal tissues are intimately related. The pulp originates from the dental papilla and the PDL from the dental follicle. They are separated by Hertwig's epithelial root sheath .

As the tooth matures and the root is formed, three main avenues for communication between the dental pulp and the periodontium are formed.

Dental Tubules

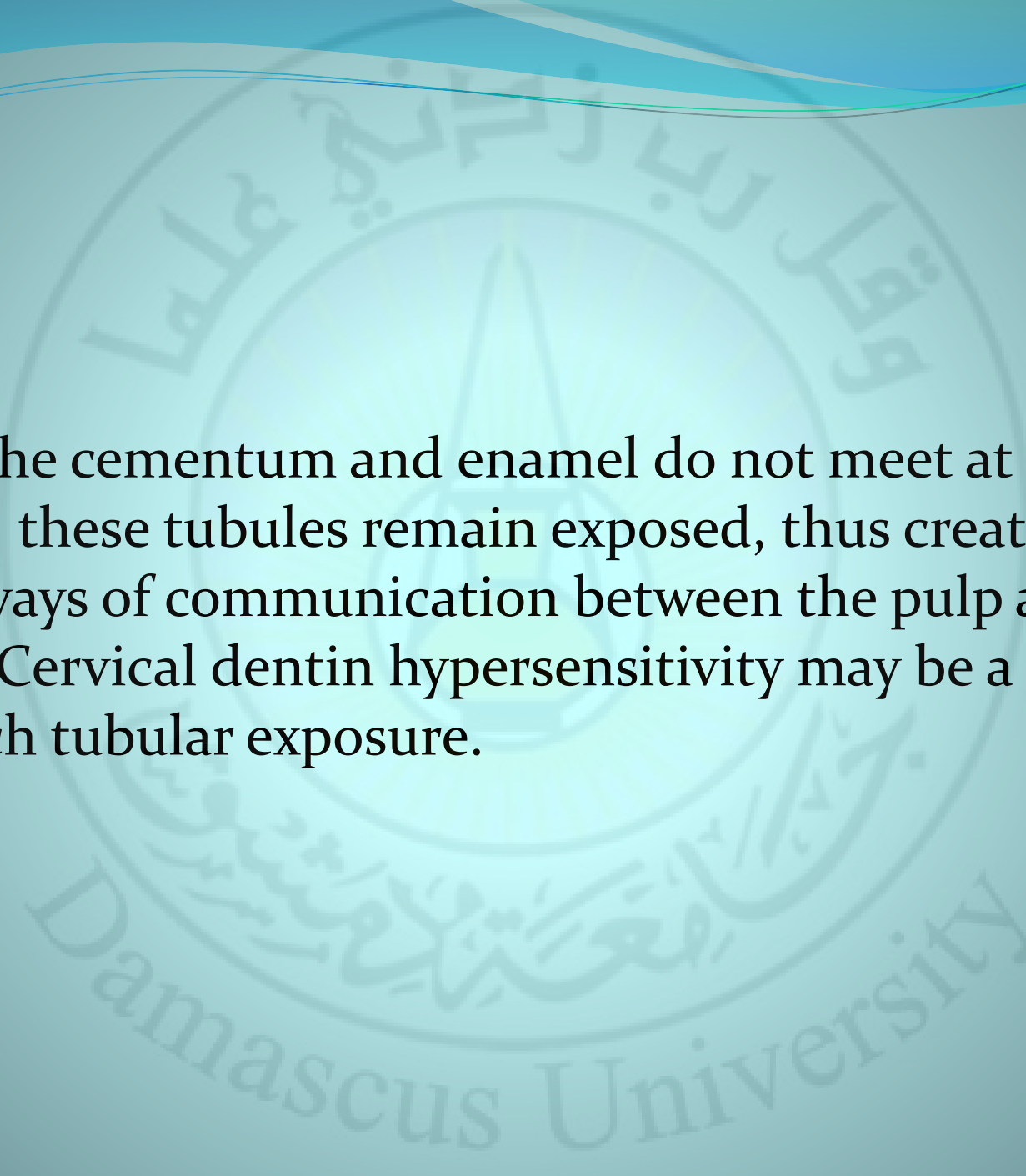
Cementum acts as a protective barrier, but direct communication may be established between the pulp and the periodontium via patent dentinal tubules if the cementum is missing.

The cementum may be missing as a result of developmental defects, disease processes, or periodontal or surgical procedures.

Patent dentinal tubules is essential to understand the permeability of root dentin, and clinical conditions such as dentin hypersensitivity.

Radicular dentin tubules extend from the pulp to the cementodentinal junction (CDJ) in a relatively straight course. Diameter ranges from 1 μm in the periphery to 3 μm near the pulp.

Tubular lumen decreases with age or as a response to a chronic, low-grade stimulus. Irritation of dentin can cause apposition of highly mineralized peritubular dentin.

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When the cementum and enamel do not meet at the (CEJ), these tubules remain exposed, thus creating pathways of communication between the pulp and the PDL. Cervical dentin hypersensitivity may be a result of such tubular exposure.

Dentin exposure at the CEJ occurred in about 18% of teeth in general and in 25% in anterior teeth, the same tooth may have different CEJ characteristics.

Dentin exposure plays an important role when assessing the progression of endodontic pathogens, as well as the effect of scaling and root planing on cementum integrity, trauma, and chemically induced pathosis.

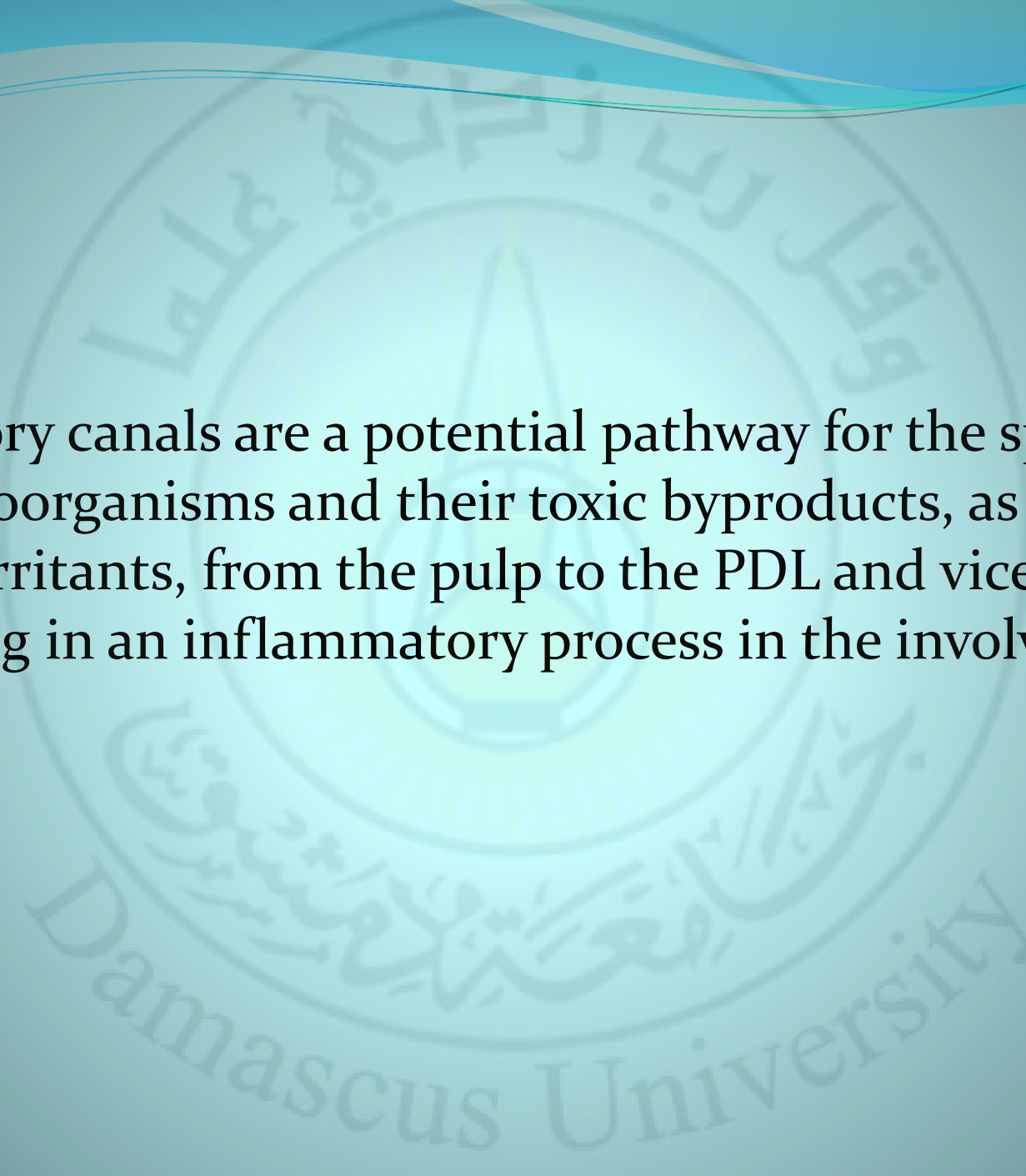
Lateral and Accessory Canals

Lateral and accessory canals can be present anywhere along the root, It is estimated that 30% to 40% of all teeth have lateral or accessory canals, mostly found in the apical third of the root.

However, it appears that the incidence of periodontal disease associated with lateral canals caused by irritants in the dental pulp is relatively low.

Accessory canals in the furcation of molars may also be a direct pathway of communication between the pulp and the periodontium.

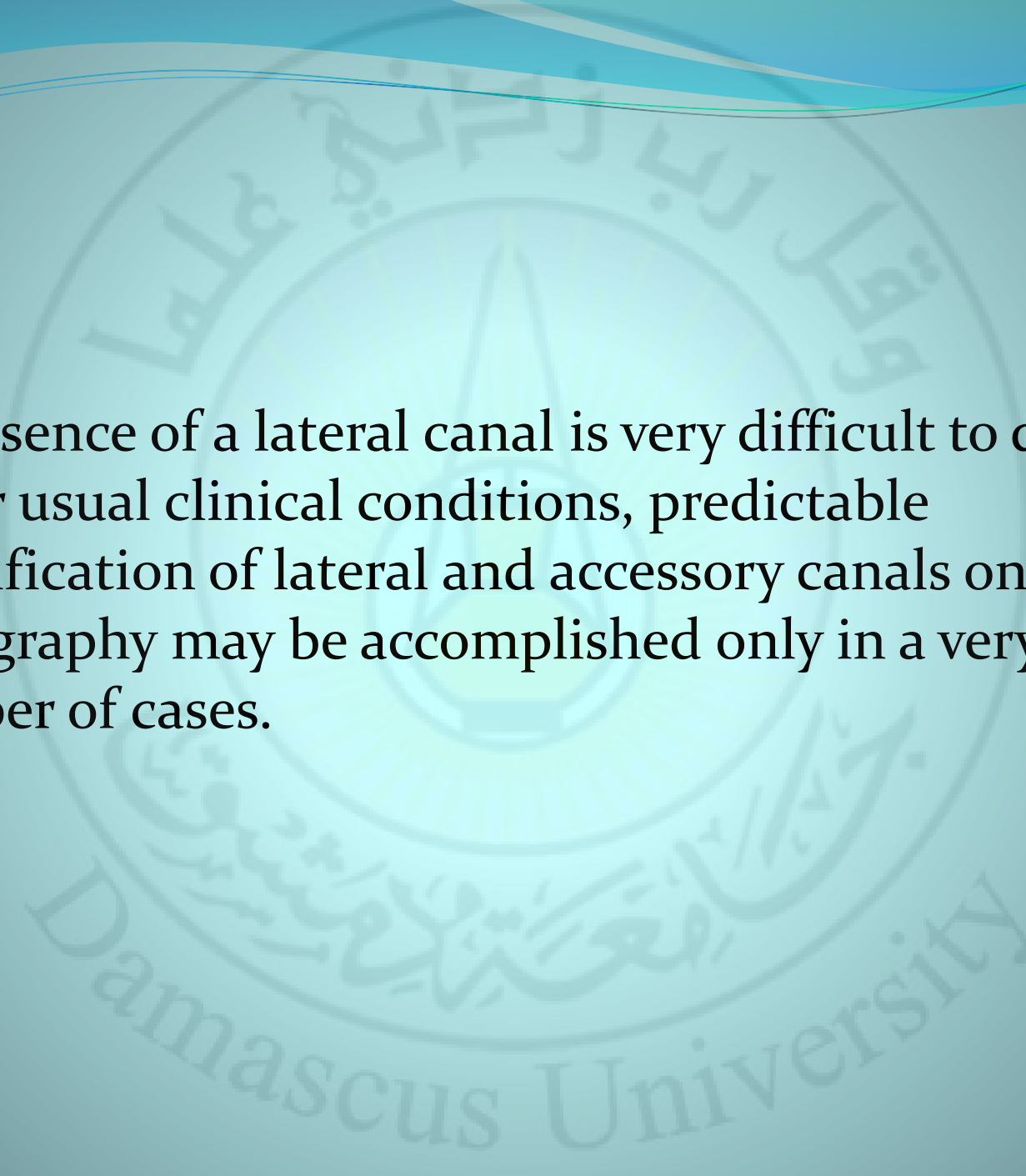
Incidence of accessory canals varies from 23% to 76%, They contain connective tissue and blood vessels that connect the circulatory system of the pulp with that of the periodontium. However, not all canals extend the full length from the pulp chamber to the floor of the furcation.

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Accessory canals are a potential pathway for the spread of microorganisms and their toxic byproducts, as well as other irritants, from the pulp to the PDL and vice versa, resulting in an inflammatory process in the involved tissues



A, Postoperative radiograph of endodontic treatment in a maxillary central incisor showing radiopaque material extruding through a lateral canal. B, Scanning electron micrograph showing vascular content in lateral canal.

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The presence of a lateral canal is very difficult to detect under usual clinical conditions, predictable identification of lateral and accessory canals on radiography may be accomplished only in a very small number of cases.

Several clinical aids may be helpful for identification:

- (1) a radiographic image of a discrete lateral lesion associated with a necrotic pulp
- (2) radiographic identification of a notch on the lateral root surface
- (3) demonstration of root canal filling material, or sealer, extruding through the patent orifices.

Apical Foramen

The apical foramen is the principal route of communication between the pulp and periodontium. Infectious and inflammatory byproducts of a diseased pulp may permeate readily through the apical foramen, resulting in periapical pathosis and inflammatory response often associated with bone and root resorption.

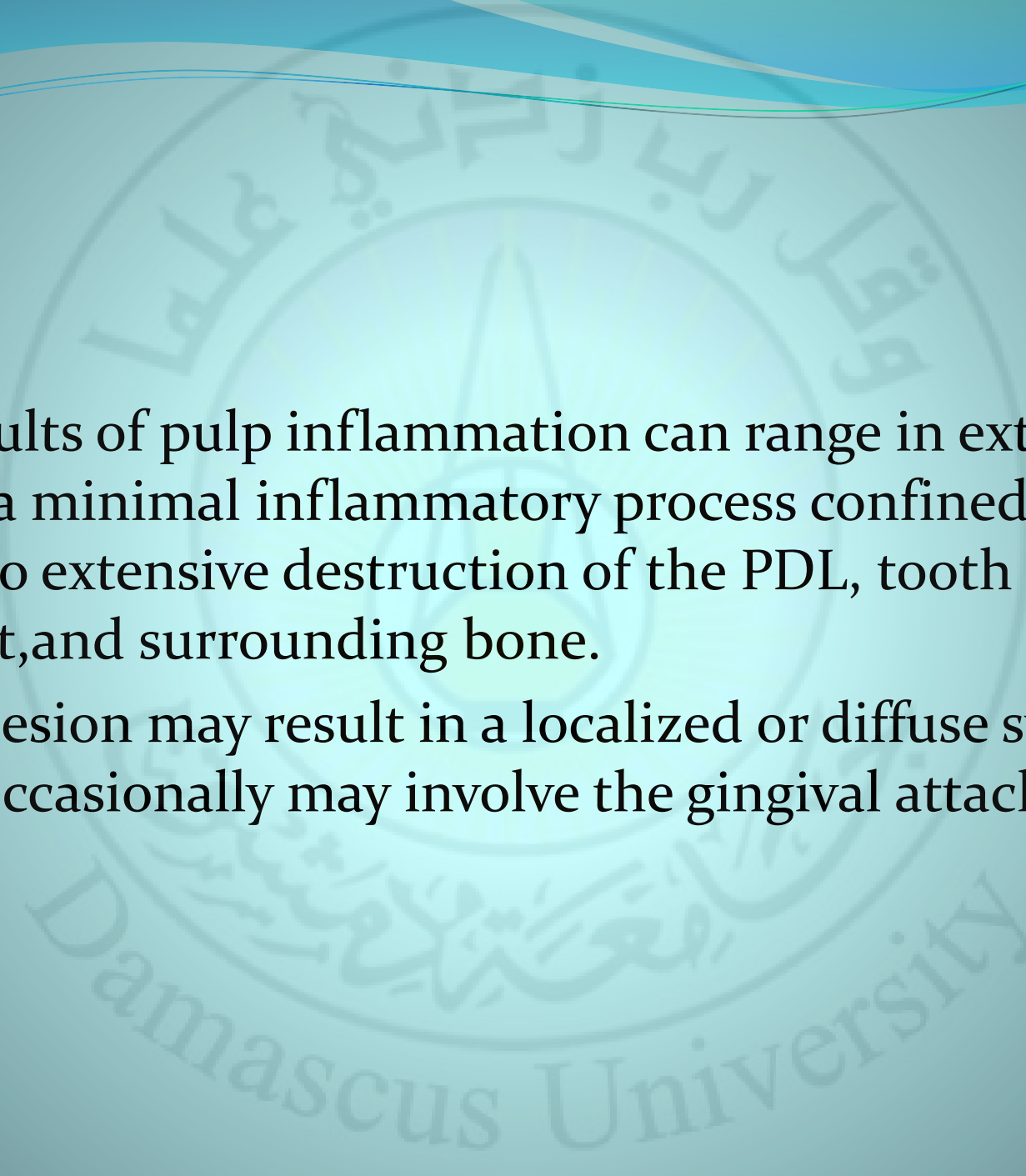
The apical foramen may also be a portal of entry of inflammatory elements from deep periodontal pockets to the pulp.

Elimination of the etiologic factors from the root canal is essential to promote healing.

EFFECT OF ENDODONTIC DISEASE ON THE PERIODONTIUM

When the pulp becomes infected, Inflammatory Byproducts may permeate through the apex, lateral or accessory canals, and dentinal tubules to trigger an inflammatory vascular response in the periodontium. Among those products are living pathogens, such as certain bacteria strains, fungi, and viruses as well as several nonliving pathogen.

In certain cases, pulpal disease will stimulate epithelial growth that will affect the integrity of the periradicular tissues.

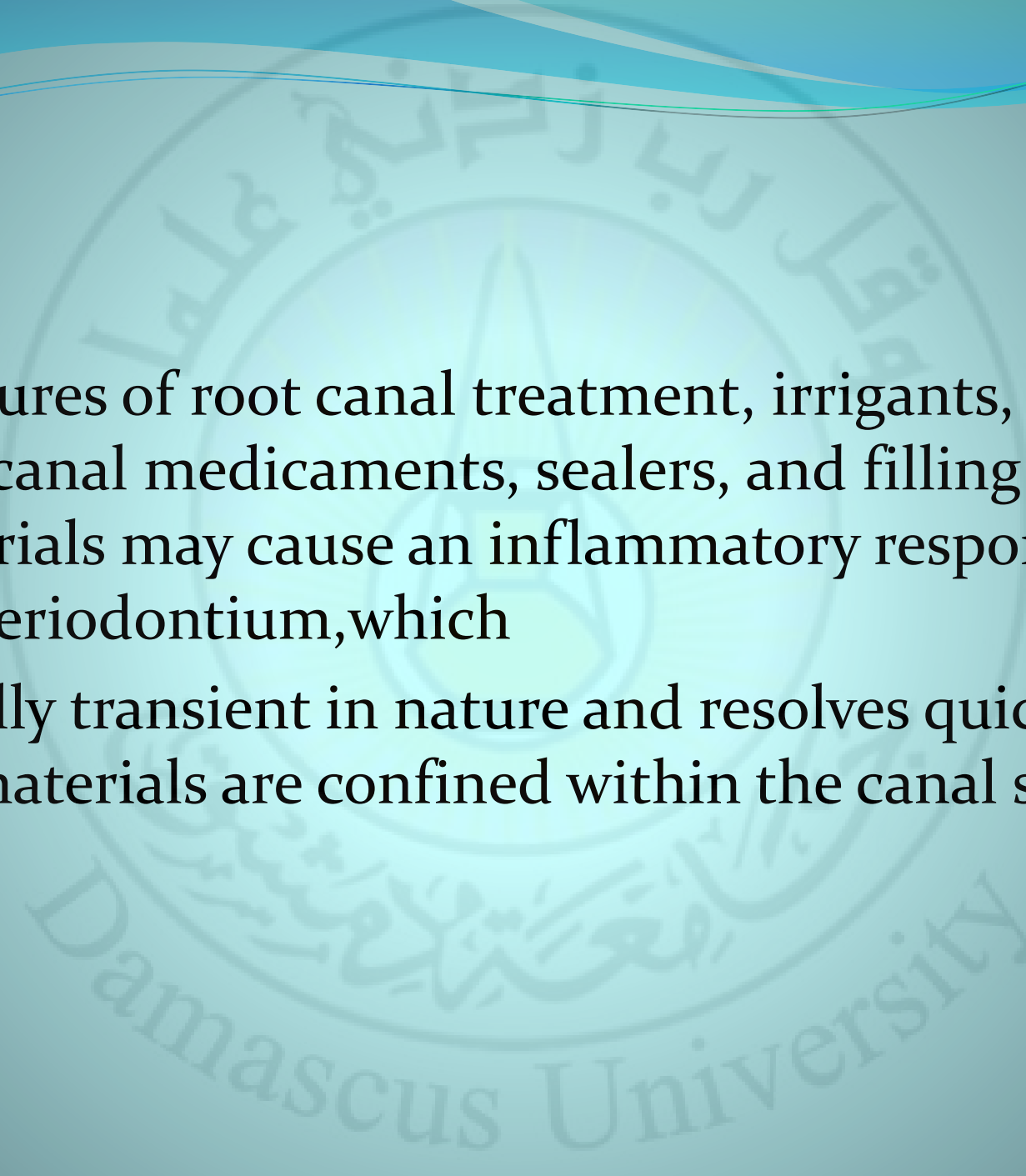
A large, faint watermark of the Damascus University seal is centered in the background. The seal is circular, featuring Arabic calligraphy around the perimeter and a central emblem with a star and crescent. The text 'Damascus University' is written in English at the bottom of the seal.

The results of pulp inflammation can range in extent from a minimal inflammatory process confined to the PDL to extensive destruction of the PDL, tooth socket, and surrounding bone.

Such a lesion may result in a localized or diffuse swelling that occasionally may involve the gingival attachment.

A lesion related to pulpal necrosis may also result in a sinus tract that drains through the alveolar mucosa or attached gingiva. It may also drain through the gingival sulcus of the involved tooth or an adjacent tooth.

After appropriate root canal treatment, lesions resulting from pulpal necrosis resolve in most instances, Subsequently, the integrity of the periodontal tissues will be reestablished.

The background of the slide features a large, faint watermark of the Damascus University logo. The logo is circular, containing Arabic calligraphy and the English text "Damascus University" at the bottom. The text on the slide is positioned in front of this watermark.

Procedures of root canal treatment, irrigants, intracanal medicaments, sealers, and filling materials may cause an inflammatory response in the periodontium, which is usually transient in nature and resolves quickly if the materials are confined within the canal space.

Procedural errors during RCT can also cause inflammatory response in the periodontium.

Periodontal defects resulting from attachment breakdown may occur after procedural mishaps, such as perforations of the floor of a pulp chamber or the root surface apical to the gingival attachment, strip or root perforations, and vertical root fractures associated with uncontrolled forces used for canal obturation.



Inadequate canal access and instrumentation in mandibular first molar. As a result, strip perforation and gross extrusion of sealer has occurred.

EFFECT OF PERIODONTAL DISEASE ON THE PULP

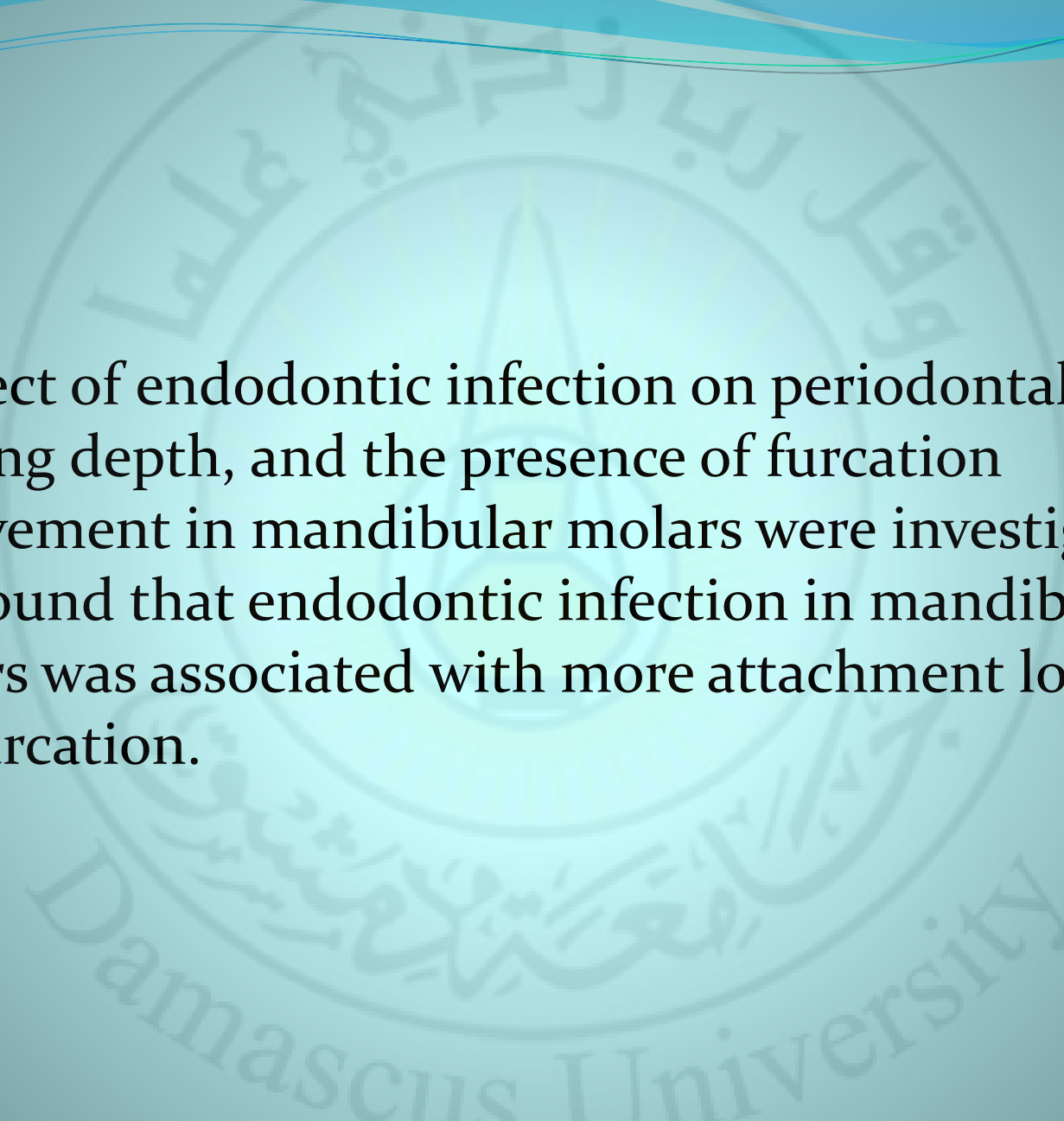
Effect of periodontal inflammation on pulp is
contraversial

It has been suggested that periodontal disease has no major effect on the pulp, at least until it involves the apex, In contrast, several studies suggest that the effect of periodontal disease on the pulp is degenerative in nature, causing an increase in calcifications, fibrosis, collagen resorbtion, and direct inflammatory sequelae.

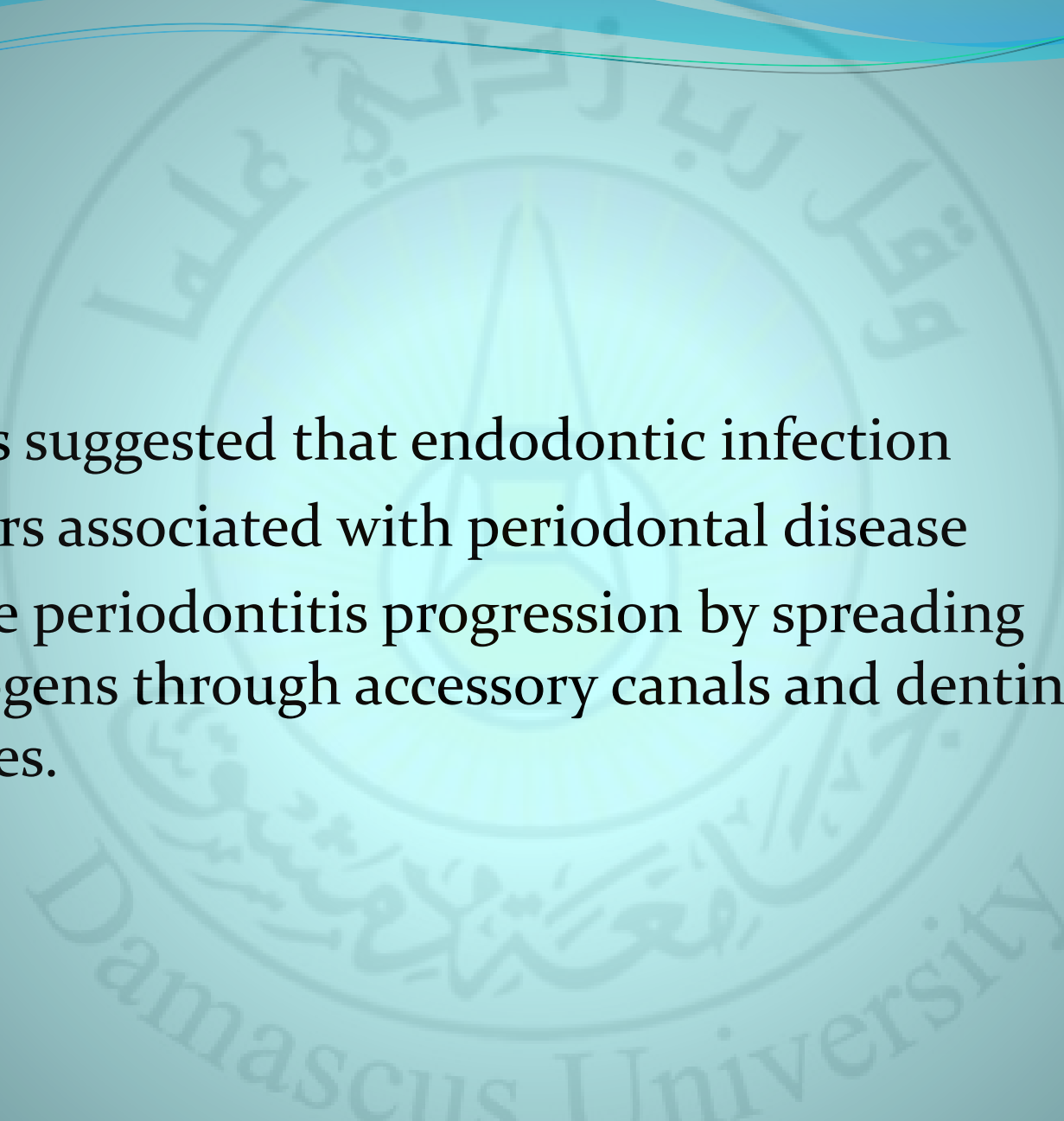
It appears that the pulp is usually not severely affected by periodontal disease until the defect has exposed an accessory canal to the oral environment, at this stage, pathogens leaking from the oral cavity through the accessory canal into the pulp may cause an inflammatory reaction followed by pulp necrosis.

However, if the microvasculature of the apical foramen remains intact, the pulp may test positive to pulp vitality tests.

The effect of periodontal treatment on the pulp is similar during scaling, curettage, or periodontal surgery if accessory canals are severed and/or opened to the oral environment. In such cases, pathogenic invasion and secondary inflammation and necrosis of the pulp can occur.

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The effect of endodontic infection on periodontal probing depth, and the presence of furcation involvement in mandibular molars were investigated, it was found that endodontic infection in mandibular molars was associated with more attachment loss in the furcation.

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Authors suggested that endodontic infection in molars associated with periodontal disease enhance periodontitis progression by spreading pathogens through accessory canals and dentinal tubules.

ETIOLOGICAL FACTORS

Live Pathogens

Among the live pathogens encountered in a diseased pulp that can cause lesions in the periodontium are bacteria ,spirochetes ,fungi, and viruses.

These pathogens and their byproducts, which may affect the integrity of the periodontium, need to be eliminated during endodontic treatment.

Nonliving Pathogens

Nonliving pathogens can be extrinsic (such as foreign bodies) or intrinsic, including a variety of tissue components. These include foreign bodies such as dentin and cementum chips, root canal filling materials, food debris, calculus-like deposits, inflamed epithelium, cholesterol crystal, Russell bodies, Rushton hyaline bodies, and charcot- Leyden crystals.

CONTRIBUTING FACTORS

An important contributing factor is inadequate endodontic treatment.

It is essential to clean, shape, and obturate the canal system well to enhance successful outcomes. Poor endodontic treatment allows canal reinfection, which may often lead to treatment failure and inflammatory reaction in the periodontal tissues.

Endodontic failures can be treated either by orthograde or retrograde retreatment with good success rates.

In recent years, retreatment techniques have improved dramatically because of the use of the operating microscope and the development of new armamentarium.

Other factors, such as coronal leakage, traumatic root resorption, root perforation, and developmental malformations, may play a role in both endodontic and periodontal inflammatory processes.

An excellent and conservative treatment modality for perforations, root resorptions, and certain root fractures in the cervical third region is **controlled root extrusion**.

The goal of controlled root extrusion is to modify the soft tissues and bone; it is therefore used to correct gingival discrepancies and osseous defects of periodontally involved teeth.

It is also used in the management of nonrestorable teeth and as a nonsurgical alternative to crown lengthening.



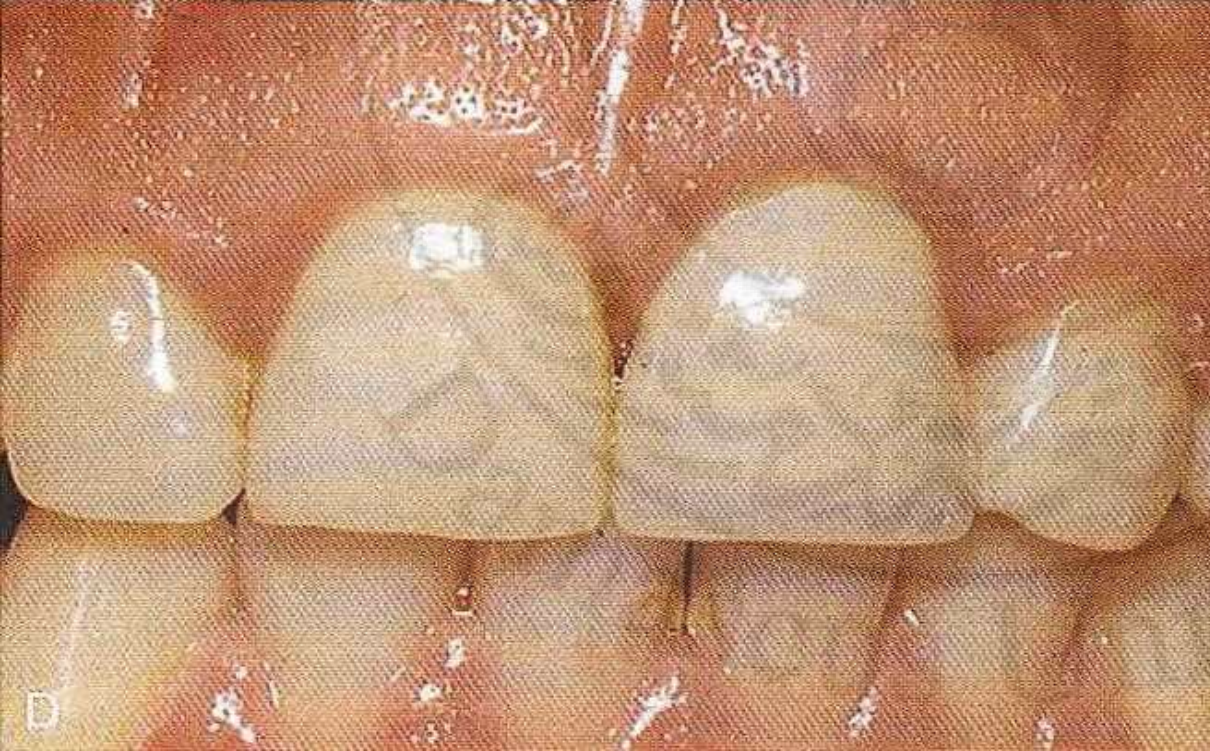
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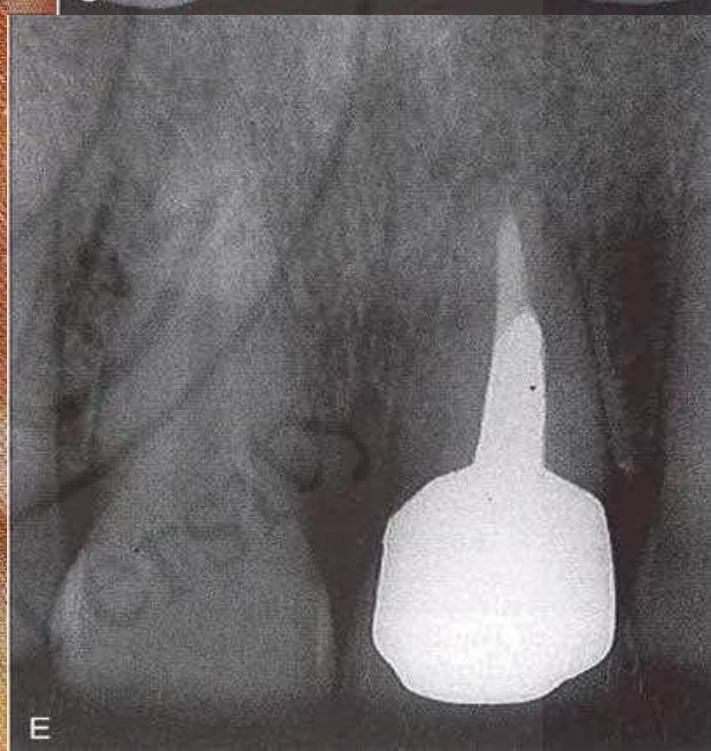
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CLASSIFICATION AND DIFFERENTIAL DIAGNOSIS

For differential diagnosis and treatment purposes, the endodontic-periodontal (endo-perio) lesions can be classified as endodontic, periodontal or combined diseases, these include:

(1) primary endodontic diseases, (2) primary periodontal diseases, and (3) combined diseases.

The combined diseases include: (1) primary endodontic disease with secondary periodontal involvement, (2) primary periodontal disease with secondary endodontic involvement, and (3) true combined diseases.

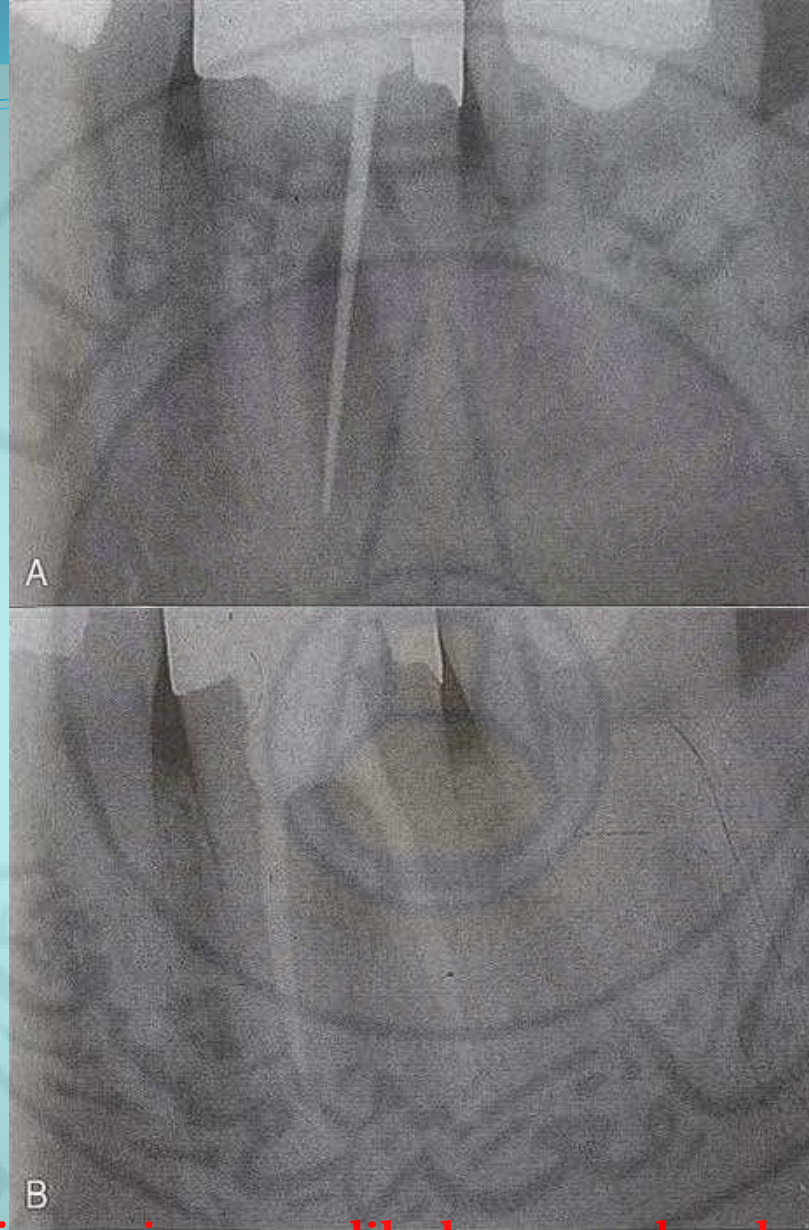
Primary Endodontic disease

Clinical Findings:

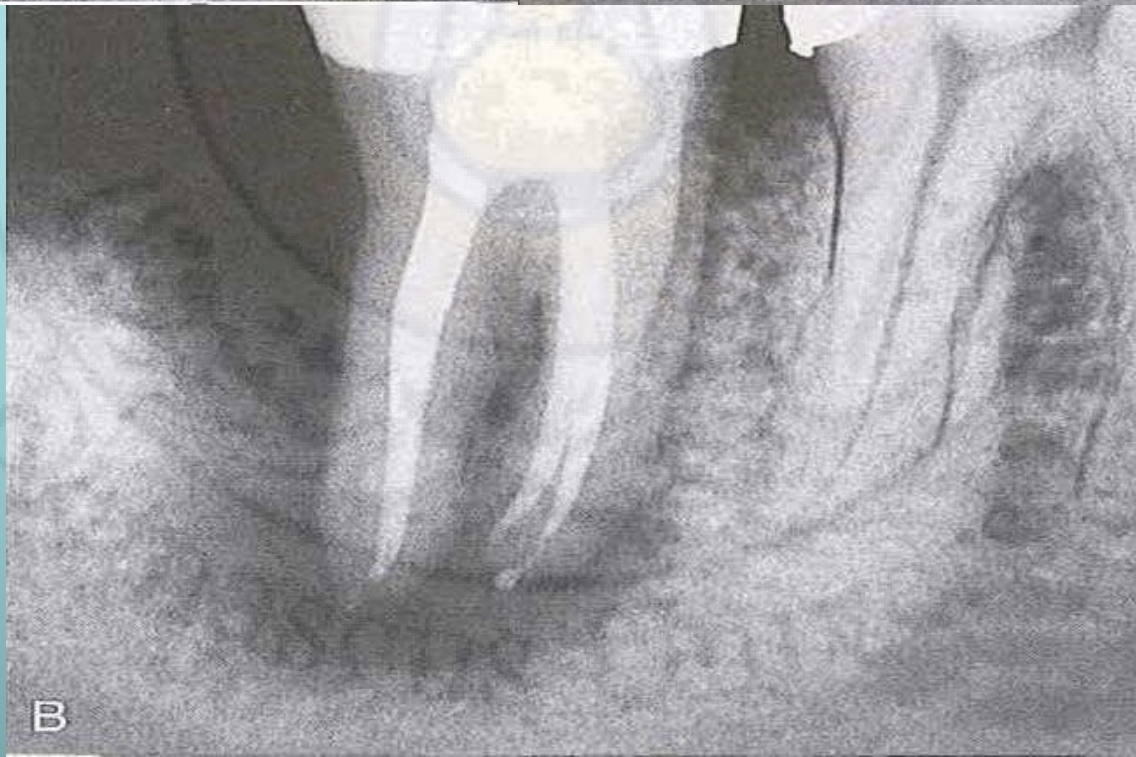
An acute exacerbation of a chronic apical lesion in a tooth with a necrotic pulp may drain coronally through the PDL into the gingival sulcus. Clinically, this condition may mimic the presence of a periodontal abscess .

In reality, it is a sinus tract of pulpal origin that opens through the PDL. **A deep, solitary pocket in the absence of periodontal disease** may indicate the presence of a lesion of endodontic origin or a vertical root fracture.

To determine the origin of the lesion ,a guttapercha cone should be inserted into the sinus tract, and radiographs should be taken.



Primary endodontic disease in a mandibular second molar. A, Preoperative radiograph large furcal radiolucency. A deep, narrow periodontal pocket probed to the apex of the mesial root, pulp necrosis, endodontic treatment was carried out. One year after RCT resolution of the furcal radiolucency is evident.



Radiographic Findings:

In the early stages of the disease, radiographic changes may not be noticeable. As the disease progresses, a widening of the PDL space of the affected tooth, a periapical radiolucency, or a bony lesion extending from apical to cervical can be observed.

Pulp Tests:

Pulp tests will reveal an abnormal or completely absent response.

Probing:

When the pocket is probed, it is **narrow** and lacks width.

A similar condition occurs where drainage from the apex of a molar tooth extends coronally into the furcation area. This may also occur in the presence of lateral canals extending from a necrotic pulp into the furcation area.

Prognosis:

Primary endodontic diseases usually **heal after root canal treatment**. The sinus tract extending into the gingival sulcus or furcation area disappears at an early stage, once the affected pulp has been removed and the root canals have been well cleaned, shaped, and obturated.

Primary Periodontal disease

Clinical Findings:

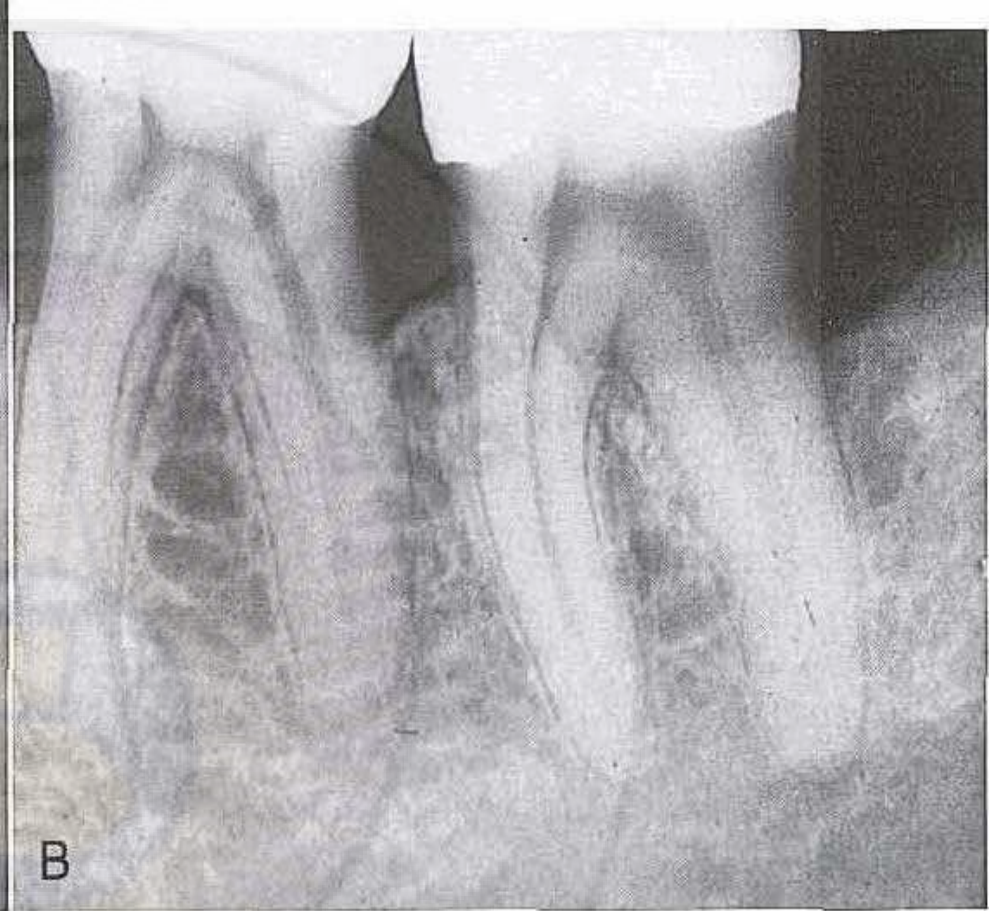
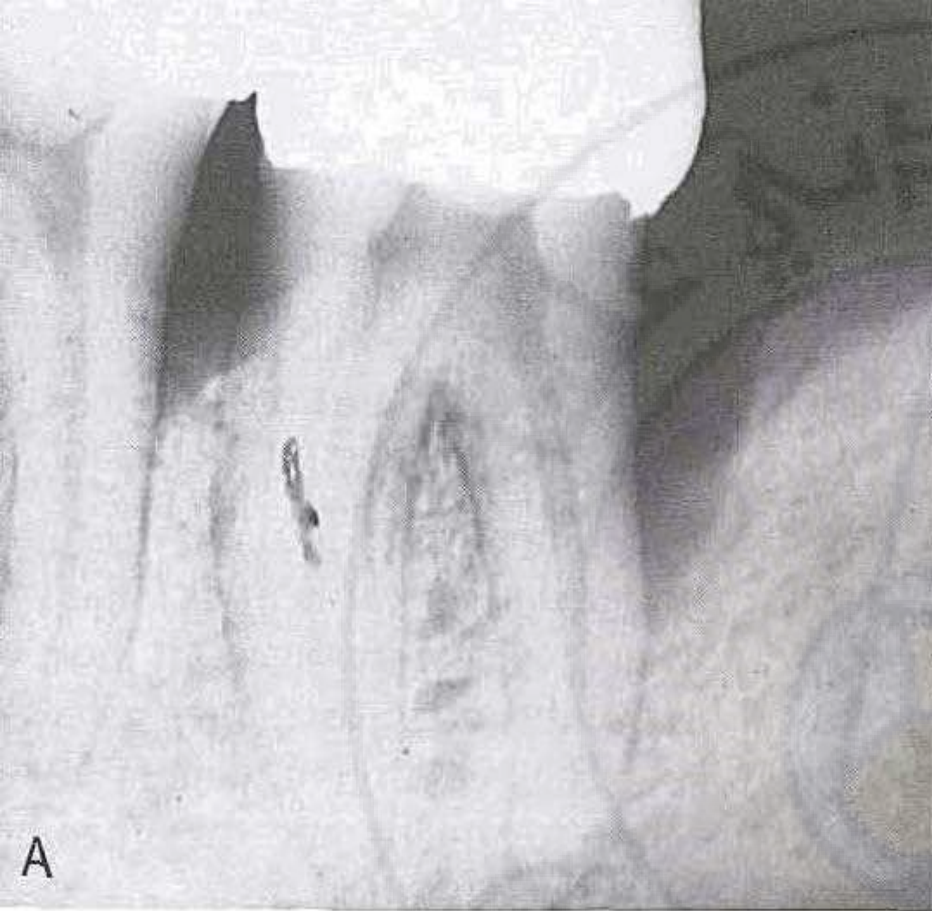
Periodontal lesions are caused primarily by periodontal pathogens. In this process, **chronic marginal periodontitis progresses apically along the root surface.**

There is frequently an accumulation of plaque and calculus, and the pockets are wider.

Radiographic Findings:

Bony lesions associated with **angular bone loss** are usually found and **extend from the cervical region toward the apex**. The lesions may not be limited to just one tooth and **often involve adjacent teeth** as well.

In contrast to primary endodontic lesions, **the absence of buccal, lingual, or both plates may clearly show root and canal to the level of the bone loss**.



Primary periodontal disease in a mandibular second molar. A, Preoperative radiograph of a periodontal lesion. All teeth responded within normal limits to pulp tests. B, Two-year recall radiograph of successful periodontal treatment.

Pulp Tests:

In most cases, pulp tests indicate a clinically **normal pulpal response**. This is an important test to distinguish between primary endodontic disease and primary periodontal disease conditions.

Probing :

will reveal **wide pockets that do not necessarily extend toward the apex**.

Prognosis:

The prognosis depends on **the stage of periodontal disease and the efficacy of periodontal treatment**.

Combined diseases

Primary Endodontic Disease with Secondary Periodontal Involvement

If a suppurating primary endodontic disease remains untreated after a period of time, it may become secondarily involved with marginal periodontal breakdown.

Clinical Findings:

Plaque is found at the gingival margin of the solitary sinus tract, which leads to marginal periodontitis.

When plaque or calculus is present, the treatment and prognosis of the tooth are different than for teeth involved with only primary endodontic disease.

Adjacent teeth are not necessarily involved.

Radiographic Findings:

A clear widening of the PDL space of the affected tooth extending from apical to cervical can be observed.

Pulp Tests:

Pulp tests will usually reveal absence of response.

Probing:

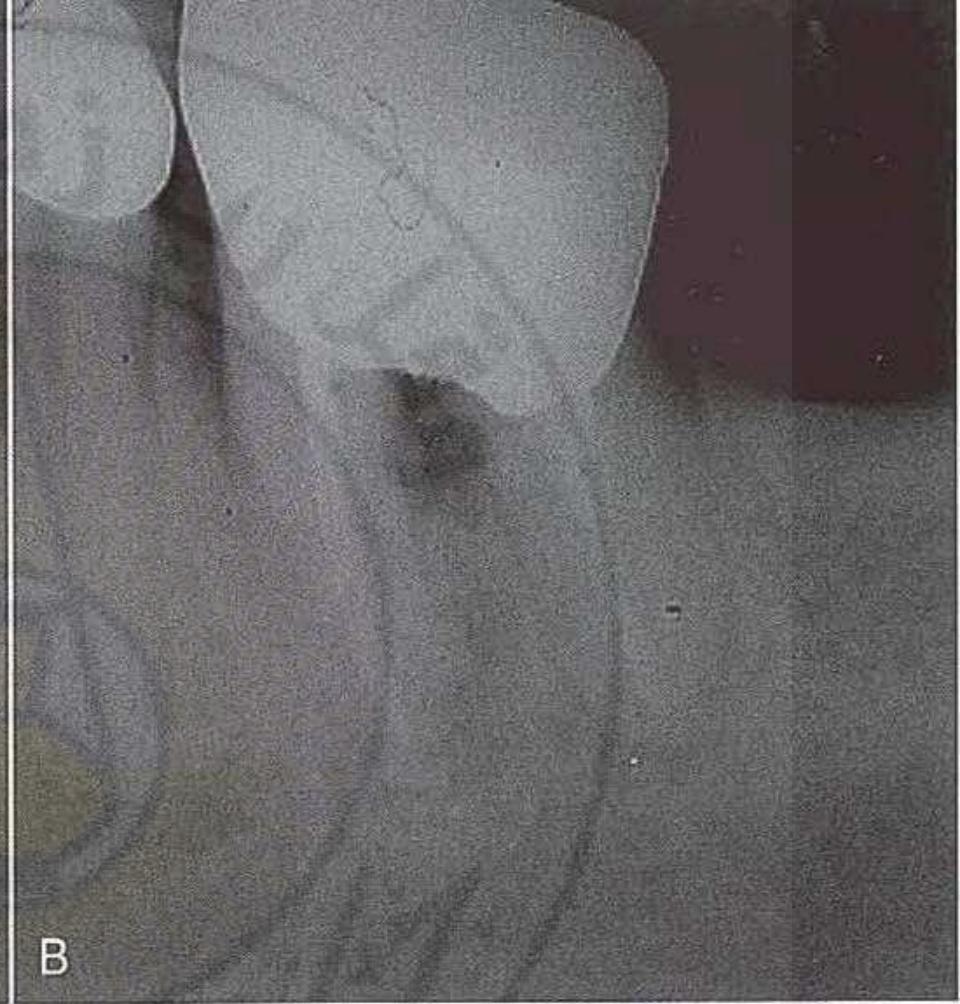
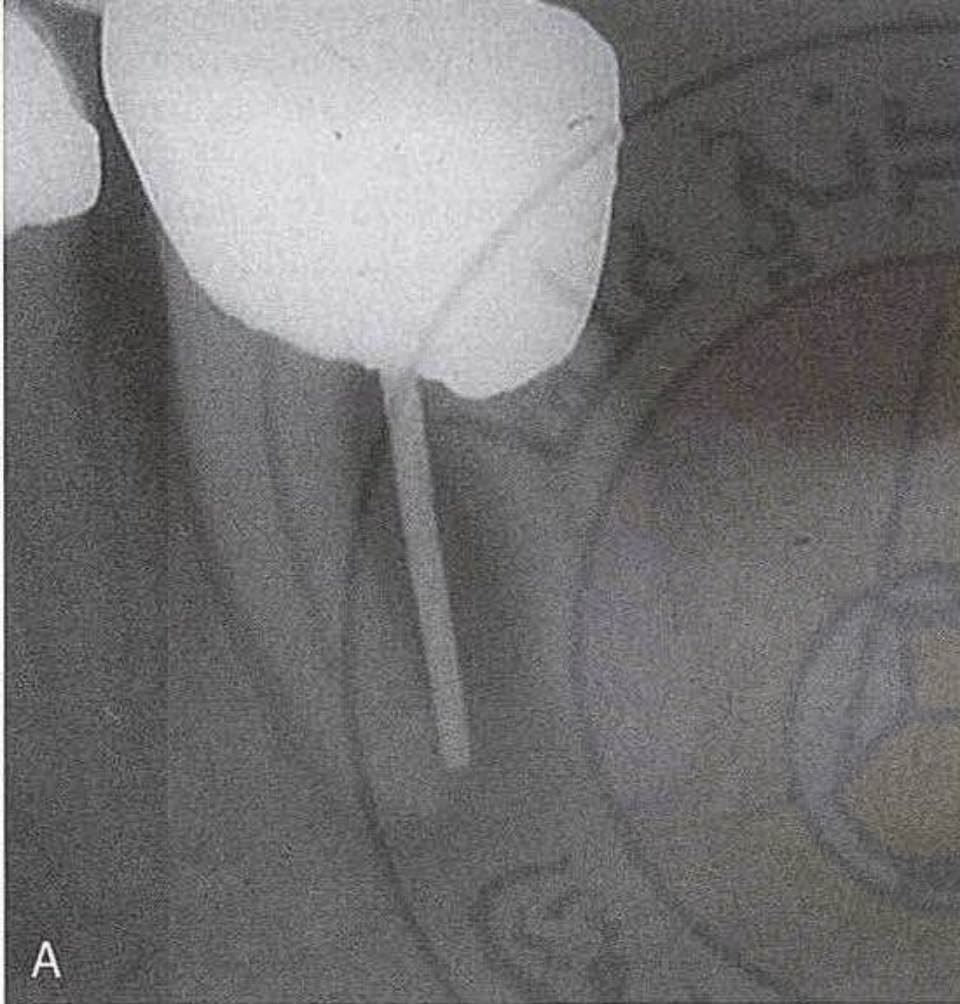
A solitary, but wider pocket extending toward the apex is usually found.

Prognosis:

The affected tooth requires **both endodontic and periodontal treatments**. If the endodontic treatment is adequate, the prognosis depends on the severity of the marginal periodontal damage and the efficacy of periodontal treatment.

With endodontic treatment alone, only that part of the lesion that is of endodontic etiology will heal to the level of the secondary periodontal lesion.

A similar clinical picture may also occur as a result of root perforation or misplaced pins or posts.



Primary endodontic disease with secondary periodontal involvement in a mandibular first molar. **A.** Preoperative radiograph showing deep furcal defect extending to the apex of the mesial root, pulp necrosis. **B,** *One-year follow-up radiograph showing resolution of most of the periradicular lesion;* Periodontal treatment was necessary for further healing of the furcal area

Sometimes symptoms may be acute, including periodontal abscess associated with pain, swelling, pus exudate, pocket formation, and tooth mobility.

- A more chronic response may also occur without pain and involves the sudden appearance of a pocket with bleeding on probing or exudation of pus.

Root fractures may also mimic the appearance of primary endodontic lesions with secondary periodontal Involvement, These typically occur on endodontically treated teeth with posts and crowns. The signs may range from a local deepening of a periodontal pocket to more acute periodontal abscess formation.

Primary Periodontal Disease with Secondary Endodontic Involvement

The progression of a periodontal pocket may continue until the apical tissues are involved. In this case, the pulp may become necrotic as a result of infection entering via lateral canals or the apical foramen.

Bacteria originating from the periodontal pocket can be a source of root canal infection.

As long as neurovascular supply of the pulp remains intact, prospects for survival are good, If lost to periodontal disease, pulpal necrosis will likely occur.

Clinical Findings:

Bony lesions associated with angular bone loss are usually found and extend from the cervical region toward the apex.

Generalized periodontitis or periodontal involvement of adjacent teeth is common.

Symptoms associated with pain originating from an inflamed pulp are common at the early stages of the disease, As the disease progresses, the pulp is expected to lose its vitality.

Treatment complications of periodontal disease can also lead to secondary endodontic involvement.

Lateral canals and dentinal tubules may be opened to the oral environment by curettage, scaling, or surgical flap procedures.

It is possible for a blood vessel within a lateral canal to be severed by a curette and for microorganisms during treatment, resulting in pulp inflammation and necrosis .



Primary periodontal disease with secondary endodontic involvement in a maxillary central incisor. A, bone loss of one-half root length and a separate periapical lesion. The crown was intact; however, pulp tests negative. B, Radiograph taken immediately after root canal treatment reveals lateral canals exposed to the oral environment because of the bone loss. In this case, This resulted in infection of the root canal and pulp necrosis.

Radiographic Findings:

Bony lesions associated with angular bone loss are usually found and extend from the cervical region toward the apex. Additional periapical radiolucency can also be detected.

Pulp Tests:

Pulp tests will reveal an abnormal or complete absence of response.

Probing:

Probing will reveal a wide pocket extending apically. However, probing does not necessarily extend all the way to the apex.

Prognosis

In single-rooted teeth, the prognosis is usually poor. In molar teeth, the prognosis may be better since all the roots may not suffer the same loss of supporting tissues.

In such cases, root resection can be considered as a treatment alternative.

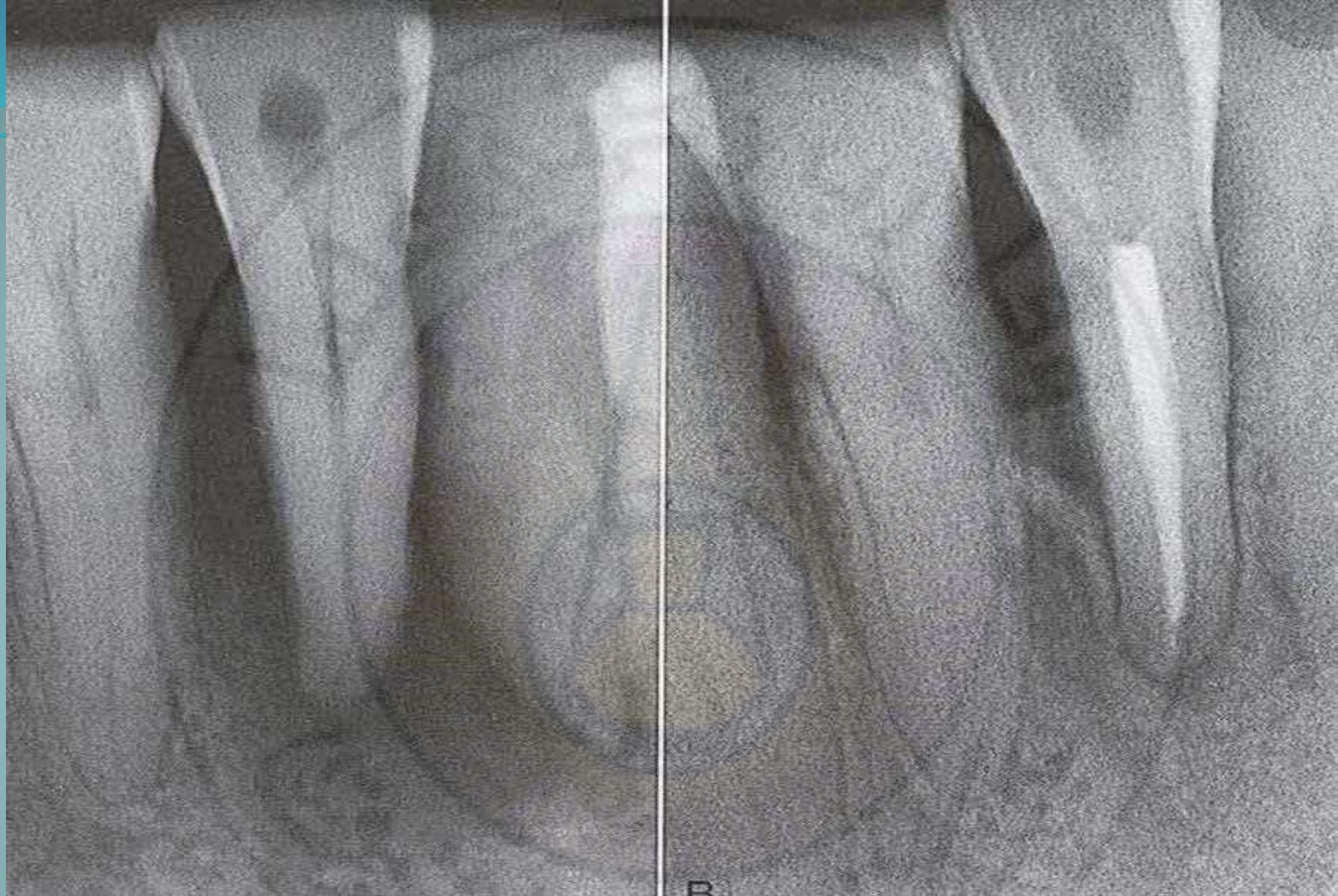
True Combined Diseases

True combined endo-perio diseases occur *less often*.

Clinical findings:

True combined endo-perio diseases occur when an endodontic disease progressing coronally joins with an infected periodontal pocket progressing apically.

The degree of attachment loss in this type of lesion is great.



True combined perio-endo lesion. A, Mandibular incisor with a large lesion at the distal. The lesion probed with a conical contour: Within the conical lesion there was a defect that probed to the apex, demonstrating communication. B, An 11-year recall will demonstrate resolution of the lesion around the apex. An angular defect remains at the distal.

Radiographic Findings:

Extensive bony radiolucencies from endodontic and periodontal origins are found associated with the affected tooth, This is due to the long-standing nature of this condition.

Depending on the stage of the disease, the lesions may or may not communicate.

The radiographic appearance of combined endo-perio disease may be similar to that of a vertically fractured tooth, correct differential diagnosis is essential.

Pulp Tests:

Pulp tests will reveal complete absence of response.

Probing:

Probing will show a wide and conical periodontal pocket, characteristic of periodontal disease.

Prognosis:

The prognosis is usually guarded. This is particularly true in single-rooted teeth. In molar teeth, root resection *can be considered as a treatment alternative* , In most cases, *periapical healing* may be anticipated **after successful endodontic treatment**. The periodontal tissues, however, may not respond well to treatment, and **depend on the severity** of the condition.

A fracture that has invaded the pulp space with resultant necrosis may also be labeled a true combined lesion, but it may not be amenable to successful treatment.

If a sinus tract is present, it may be necessary to raise a flap to establish the diagnosis.

Treatment plan :

Prognosis depends primarily on the diagnosis of the specific endodontic or periodontal disease, **The main factors to consider are pulp vitality and extent of the periodontal condition.**

For example, the prognosis for a tooth with a necrotic pulp, with or without a sinus tract, is excellent after appropriate root canal therapy. However, the prognosis of root canal treatment in a tooth with severe periodontal disease depends on the success of the periodontal therapy.

Primary endodontic disease should only be treated by endodontic therapy, Excellent prognosis is to be expected if appropriate endodontic treatment is carried out.

Primary periodontal disease should only be treated by periodontal therapy. In this case, the prognosis depends on the severity of the periodontal disease and the patient's tissue response.

Primary endodontic disease with secondary periodontal involvement should first be treated with endodontic therapy.

Treatment results should be evaluated in 2 to 3 months and only then should periodontal treatment be considered.

This sequence of treatment allows sufficient time for initial tissue healing and better assessment of the periodontal condition, it also reduces the potential risk of introducing bacteria and their byproducts during the initial phase of healing.

Aggressive removal of the PDL and underlying cementum during interim endodontic therapy might adversely affect periodontal healing.

Adequate endodontic therapy cause healing of lesions of pulpal origins.

Primary periodontal disease with secondary endodontic involvement, and true combined endo-perio diseases require both endodontic and periodontal considerations.

The prognosis depends primarily on the severity of the periodontal disease, and the periodontal tissues' response to treatment.

True combined diseases, have a more guarded prognosis.

In general adequate endodontic treatment will result in healing of lesions of pulpal origin.

The prognosis of combined diseases depends mainly on the success of periodontal therapy. If the etiology of the condition is not clear, a consultation with a Specialist and a referral for appropriate diagnosis and treatment are indicated.

Endodontic Microbiology

Damascus University

Most pathoses of the dental pulp and Periradicular tissues are either directly or indirectly related to **microorganisms**.

Bacteria Associated with Endodontic Infections

TERMINOLOGY

Colonization is the establishment of bacteria or other microorganisms in a living host.

Colonization occurs **if** appropriate biochemical and physical conditions are available for growth.

Permanent colonization in a symbiotic relationship with the host results in establishment of normal oral flora.

These organisms participate in many beneficial relationships but are considered *opportunistic pathogens* if they gain access to a normally sterile area of the body and produce disease.

Infectious disease results if microorganisms damage the host and produce clinical signs and symptoms.

Pulpal and Periradicular pathoses result from opportunistic pathogens infecting the pulp cavity and Periradicular tissues.

Pathogenicity is the capacity of organisms to produce disease within a particular host.

Virulence expresses the degree of pathogenicity in a host under defined circumstances.

Stages in development of an endodontic infection include microbial invasion, colonization, multiplication, and pathogenic activity.

PORTALS OF ENTRY TO THE PULP

Microbes take several routes to invade the pulp. If enamel or cementum is missed microorganisms may invade the pulp through exposed dentinal tubules.

Caries are the most common source of bacterial penetration through the tubules.

Bacteria can invade and multiply within permeable tubules.

Tubule permeability is reduced by the presence of various components:

Dentinal fluid, living odontoblastic processes, and the formation of peritubular dentin or tertiary dentin.

Bacteria are preceded through the tubules by their byproducts and breakdown products, which may be pulp irritants.

Microorganisms may reach the pulp after direct pulpal exposure associated with caries restorative procedures, or traumatic injury that fractures, cracks, displaces teeth.

Pulp status is an important factor in susceptibility to microbial invasion, vital pulp is very resistant to microbial invasion.

There is also an intimate relationship between pulp and periodontium via:

Tubules, accessory canals, furcation canals,
and the apical foramen.

Pulpal necrosis and the egress of irritants by these routes may affect the periodontal ligament and surrounding tissues.
The reverse seems less likely.

Presumably, pulpal inflammation results if bacteria can penetrate the lateral canals, furcation canals, or denuded dentin after periodontal treatment.

The removal of cementum during periodontal therapy exposes dentinal tubules to oral flora.

Anachoresis is a process by which microorganisms are transported in the blood to an area of inflammation where they establish an infection.

How often anachoresis contributes to pulpal or periradicular infections in humans has not been determined.

CARIES AND PULPAL DISEASE

The most common source of bacteria to the pulp is from caries.

Bacteria associated with caries are not motile but apparently advance through the dentinal tubules by dividing and by dentinal fluid movement.

In humans, Streptococcus mutans and Streptococcus sobrinus, have been associated with smooth surface and pit-fissure caries, where as actinomyces have been associated with root caries.

Although mutans streptococci are important in initiating caries, they are not important in the progression of deep caries.

Bacteria in the deepest layers of caries are predominantly strict anaerobes.

After exposure of the dental pulp by caries, numerous species of opportunistic oral flora may invade and colonize necrotic tissue.

This allows microbial selection by the ecosystem associated with infections of endodontic origin.

REACTION OF PULP TO BACTERIA

Like other connective tissues, pulp responds to irritants with:

- (1) nonspecific inflammation.
- (2) specific immunologic reactions.

Pulpal inflammation from caries begins as a chronic cellular response characterized by the presence of: lymphocytes, plasma cells, and macrophages.

The response to caries by the pulp-dentin complex includes :

Formation of peritubular dentin, decreased permeability of dentinal tubules, and production of tertiary dentin.

Generally, the pulp is not severely (not irreversibly) inflamed when caries do not penetrate to the pulp.

After pulp exposure by caries, numerous species of opportunistic oral flora may colonize the exposed tissue.

Polymorphonuclear (PMN) leukocytes characteristic of acute inflammation are chemotactically attracted to the area.

An accumulation of PMN leukocytes results in abscess formation.

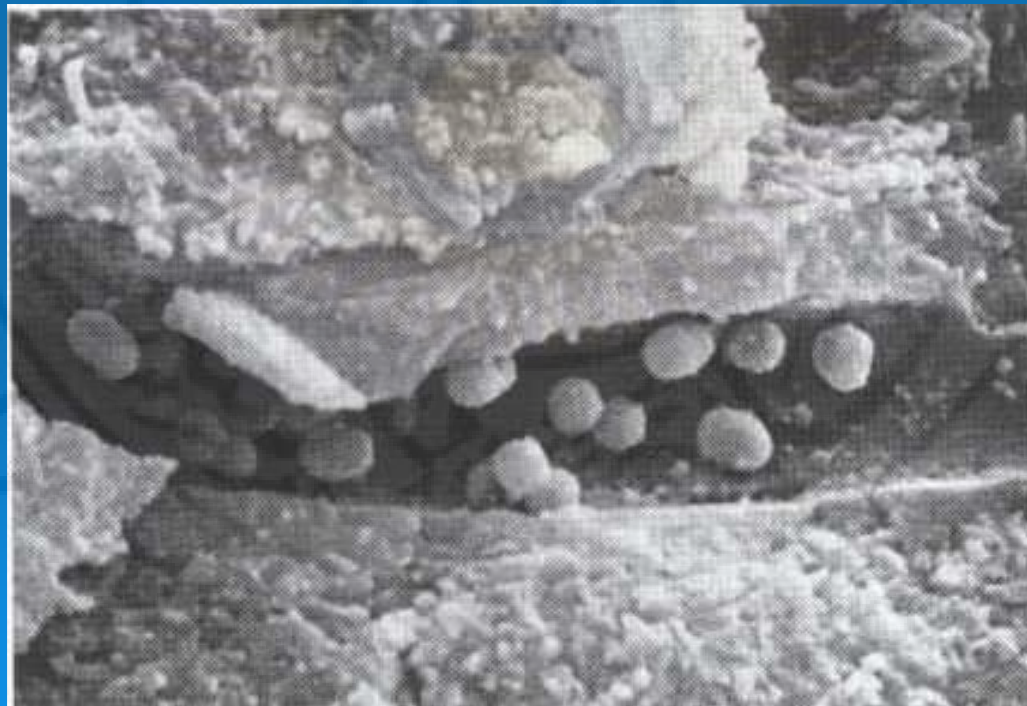
Pulp may remain inflamed for long time or may undergo rapid necrosis, pulpal reaction is related to :

Virulence of bacteria, host response, amount of pulpal circulation, degree of drainage.

Because it is surrounded by hard tissue, the intrapulpal pressure when extravascular inflammatory cells and fluids accumulate, will interfere with normal circulation and cell function, and leads to injury or death.

POLYMICROBIAL INFECTIONS

Microorganisms invade the necrotic pulp, multiply, and infect the root canal system, including the dentinal tubules.



The pulp becomes a reservoir for microorganisms, microbial byproducts, and microbial breakdown products.

Endodontic infections include infections of both the pulp cavity and the periradicular diseased tissues.

Of about 500 species of bacteria recognized as normal oral flora, only a relatively small group are commonly isolated from infected pulp cavities.

Strict anaerobic bacteria predominate, with some facultative anaerobes and rarely aerobes.

Many bacteria (especially strict anaerobes) are difficult to cultivate.

Predominant isolates from the root canals of 65 teeth with periapical lesions

BACTERIAL SPECIES	NO. STRAINS ISOLATED	CHARACTERISTICS
<i>Eubacterium</i> spp.	59	Gram-positive rod, nonmotile
<i>Peptostreptococcus</i> spp.	54	Gram-positive cocci, nonmotile
<i>Fusobacterium</i> spp.	50	Gram-negative fusiform, nonmotile
<i>Porphyromonas</i> spp. (black-pigmented)	32	Gram-negative rod, nonmotile
<i>Prevotella</i> spp. (black-pigmented)	30	Gram-negative rod, nonmotile
<i>Streptococcus</i> spp.	28	Gram-positive cocci, nonmotile
<i>Lactobacillus</i> spp.*	24	Gram-positive rod, nonmotile
<i>Wolinella</i> spp.	18	Gram-negative rod, motile
<i>Prevotella</i> spp. (nonpigmented)	15	Gram-negative rod, nonmotile
<i>Actinomyces</i> spp.	14	Gram-positive rod, nonmotile
<i>Propionibacterium</i> spp.	7	Gram-positive rod, nonmotile
<i>Capnocytophaga ochracea</i>	7	Gram-negative fusiform, motile
<i>Veillonella parvula</i>	6	Gram-negative cocci, nonmotile
<i>Selenomonas sputigena</i>	6	Gram-negative rod, motile
Other spp.*	3	
Total number of strains isolated	353	
	(average 5.3 strains per root canal)	

Modern culturing techniques demonstrated the association of polymicrobial opportunistic oral bacteria and the predominance of strict anaerobes, with pulp and periradicular diseases.

The relative proportion of strict anaerobic bacteria to facultative bacteria increases with time, as does the total number of bacteria.

Black-pigmented bacteria (BPB) associated with endodontic infections.

Species of BPB were previously located in the genus *Bacteroides*.

BPB are nonmotile, Gram-negative rods.

Three asaccharolytic species of BPB have been reclassified into a separate genus named *Porphyromonas*.

Species of saccharolytic BPB have been reclassified into a separate genus named *Prevotella*.

Recent taxonomic changes for previous bacteroides species

Porphyromonas, black-pigmented (asaccharolytic *Bacteroides* species)

Porphyromonas asaccharolytica (usually nonoral)

*Porphyromonas gingivalis**

*Porphyromonas endodontalis**

Prevotella, black-pigmented (asaccharolytic *Bacteroides* species)

Prevotella melaninogenica

Prevotella denticola

Prevotella loescheii

Prevotella intermedia

Prevotella nigrescens†

Prevotella corporis

Prevotella tannerae

Prevotella, nonpigmented (saccharolytic *Bacteroides* species)

*Prevotella buccae**

Prevotella bivia

Prevotella oralis

Prevotella oris

Prevotella oulorum

Prevotella ruminicola

No absolute correlation has been made between any species of bacteria and the signs or symptoms of endodontic pathosis.

BPB studies have found that *Porphyromonas gingivalis* and *Porphyromonas endodontalis* were isolated only **from acute infections**, **whereas** *Prevotella intermedia* was found with both symptomatic and asymptomatic infections

Recently, with DNA methods, *Prevotella nigrescens*, is the BPB most commonly cultivated from endodontic infections.

Molecular methods have also been used to detect and identify the presence of another BPB, *Prevotella tannerae*, in endodontic infections.

Other bacteria often associated with clinical signs and symptoms include *Prevotella buccae* and species of *Peptococcus*, *Peptostreptococcus*, *Eubacterium*, *Actinomyces*, and *Fusobacterium*.

Actinomyces, *Propionibacterium* and *enterococcus faecalis* species are able to persist in periradicular tissues in the presence of chronic inflammatory tissue.

However, no absolute causative relationship between specific microorganisms and endodontic disease have been defined.

Most of these infections apparently respond to conventional root canal treatment. However, surgery or antibiotics may be needed to resolve these infections.

Studies demonstrated absence of healing when canals are obturated in the presence of microbes in the root canal .

Yeasts and viruses are also found in the pulp. Fungi have been identified in root canals and in teeth refractory to endodontic treatment. Viruses, including the human immunodeficiency virus (HIV), are present in the pulp and may be associated with endodontic disease

MICROBIAL ECOSYSTEM IN THE ROOT CANAL

When a necrotic pulp is sampled, a mix of bacterial species are recovered.

Because of the lack of circulation within a necrotic pulp, normal host defense mechanisms (inflammation and immunity) are absent or compromised.

The root canal system is a special environment ,where selection results in a restricted group of bacteria.

Tissue fluid and disintegrated cells from necrotic tissue form a substrate of nutrients (especially polypeptides and amino acids) essential for microorganisms.

These nutrients, low oxygen tension, and bacterial interactions are the key ecologic determinants of which bacteria will predominate.

Conditions favor the growth of anaerobes able to metabolize peptides and amino acids rather than carbohydrates.

The growth of one bacterial species may depend on other species, which supplies an essential nutrient as a metabolic byproduct.

Likewise, antagonistic relationships may develop among bacteria.

Some by-products (e.g., ammonia) may be either a nutrient or a toxin, depending on the species of bacteria and the concentration of its by-products in the ecosystem.

Root canal treatment uses Chemomechanical methods of debridement to destroy, and remove the microbial ecosystem.

This is accomplished through the cleaning and shaping process and the adjunctive use of antimicrobials within the pulp system.

Effective obturation of the root canal space and coronal restoration prevents apical and coronal leakage.

Association of Bacteria with Periradicular Disease

Bacteria and bacterial by-products emanating from the root canal are the major irritants associated with periradicular inflammation.

Bacterial by-products alone are capable of causing periradicular pathosis.

VIRULENCE FACTORS

Bacterial fimbriae are important for attachment to surfaces and to other bacteria (synergistic relationships).

Capsules are a significant resistance factor for bacteria, enabling them to avoid phagocytosis.

Lipopolysaccharides

LPSs are found on the surface of Gram-negative bacteria and have numerous biologic effects that induce periradicular pathosis.

LPSs have nonspecific antigens that are not well neutralized by antibodies.

LPS antigens activate the complement cascade.

LPSs are known as endotoxins.

Endotoxin is capable of diffusing across dentin.

The content of LPSs in canals of symptomatic teeth with radiographically evident lesions and exudate is higher than that of asymptomatic teeth.

Enzymes

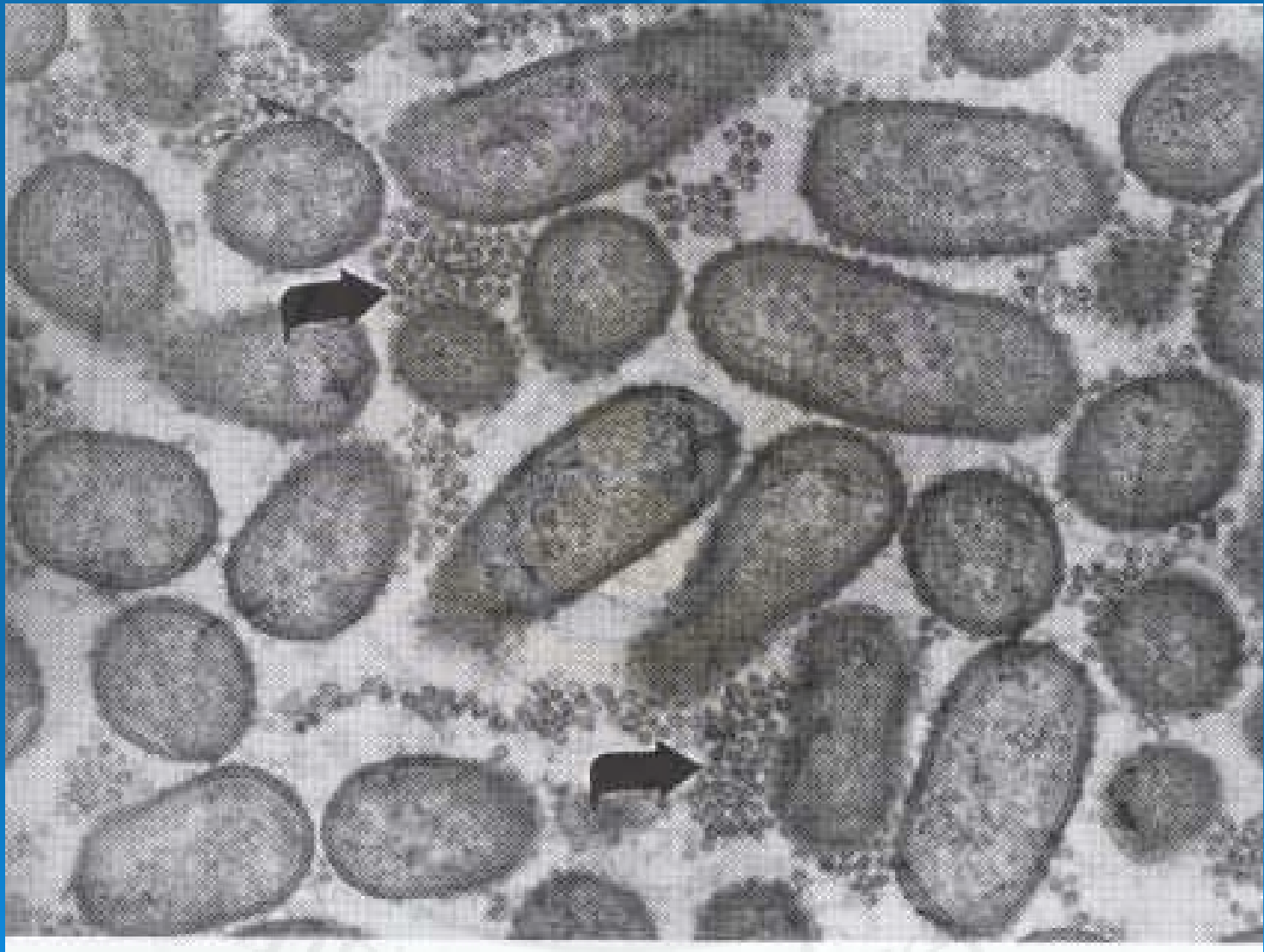
Bacteria produce enzymes (proteases) that neutralize immunoglobulins and complement components.

Recently collagenase, was detected in strains of *Porphyromonas gingivalis* isolated from endodontic infections.

Extracellular Vesicles

These may be free endotoxin, blebs, and outer membrane fragments.

They have a structure similar to that of the outer membrane of a Gram negative Bacterium.



The vesicles contain enzymes or other products that affect host cells.

They have the same antigenic determinants on their surface as their parent bacteria.

They may protect the bacteria by neutralising specific antibodies.

Fatty Acids

Anaerobic bacteria produce short-chain fatty acids such as propionic, butyric.

These acids are active virulence factors that affect neutrophil chemotaxis, phagocytosis, and other intracellular changes.

Butyric acid has been shown to stimulate production of interleukin-1, which is associated with bone resorption and periradicular path.

Polyamines

Gram-negative bacteria, contain large amounts of polyamines.

Polyamines such as putrescine, cadaverine, spermidine, and spermine are involved in the regulation of cell growth, regeneration of tissues, and modulation of inflammation.

Amounts of putrescine and total polyamines are higher in the necrotic pulps of teeth that are painful to percussion or those that have spontaneous pain.

Teeth with a sinus tract have a significantly greater amount of cadaverine in the pulp space.

CORRELATIONS WITH PATHOSES AND TREATMENT

The association of specific species of bacteria with pulpal and periapical pathoses as well as with clinical signs and symptoms is not absolute.

Endodontic infections are polymicrobial, with each species of bacteria having variable virulence factors.

From a treatment point of view, all endodontic infections are considered polymicrobial and are treated accordingly.

Root canal treatment of a necrotic pulp will disrupt the microbial ecosystem by removing bacteria, bacterial byproducts, and substrate from the root canal system.

In contrast to the necrotic debris and microbes sequestered in a pulp cavity, periradicular tissues have an excellent collateral blood supply, lymphatic drainage, and a large pool of undifferentiated cells.

The extent of the periradicular inflammatory reaction will depend on the severity of the irritation, its duration, and the host response.

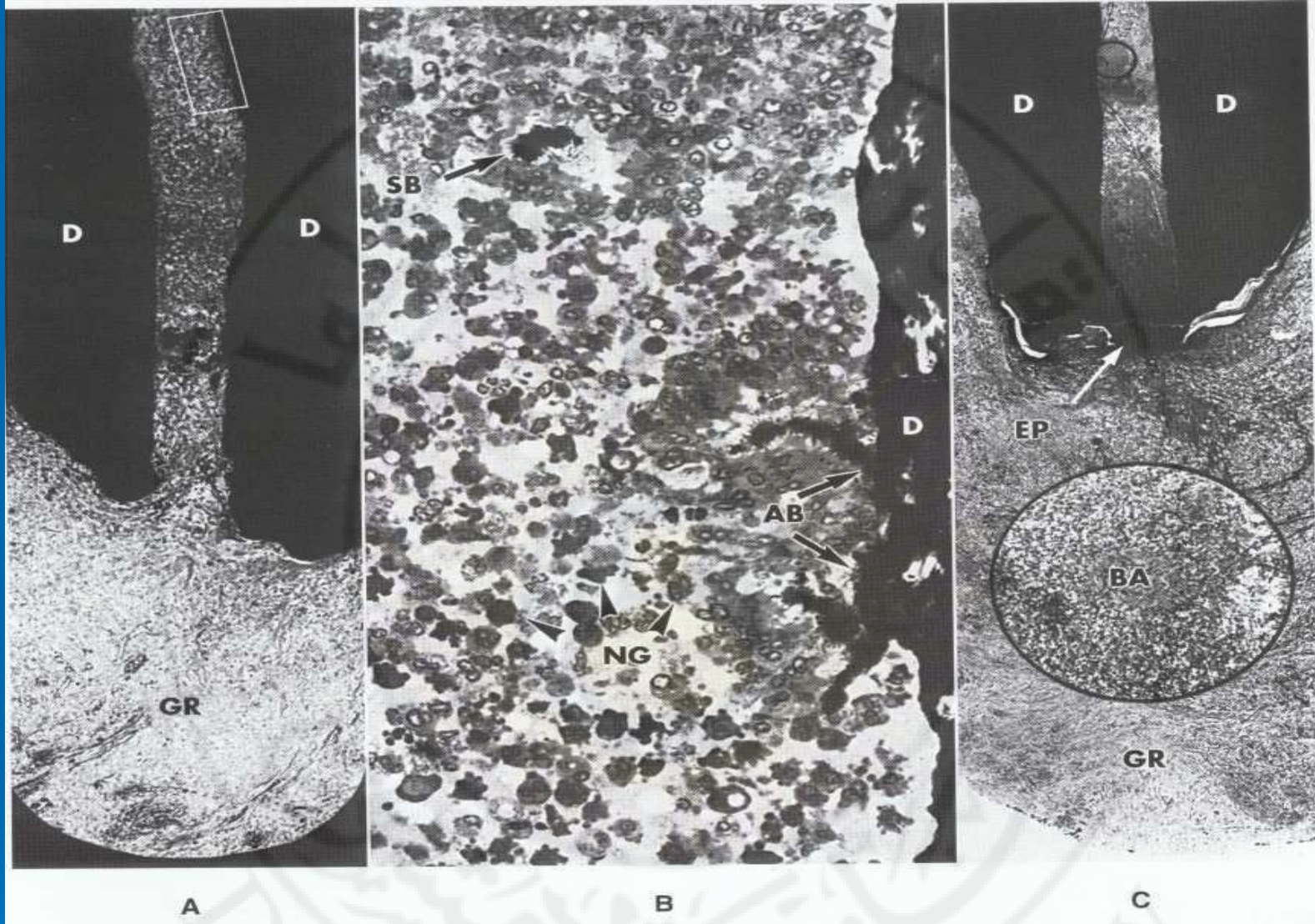
Mediators of both nonspecific inflammatory reactions and specific immunologic reactions participate in the formation of periradicular lesions

Acute apical periodontitis (AAP) is the initial response that results from extension of pulpal inflammation to the periradicular tissues. Bacteria and their byproducts are usually involved in the process.

Other factors that may be involved in AAP include inflammatory mediators from pulp, instrument trauma, and chemicals used during root canal treatment.

Histologic evaluation of periradicular samples diagnosed as CAP, rarely demonstrates bacteria in the tissue.

Other studies have shown a barrier of neutrophils or epithelium or (necrotic) tissue between bacteria in canal and periradicular inflammatory tissue.



A, Resected apical third (D) of a human tooth with pulp necrosis and chronic apical periodontitis (GR). B, The bacteria appear to be blocked by a wall of neutrophils (NG) or by (C) an epithelial plug (EP) in the apical foramen.

Actinomyces, Propionibacterium propionica, P. intermedia and Enterococcus faecalis have been identified using *immune cytochemical methods* in sections of periradicular lesions.

Acute apical abscesses (AAAs), acute exacerbation of CAP is characterized by large numbers of PMN leukocytes, necrotic tissue, and bacteria.

Under certain circumstances (*related to host resistance and virulence of bacteria*) periradicular tissues are invaded and become involved in progressive infections (abscesses and cellulitis).

The bacteria are polymicrobial and are similar to those isolated from infected root canals, with most being strict anaerobes.

Infection Control

Today's practice of dentistry, including endodontic procedures, requires universal precautions.

All patients must be treated as if they have a transmissible disease.

Precautions include preventing cross contamination between patients, and health care providers.

Not all exposures to microorganisms result in disease.

Whether a disease is transmitted depends on the dose of the infective agent, the virulence of the microorganism, and the host resistance.

An effective way to reduce the dose of microorganisms, is the use of **physical barriers**, which include the rubber dam, safety glasses or face shields, masks, gowns, and gloves.

Irrigation of canals with sodium hypochlorite provides an additional **chemical barrier** against microorganisms

Endodontic procedures pose a risk for accidental percutaneous exposure to body fluids for both patient and dentist. Techniques must be used to avoid accidental exposure to sharp instruments. Disposable items are available to minimize the chances of contamination.

Treatment of Endodontic Infections

The microbial ecosystem of an infected root canal system will persist until the source of irritation is removed.

The key to successful treatment of periradicular disease is **removal of the reservoir of infection** (necrotic tissue, bacteria, bacterial by-products) by thorough debridement.

DEBRIDEMENT OF THE ROOTCANAL SYSTEM

Root canal debridement, as a part of the cleaning and shaping process, is the removal of substrates that support microorganisms.

Because the root canal system is irregular, instruments do not reach all the areas.

Irrigants flush out loose debris, provide lubrication, exert antimicrobial action, and dissolve some debris in the canal.

Sodium hypochlorite (NaOCl) (0.5% to 5.25%)

Will *dissolve some organic debris* in areas not reached by instruments and is an excellent *antimicrobial agent*.

The chemical activity of NaOCl should be maintained by frequent irrigation of the canals being instrumented.

Straight-line access and proper flaring of the root canal will enhance debridement and allow more efficient irrigation.

Instruments have been shown to produce **smear layer** of burnished dentin and other debris about 1 to 4 Mm thick on the root canal surface with plugs of the material extending into the dentinal tubules.

The presence of a smear layer has been shown to affect the permeability of the dentin and to inhibit bacterial colonization; however, it could harbor bacteria and decrease the effectiveness of intracanal antimicrobials.

INTRACANAL MEDICATION

The antimicrobial function of intracanal medication between appointments is an important consideration as microorganisms not removed from the canal will multiply, **However**, these medicaments, (particularly phenolics) are not recommended, being antigenic and cytotoxic, and function as antimicrobials for only a short time.

calcium hydroxide is recommended in canals with necrotic pulps after instrumentation.

It has a greater antimicrobial effect, it may increase the effectiveness of sodium hypochlorite at the subsequent appointment.

DRAINAGE

Severe infections require a multifaceted approach including debridement, drainage, and pharmacotherapeutics.

Debridement of the pulp space to remove the source of the infection is key along with drainage in managing an abscess or cellulitis.

Drainage from the canal or soft tissue decreases discomfort caused the pressure of a fluctuant swelling containing purulent material.

Incision of an indurated swelling is also effective because it releases blood and serous fluids that contain bacteria, bacterial byproducts, and inflammatory mediators.

Good drainage also improves circulation to the area and improves delivery of antibiotics so a minimum inhibitory concentration may be reached.

Antibiotics (antimicrobials) should be considered adjunctive treatment of more severe infections, and are not a substitute for proper local treatment.

WHEN AND HOW TO CULTURE

Because of the wide range of bacteria found in endodontic infections, the administration of antibiotics may not be effective.

Although culturing is rarely required, at times it may provide valuable information for better antibiotic selection.

Great care must be taken to avoid contamination of the sample. In addition, the proper transport media must be obtained from the laboratory.

To prevent contamination by oral flora, a submucosal swelling should be sampled by needle aspiration.

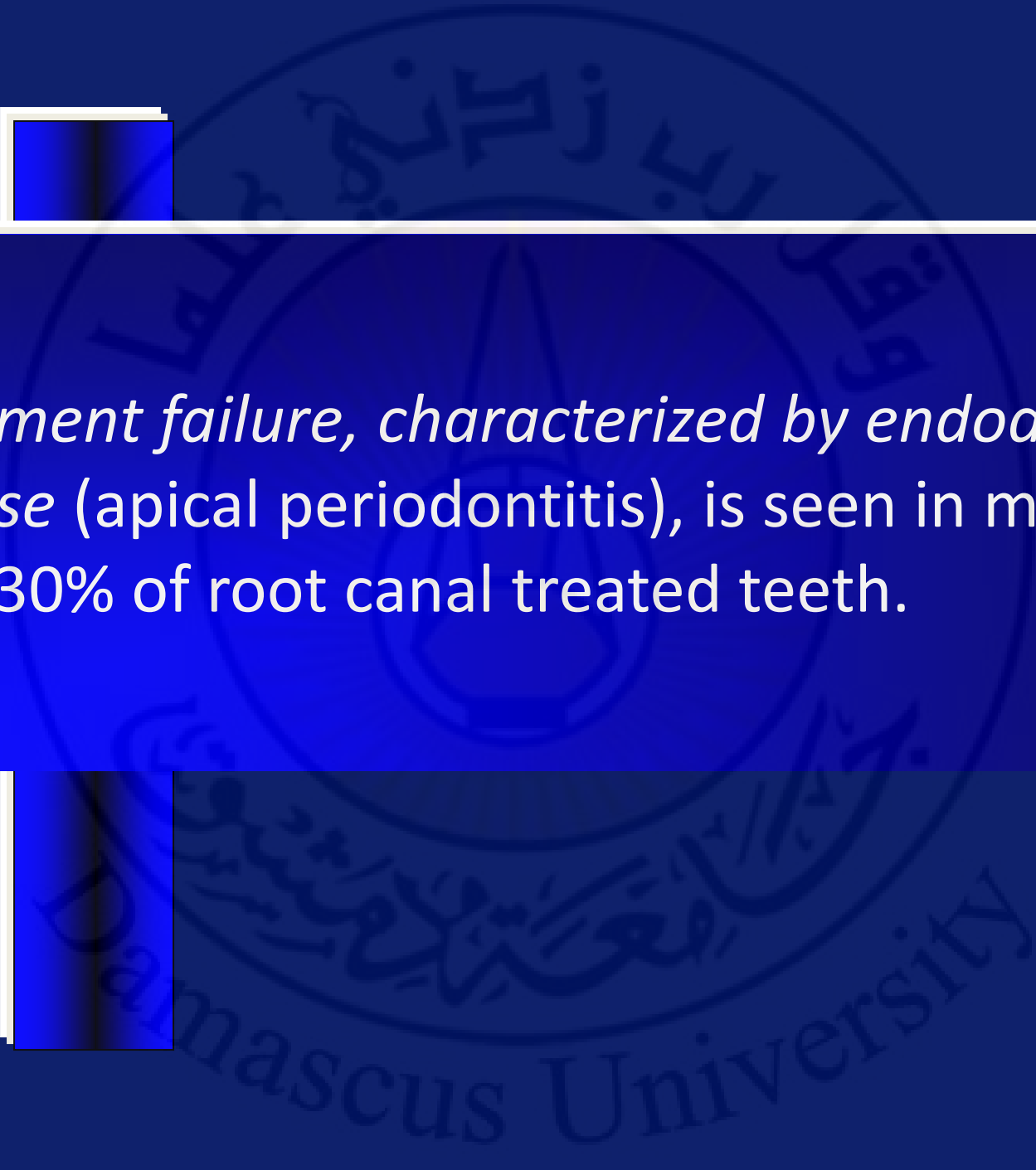
After anesthesia, the mucosal surface is disinfected and a 16- to 20-gauge needle is used to aspirate the exudate.

The aspirate should be immediately injected into a container with prereduced transport media.

Antibiotics are chosen to treat anaerobic infections based on the identification of the prominent microorganisms in the culture.

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Orthograde Retreatment

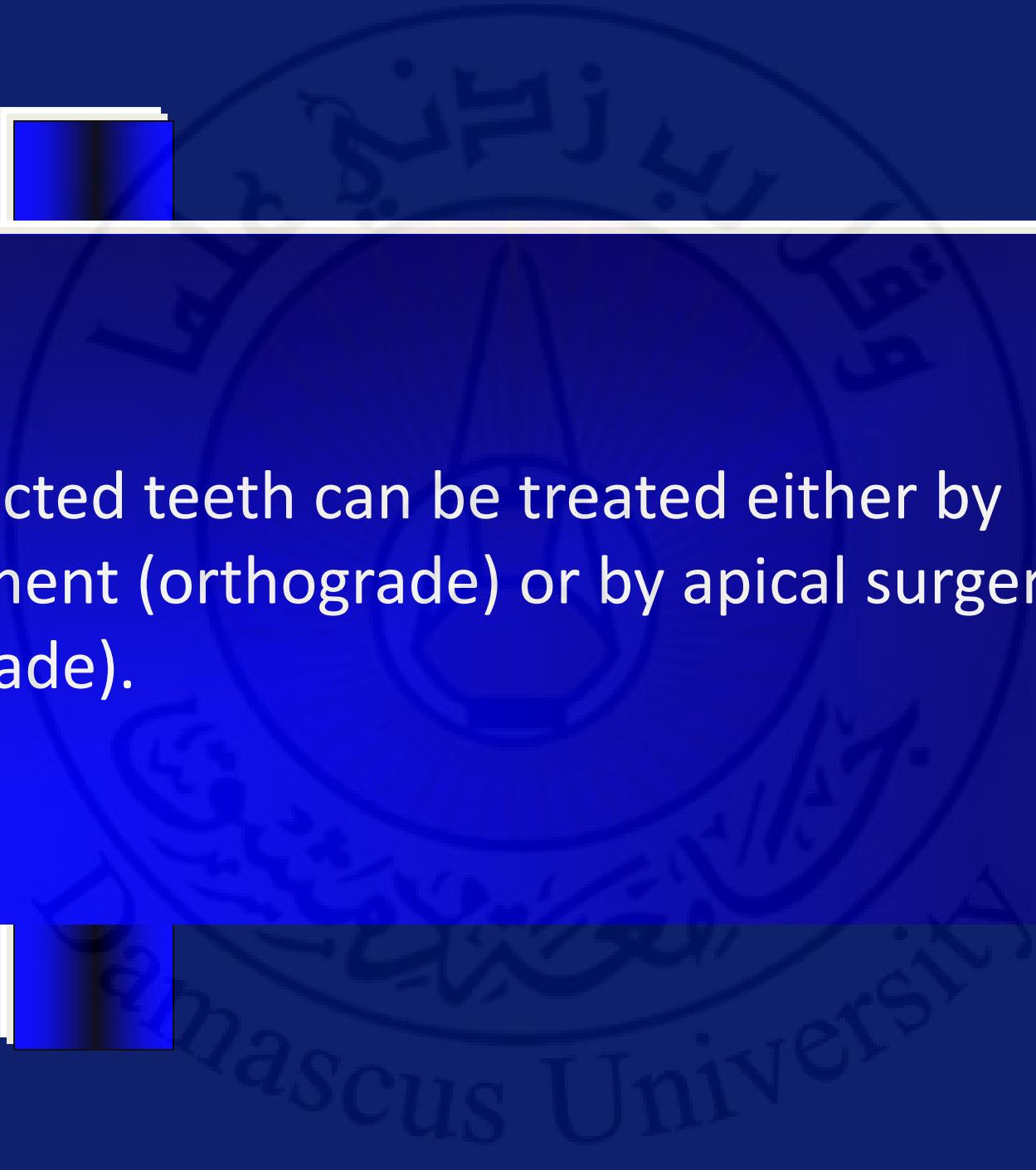
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Treatment failure, characterized by endodontic disease (apical periodontitis), is seen in more than 30% of root canal treated teeth.

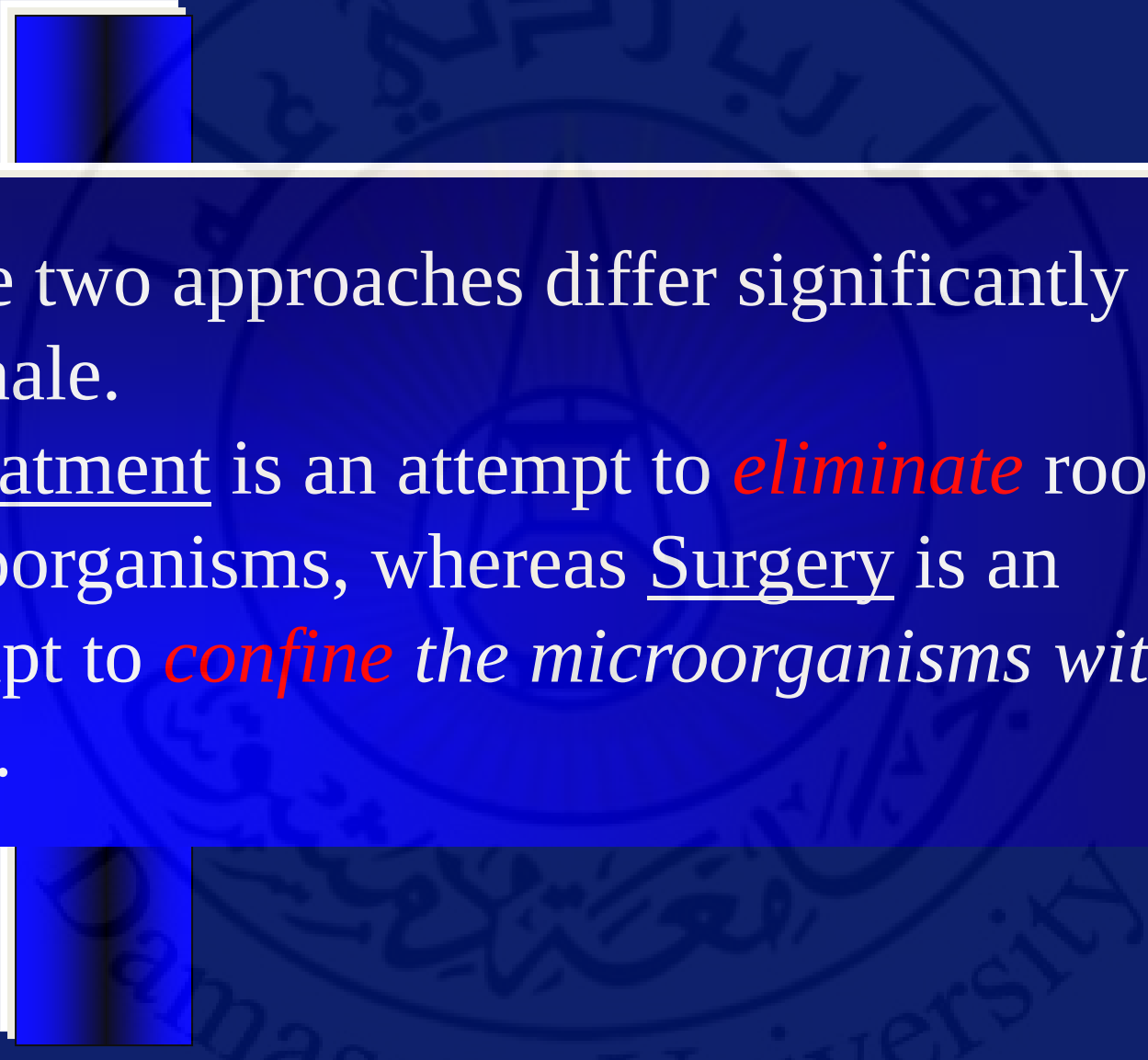
Post-treatment disease, associated with root canal-treated teeth is primarily caused by infection of the root canal system.

Microorganisms may either have survived the previous treatment or invaded the filled canal space after treatment, mainly because of coronal leakage.

Specific microorganisms (*Actinomyces* species ,
Intestinal faecalis) may established in the
periradicular tissue.

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The affected teeth can be treated either by retreatment (orthograde) or by apical surgery (retrograde).



These two approaches differ significantly in rationale.

Retreatment is an attempt to *eliminate* root canal microorganisms, whereas Surgery is an attempt to *confine the microorganisms within the canal*.

Unique Considerations

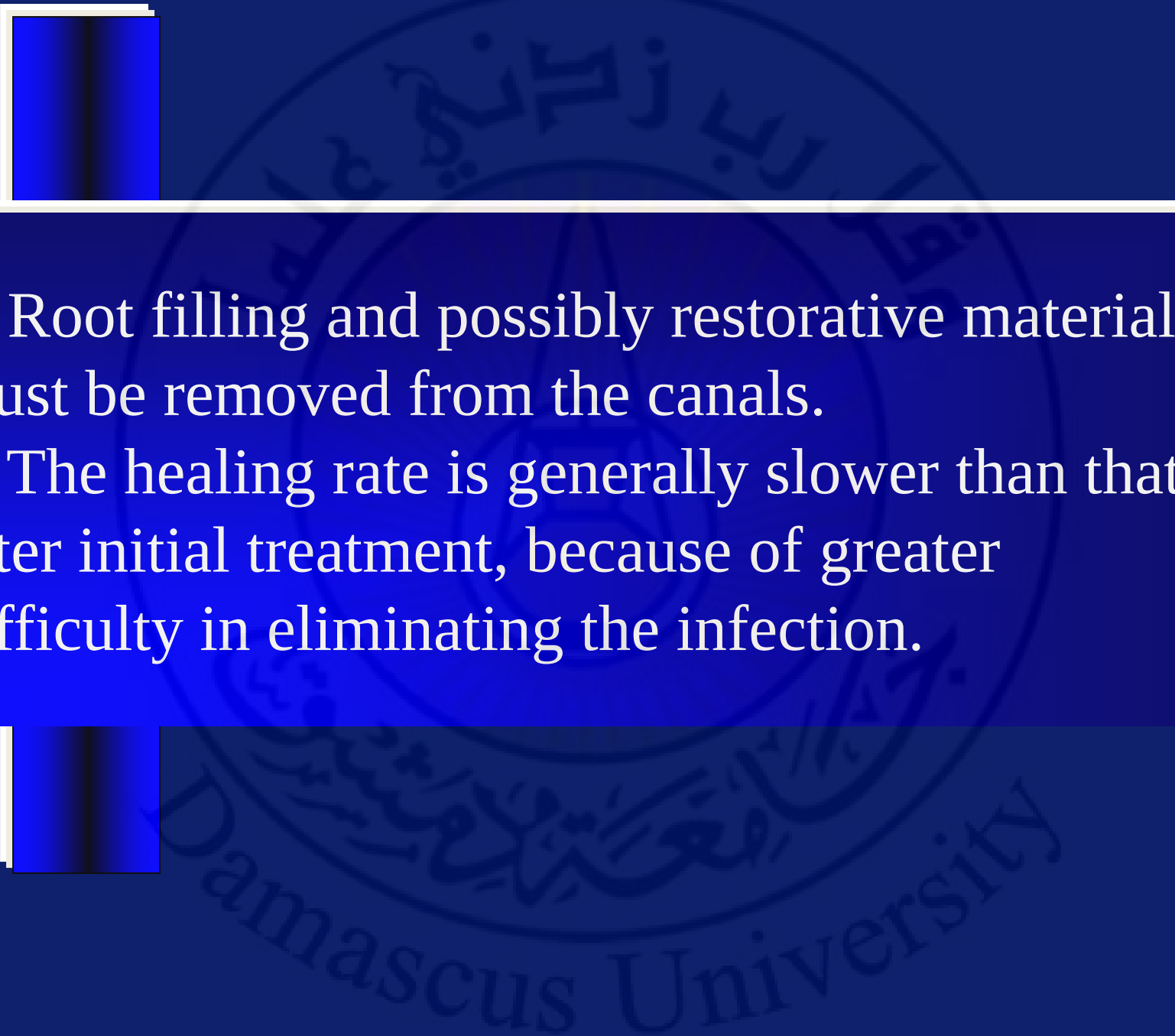
Retreatment and initial R.C.T share similar biologic principles and objectives. However, the following are unique to retreatment:

1. An extensive restoration may have to be sacrificed and remade.



2. Retreatment may be performed to prevent potential disease.

3-Morphologic alterations resulting from the previous treatment may present unusual technical and therapeutic challenges.

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4. Root filling and possibly restorative materials must be removed from the canals.
 5. The healing rate is generally slower than that after initial treatment, because of greater difficulty in eliminating the infection.

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As a result, clinicians faced with post-treatment disease frequently hesitate to intervene despite the presence of pathosis.

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For an appropriate management, definitive criteria are required to select cases for tooth extraction, retreatment, and apical surgery.

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When should retreatment be considered?

Case Selection

Retreatment is usually performed to treat existing disease, presenting with definitive signs and symptoms. However, even in the absence of disease ,retreatment may be indicated to prevent future emergence of disease.

DIAGNOSIS

The presence or absence of periradicular disease is determined according to clinical and radiographic findings. Differential diagnosis of nonendodontic disease is also considered.

SELECTION OF TREATMENT

In the past, the clinician selected and then performed the treatment. Currently, however, *the patient ultimately selects the treatment, based on information* communicated by the clinician.

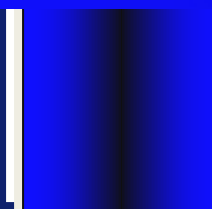
TREATMENT OF EXISTING DISEASE

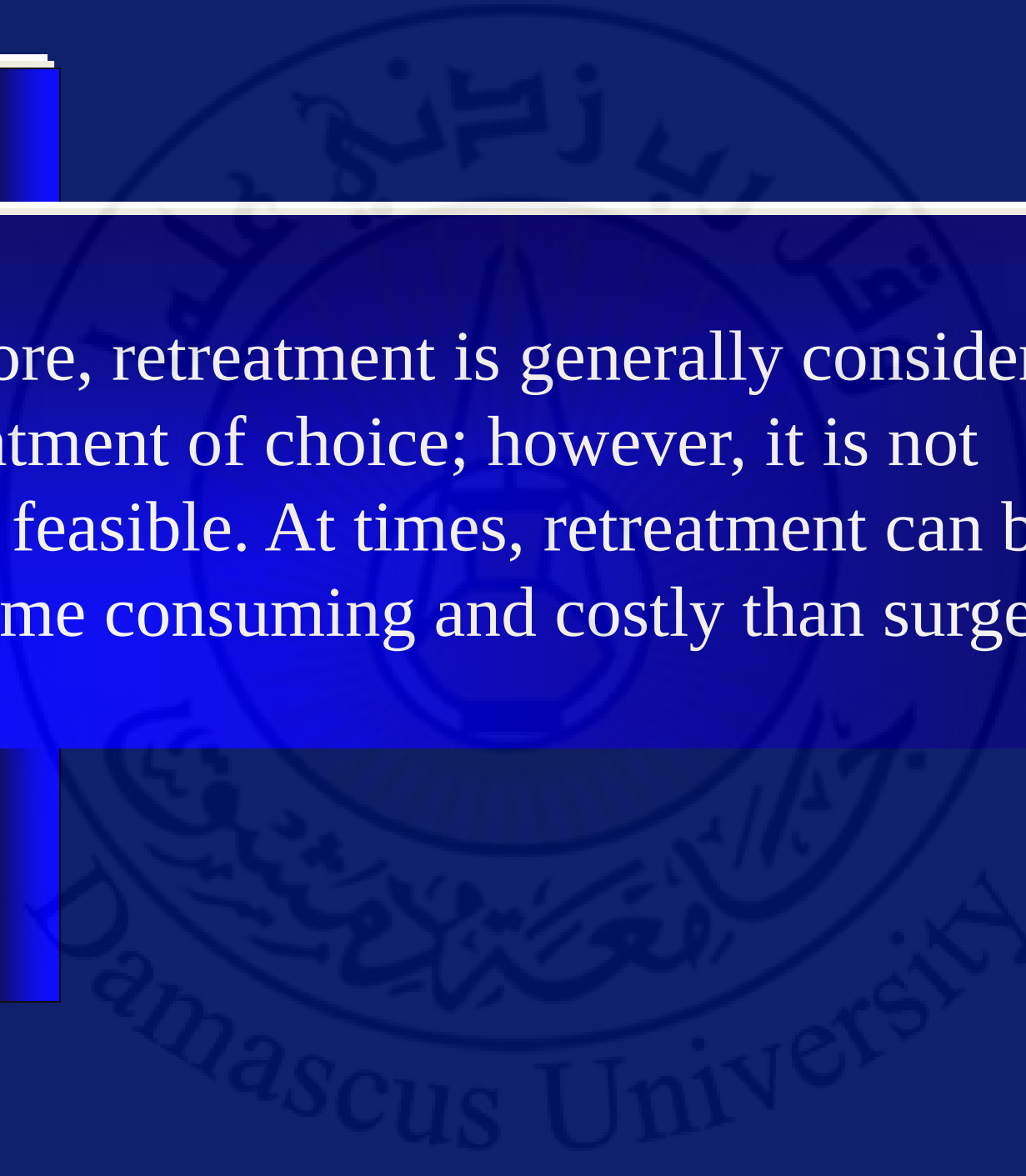
Post-treatment disease definitely requires intervention, even when symptoms are absent. When treatment is preferred over extraction, both retreatment and apical surgery should be considered.





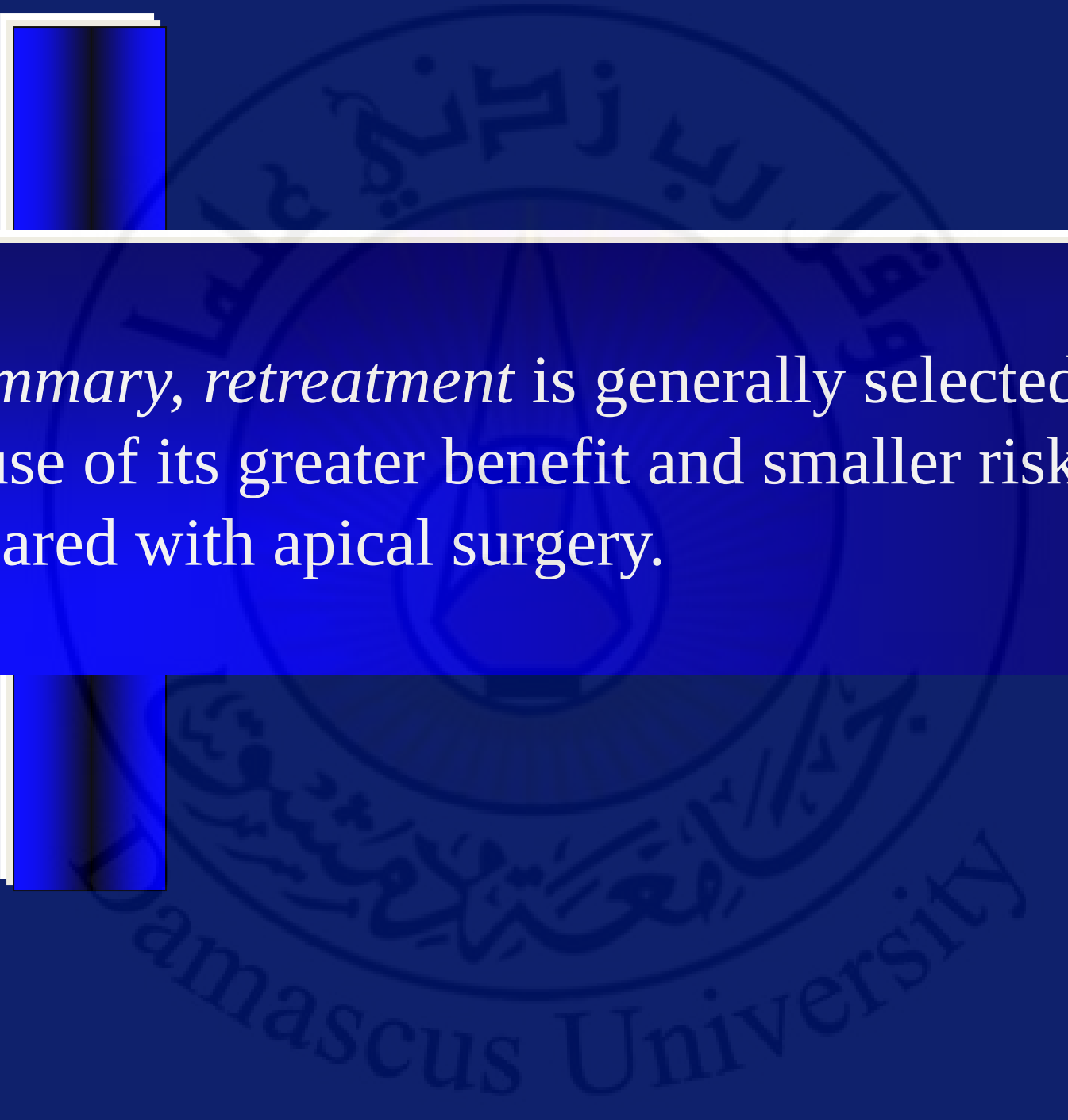
Comparing the two modalities, retreatment offers a greater benefit-a better ability to eliminate the disease's etiology (root canal infection) with minimal invasion-and a smaller risk significantly less postoperative discomfort and a lesser chance of injuring nerves, sinuses, or other structures.



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Therefore, retreatment is generally considered the treatment of choice; however, it is not always feasible. At times, retreatment can be more time consuming and costly than surgery.

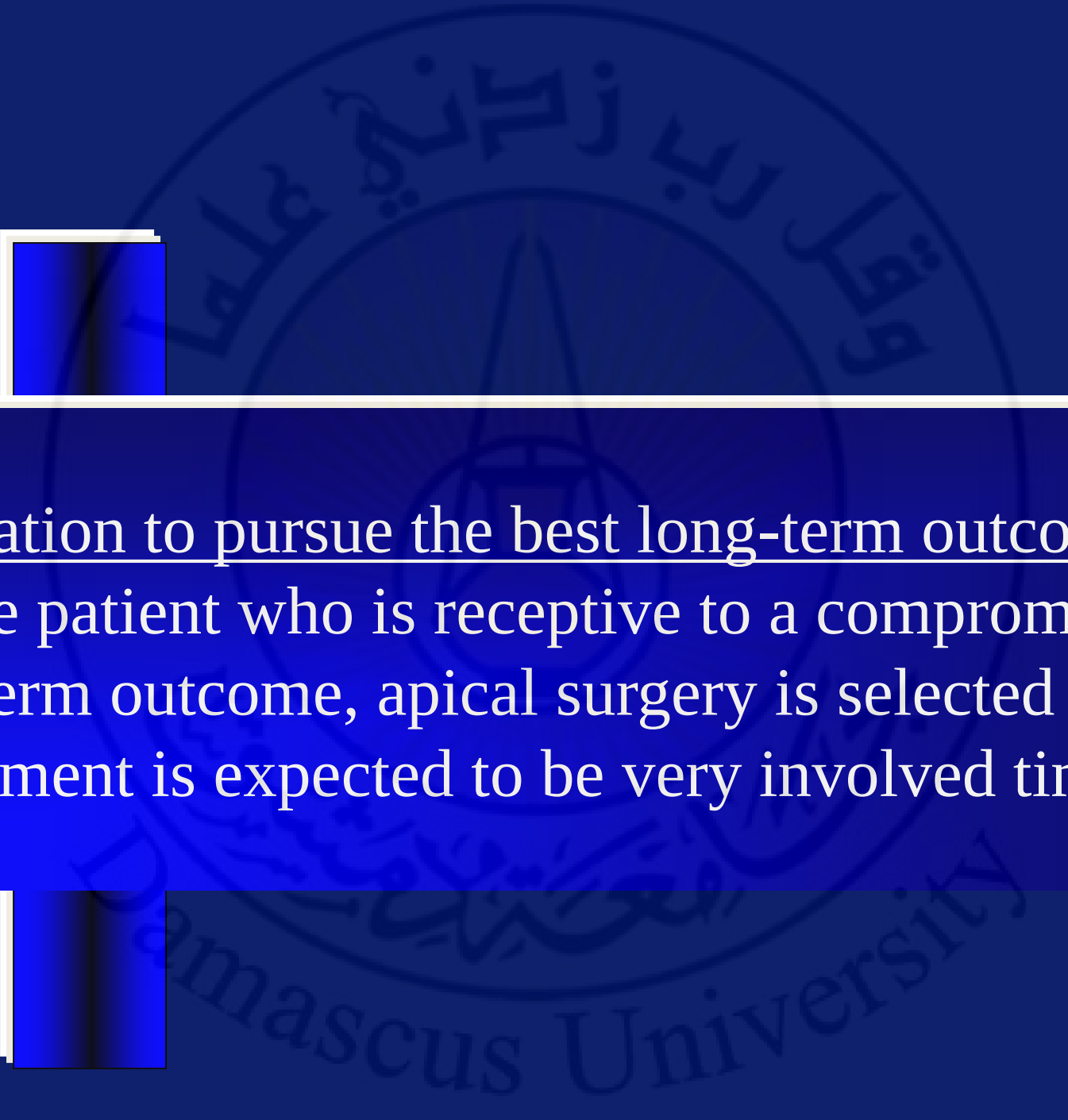
Particularly when an extensive restoration must be replaced. Furthermore, clinicians' capabilities to perform retreatment and surgery may vary considerably.

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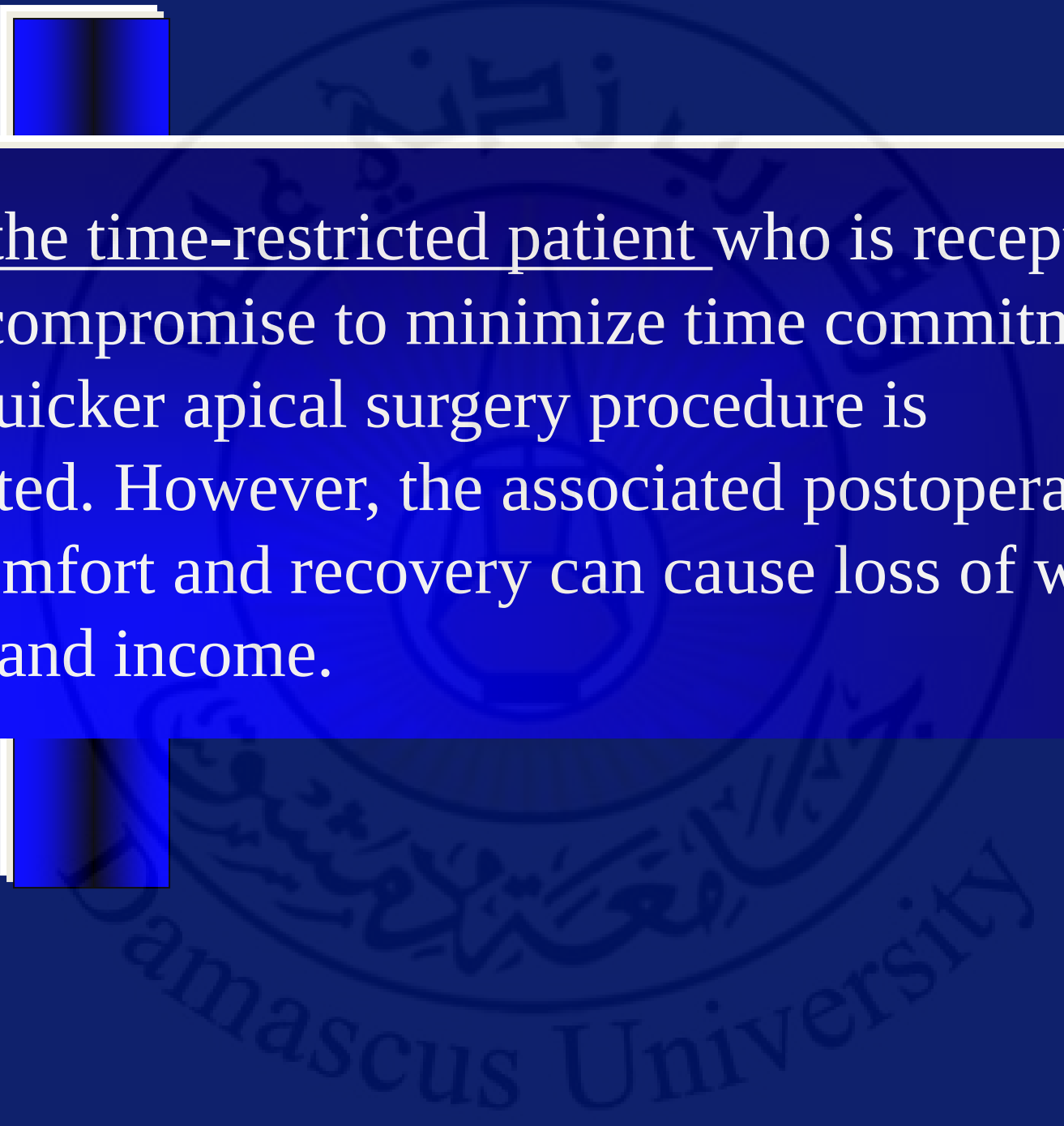
In summary, retreatment is generally selected because of its greater benefit and smaller risk compared with apical surgery.

Patient Considerations

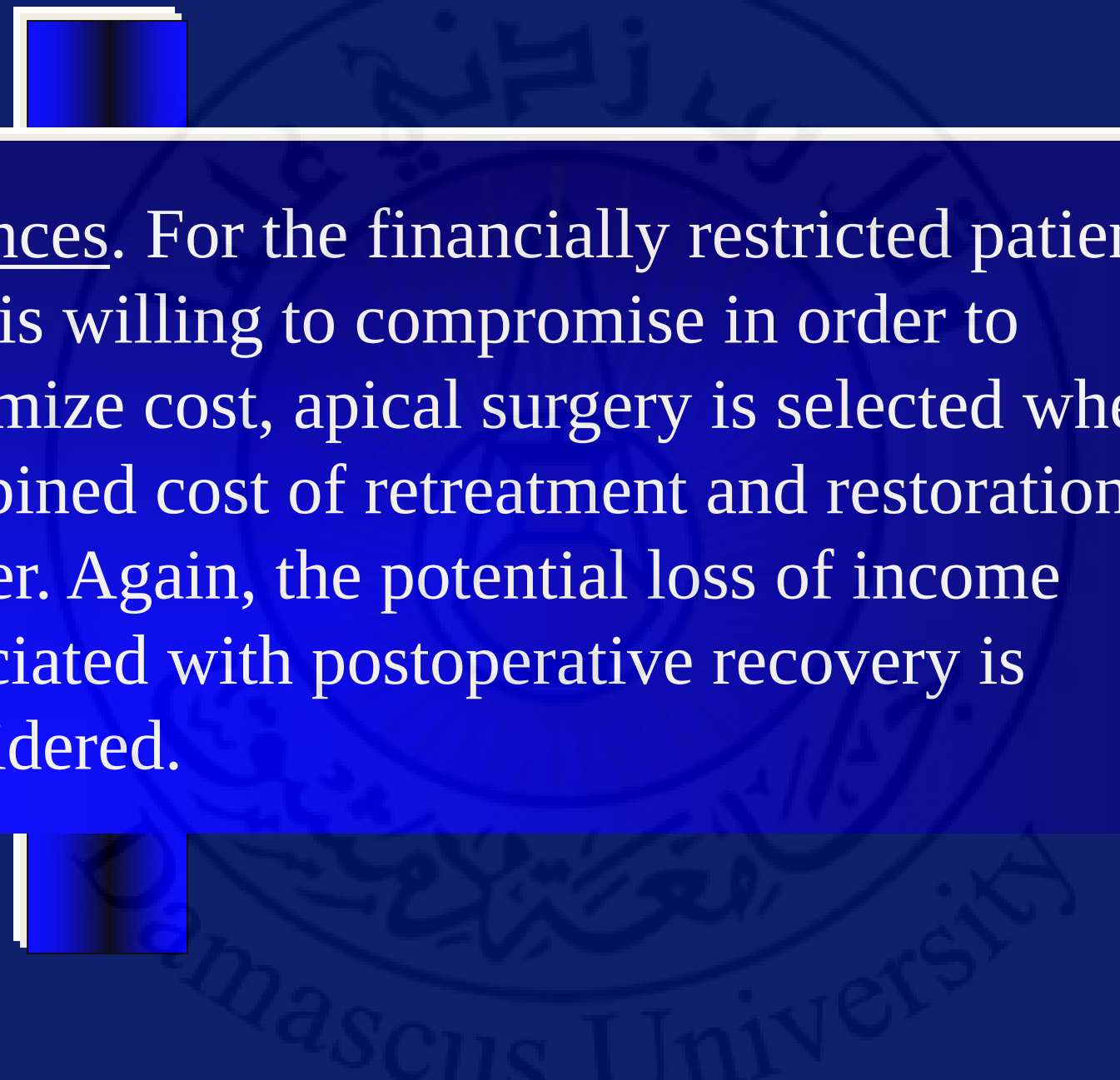
Motivation to retain the tooth. The considerable effort associated with both retreatment and surgery is justifiable by the potential to retain the tooth. For the unmotivated patient, extraction is selected.

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Motivation to pursue the best long-term outcome.
For the patient who is receptive to a compromised long-term outcome, apical surgery is selected when retreatment is expected to be very involved time.



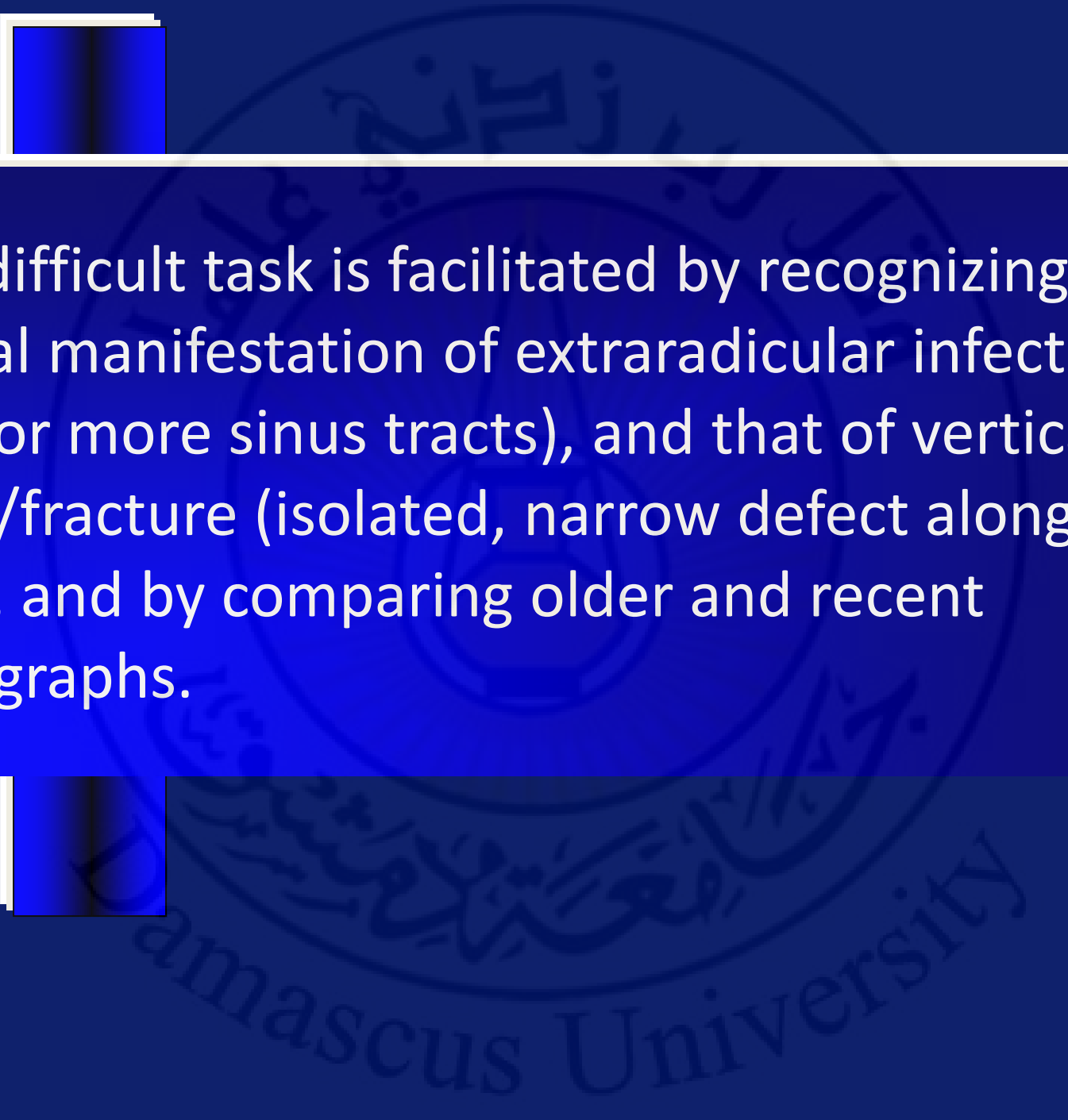
For the time-restricted patient who is receptive to a compromise to minimize time commitment, the quicker apical surgery procedure is selected. However, the associated postoperative discomfort and recovery can cause loss of work time and income.



Finances. For the financially restricted patient who is willing to compromise in order to minimize cost, apical surgery is selected when the combined cost of retreatment and restoration is higher. Again, the potential loss of income associated with postoperative recovery is considered.

Tooth Considerations

Site of infection: Root canal infection is best eliminated by retreatment. Periapical (extraradicular) infection independent of the root canal flora is best eliminated by apical surgery. In contrast, when a vertical root fracture is present, infection cannot be eliminated with either procedure.



This difficult task is facilitated by recognizing the typical manifestation of extraradicular infection (one or more sinus tracts), and that of vertical crack/fracture (isolated, narrow defect along the root), and by comparing older and recent radiographs.

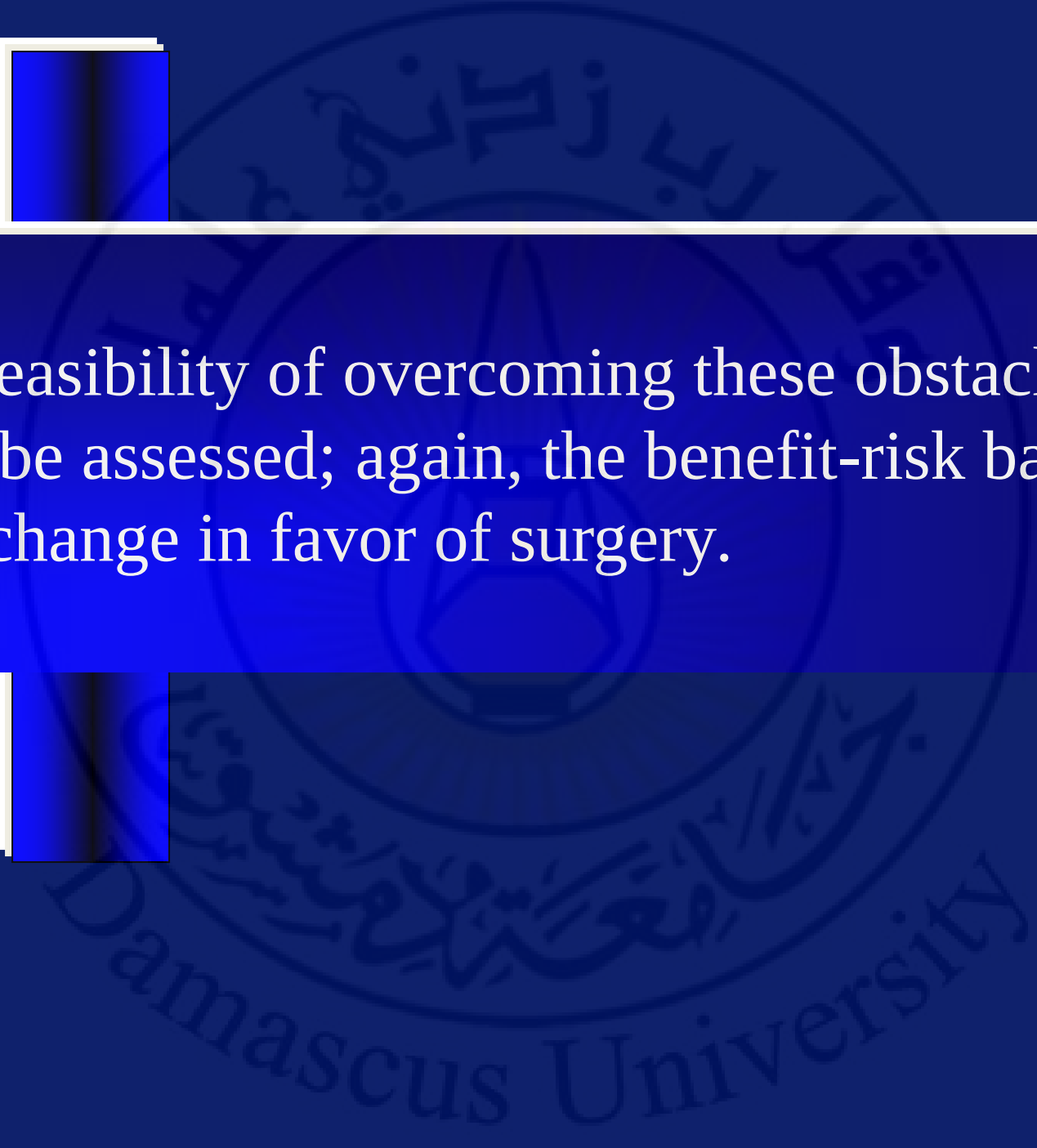
Root canal obstacles.

For retreatment to eliminate canal infection, the canal must be renegotiated throughout. Therefore, obstacles to total renegotiation reduce the potential benefit of retreatment, while attempts to overcome the obstacles increase the risk of procedural complications.

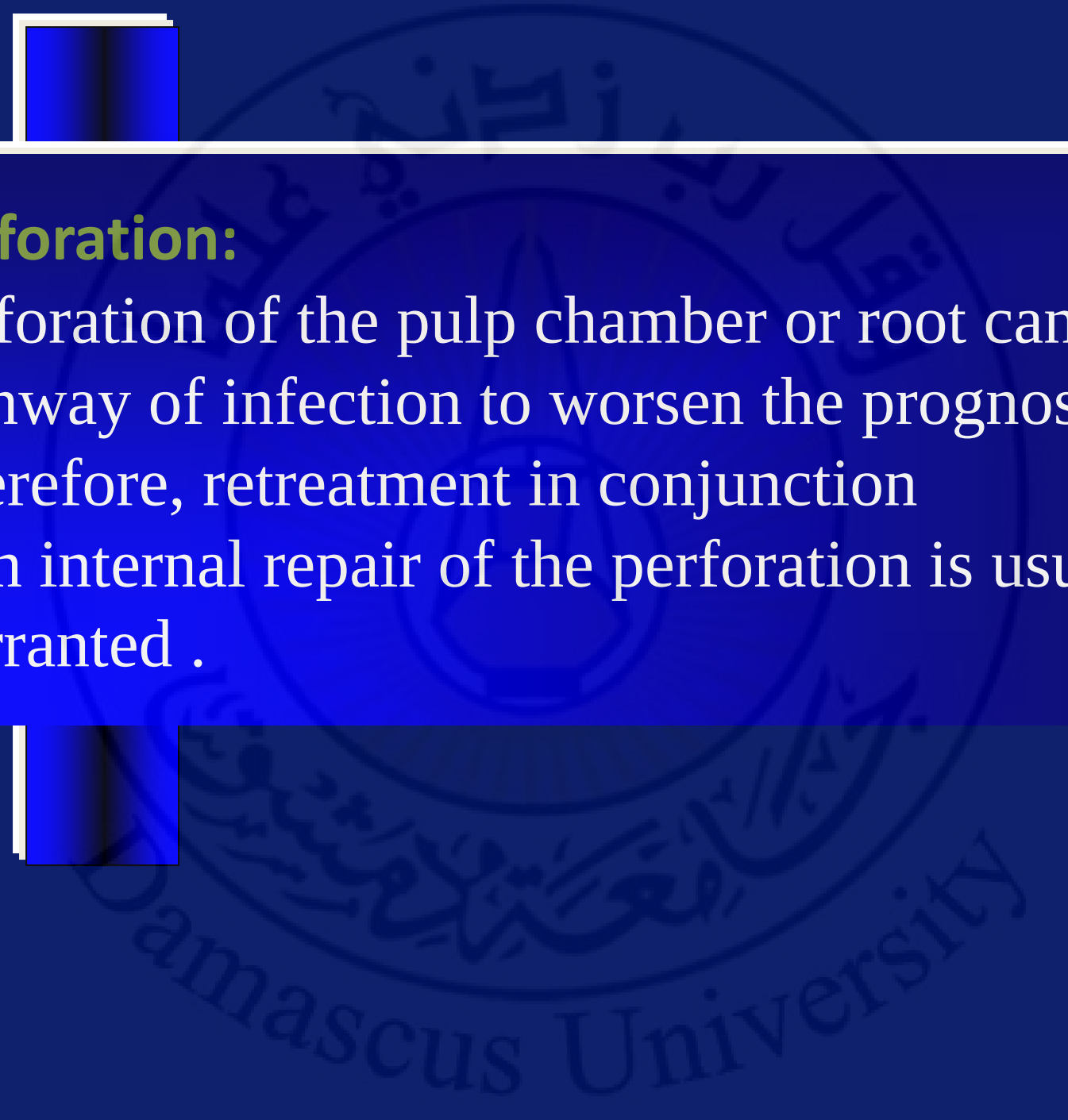
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The principal obstacles are:
calcification, complex morphology of the root canal system, suspected ledge, and separated instrument.

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The feasibility of overcoming these obstacles must be assessed; again, the benefit-risk balance may change in favor of surgery.



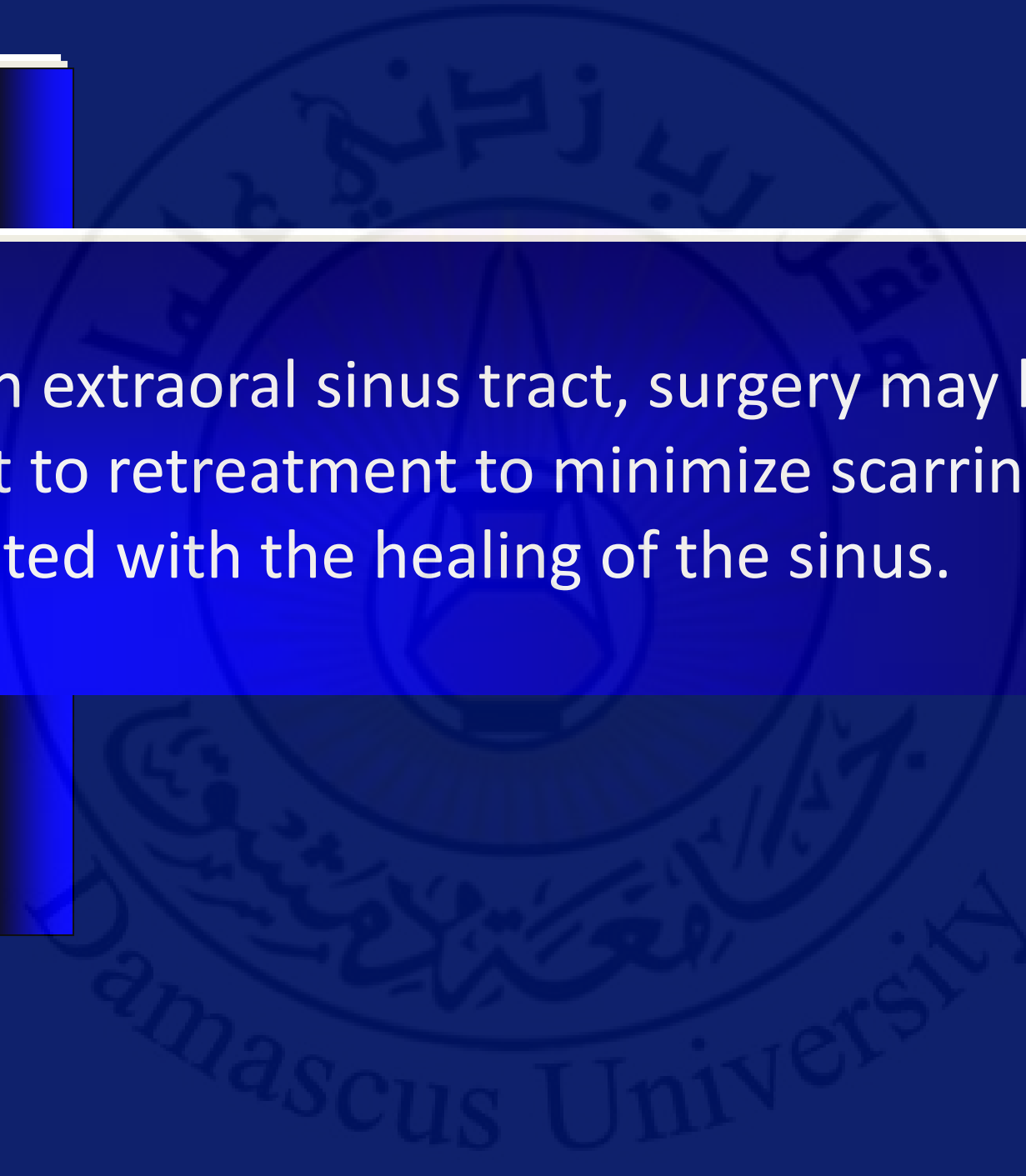
Perforation:

Perforation of the pulp chamber or root can be a pathway of infection to worsen the prognosis. Therefore, retreatment in conjunction with internal repair of the perforation is usually warranted .

Nevertheless, when healing is not expected or does not occur, surgery may be required. The surgical procedure includes external repair of the perforation.

Restorative, periodontal, and esthetic factors.

Teeth considered to have a hopeless prognosis for either restoration or periodontal healing should be extracted. With compromised periodontal support, surgery may result in an unfavorable crown-root ratio; therefore, retreatment is selected.

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With an extraoral sinus tract, surgery may be an adjunct to retreatment to minimize scarring associated with the healing of the sinus.

Clinician Considerations

Capability. Capability is a combination of training ,skill, and experience.

Endodontists usually are more capable of treating post-treatment disease than general dentists.

Armamentarium.

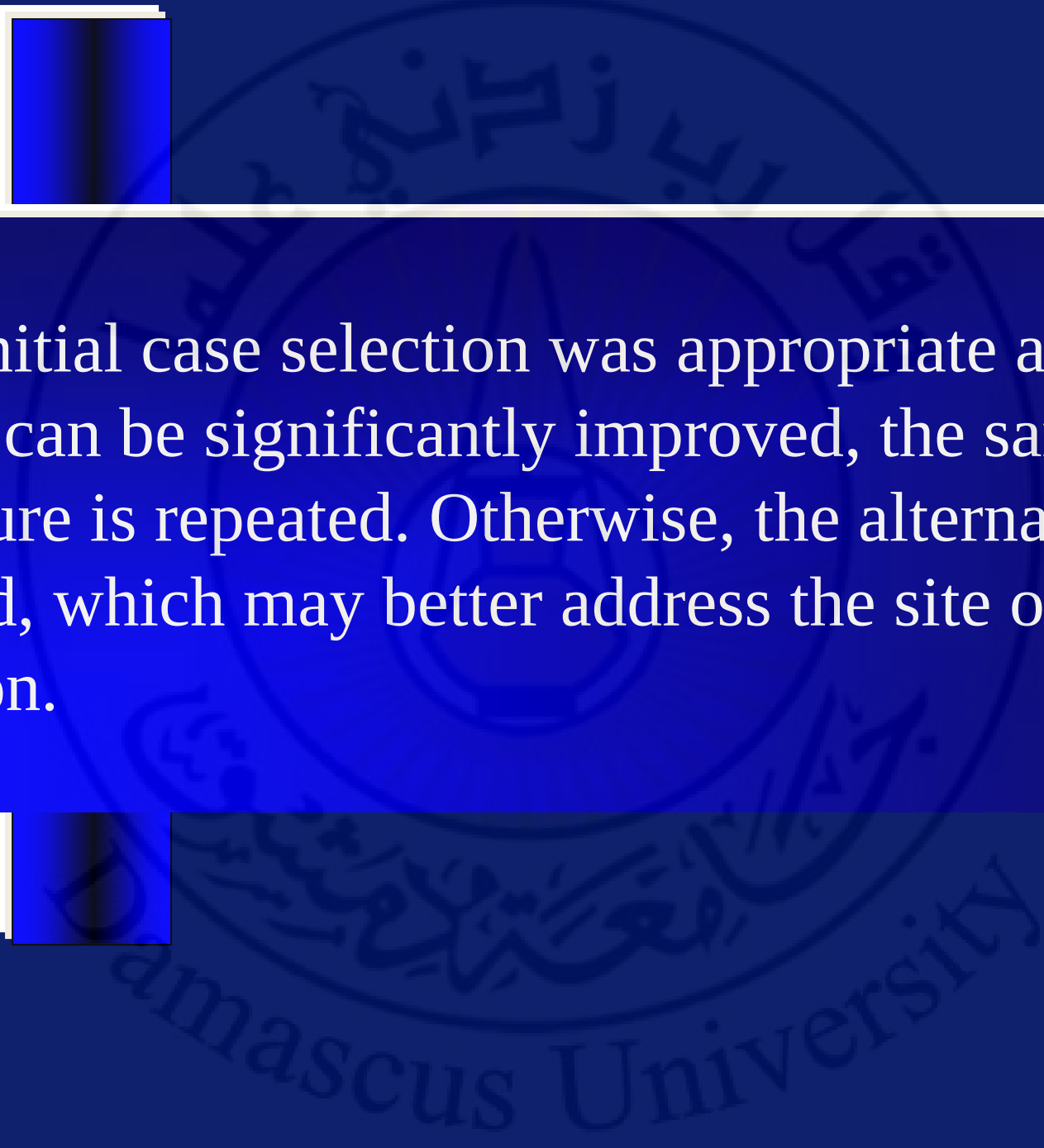
Use of special instruments can optimize the benefit-risk balance of both retreatment and apical surgery. Without the option of referral, if the instruments required to perform only one procedure are available to the attending endodontist, that procedure is usually selected.

Time availability.

In specific circumstances (geographically remote areas, community clinics), an excessive practice load may prevent the clinician from undertaking an elaborate retreatment of one tooth with a complex problem. In these circumstances only and without an option for referral, surgery is selected.

Previous Treatment Attempts

If a previous retreatment or apical surgery procedure did not result in healing, the quality of that procedure should be evaluated.

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If the initial case selection was appropriate and the quality can be significantly improved, the same procedure is repeated. Otherwise, the alternative is selected, which may better address the site of the infection.

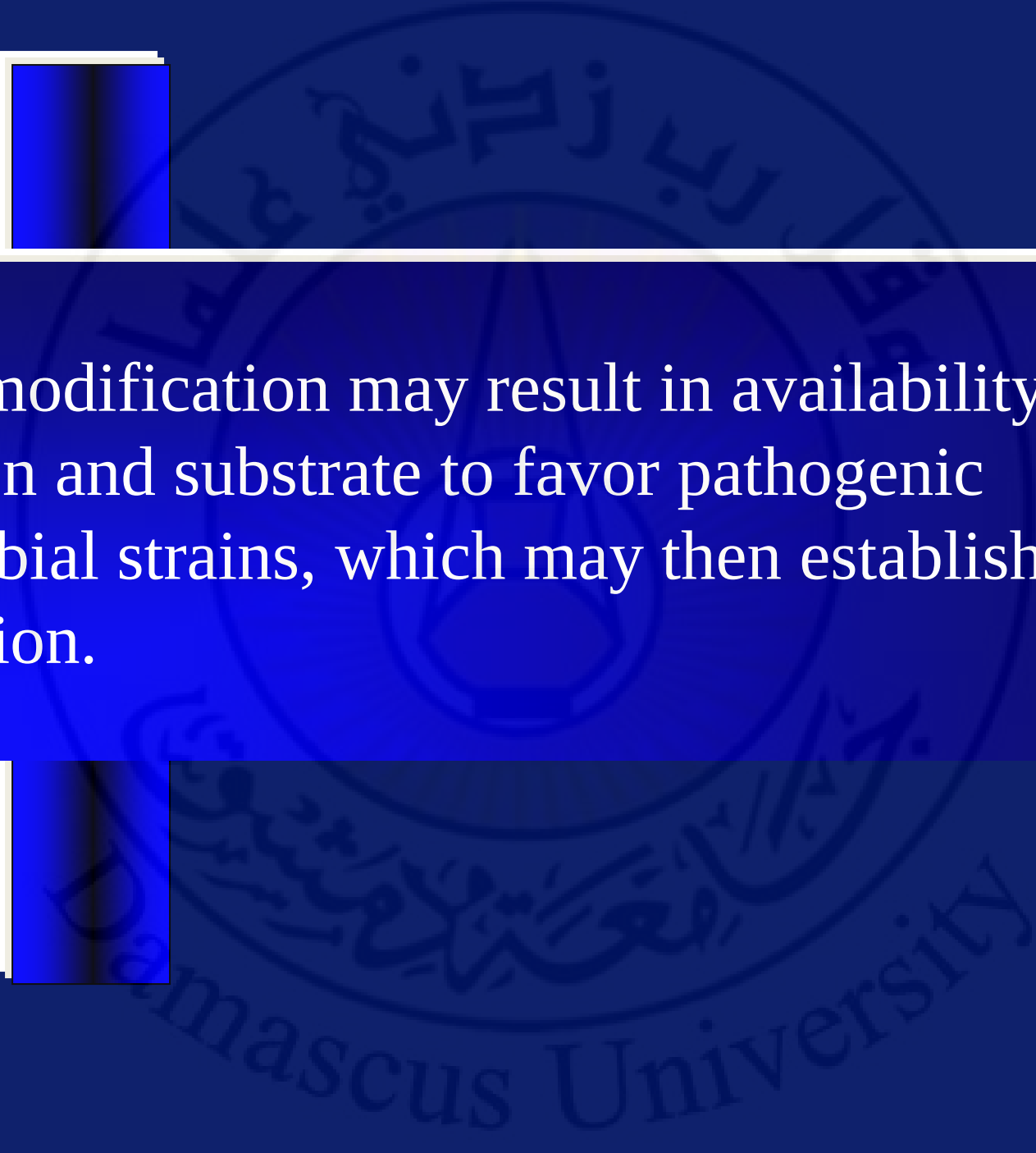
PREVENTION OF DISEASE

Root canal-treated teeth may appear to be disease free, yet harbor microorganisms in the canal suggests a balance between the intracanal microorganisms, their environment, and the host; a change in this balance can result in infection and disease.

Another possibility is coronal leakage, Microorganisms cause infection within weeks or months, even if the root canal is well filled.

The factors that may affect emergence of post treatment disease are the following:

Coronal restoration: If the endodontic system (pulp chamber, canals) has been exposed to coronal leakage or secondary caries, replacing the restoration may modify the canal environment.

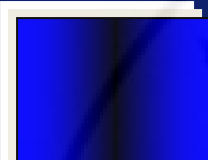
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This modification may result in availability of oxygen and substrate to favor pathogenic microbial strains, which may then establish infection.



2. Post restoration: There is a risk of canal contamination during post space preparation or post cementation.

3. Compromised host resistance: Theoretically, weakened host resistance can modify the balance and prompt infection. This factor, has not been thoroughly investigated and its incidence is unknown.



Considerations controlling prevention of post treatment disease include the following:

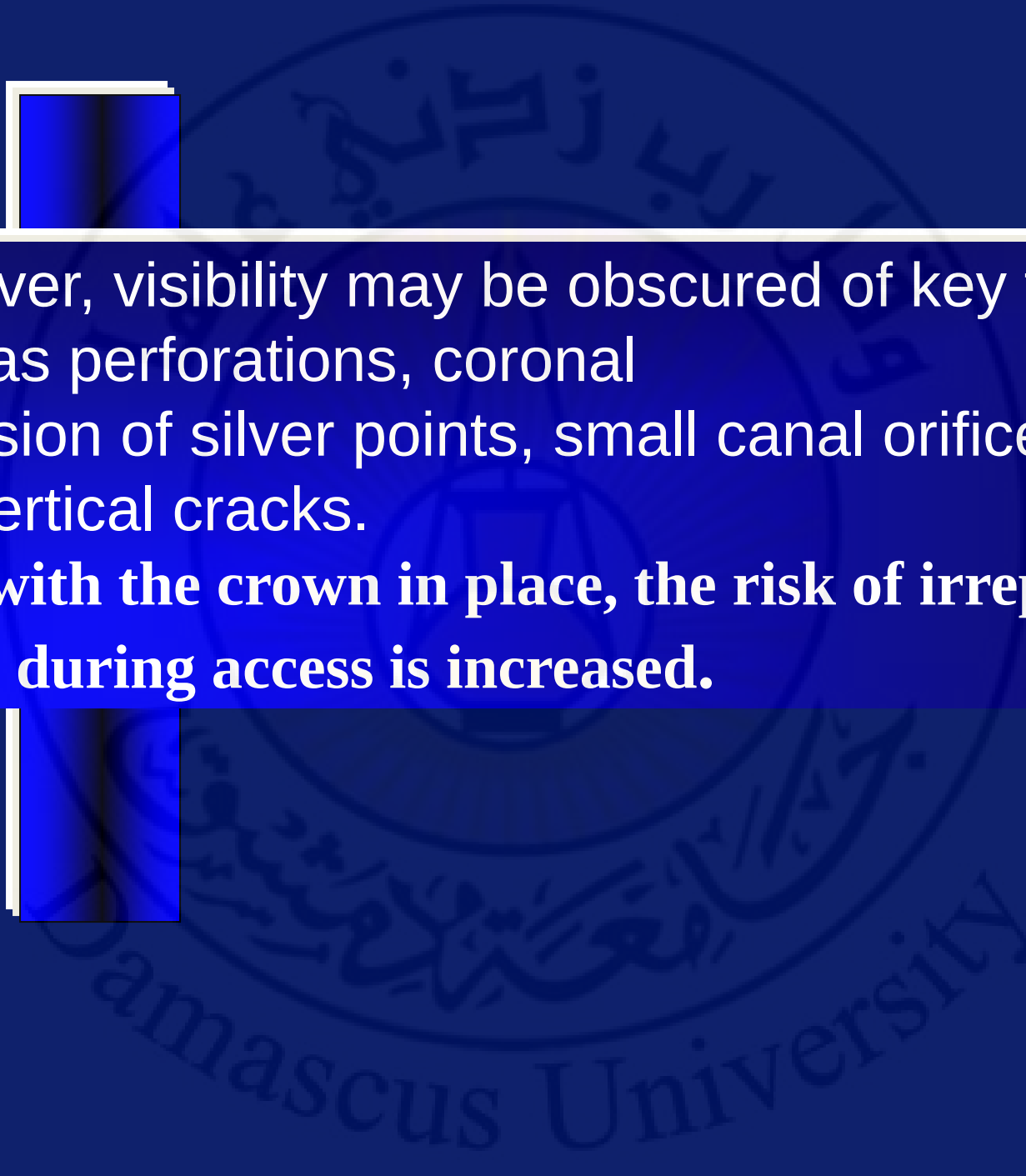
- (1) adequacy of the root filling
 - (2) adequacy of the coronal seal
 - (3) need for a new restoration (post and crown/bridge restorations represent a particular concern, because they will restrict the option of retreatment should disease emerge).
- 

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Retreatment Techniques

Access-crowns

Many retreatments require removal of a crown. sometimes, a crown may be retained if satisfactory. In these cases, retreatment can be performed through the crown; rubber dam isolation and temporization are facilitated, function and esthetics are maintained, and additional cost of replacement is avoided.



However, visibility may be obscured of key factors such as perforations, coronal extension of silver points, small canal orifices, and vertical cracks.

Also, with the crown in place, the risk of irreparable errors during access is increased.



If crown margins are poorly adapted, leakage and microbial contamination may occur during retreatment and between appointments.

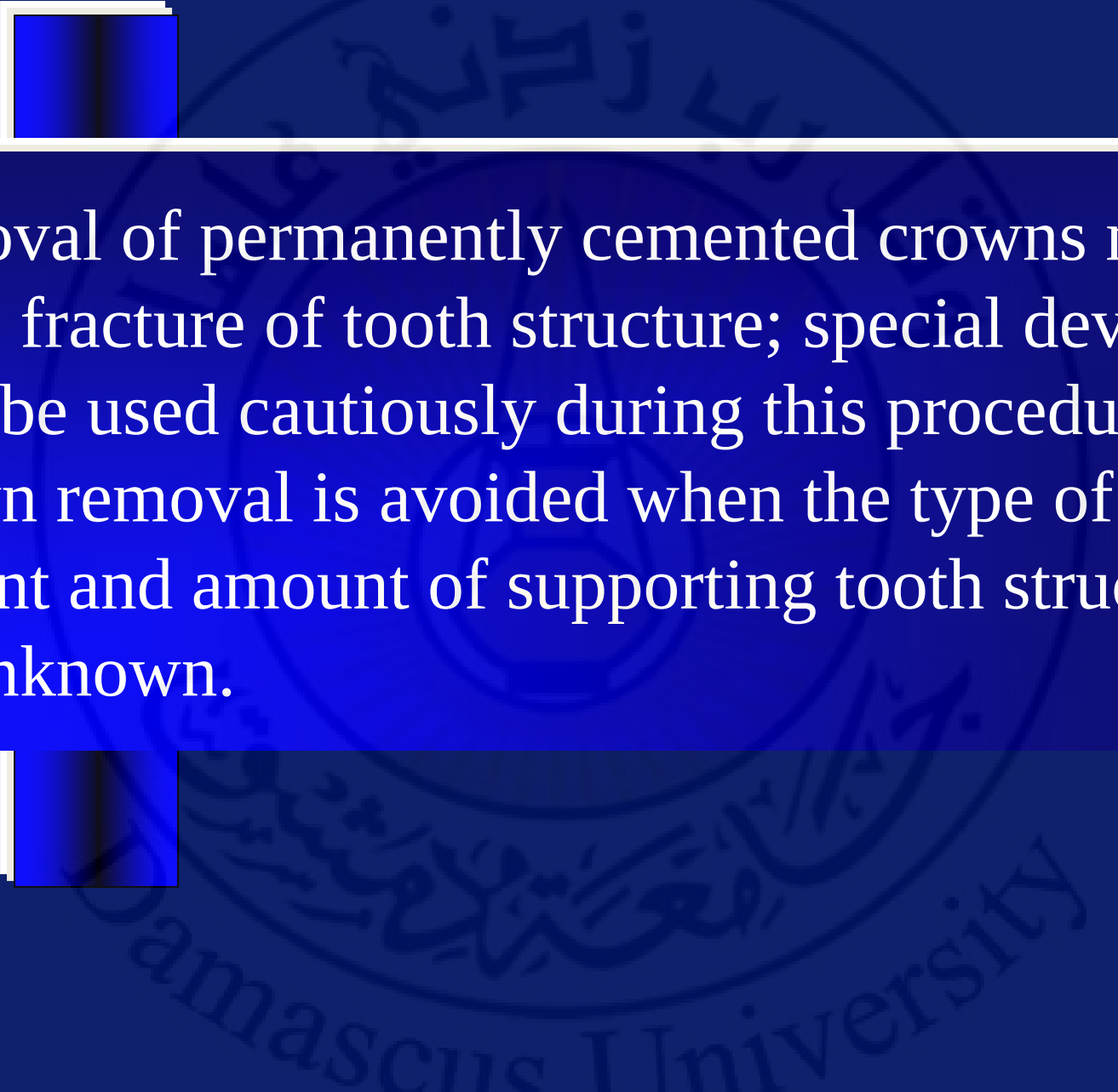
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To avoid complications, *crowns are removed for retreatment when marginal leakage or a cracked tooth is suspected or when future remake of the crown is planned..*

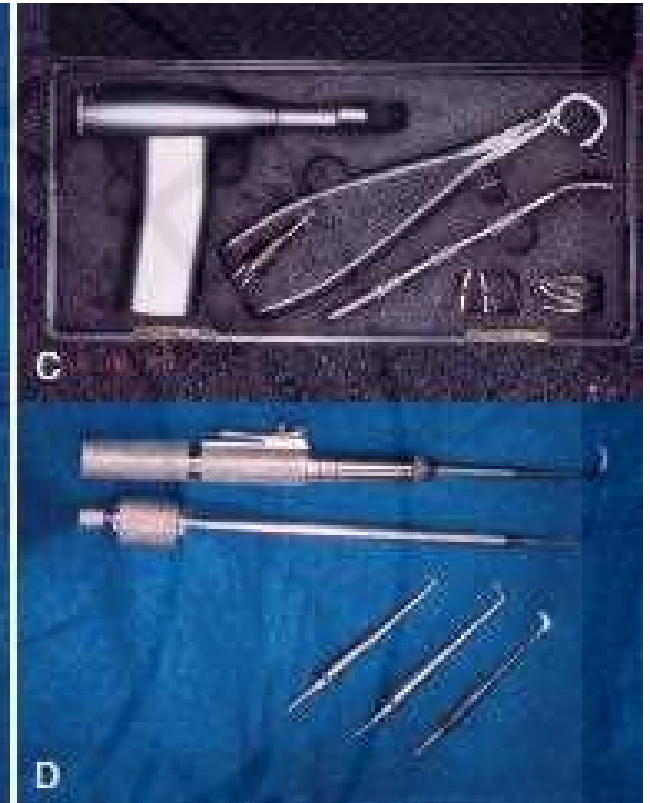
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However, to facilitate function ,esthetics, and isolation in selected teeth, the crown may be retained temporarily with appropriate steps to prevent complications.

Satisfactory crowns should be retained.
Usually, a wider-than-usual access is prepared
through the crown and repaired later .



Removal of permanently cemented crowns may cause fracture of tooth structure; special devices must be used cautiously during this procedure. Crown removal is avoided when the type of cement and amount of supporting tooth structure are unknown.



الأدوات المخصصة لإزالة
التيجان

ACCESS-POST AND CORE

Many retreatments require removal of a post and core. Long and large posts are often strongly retained; attempts to remove them must preclude risks of root fracture or post .

Retention

Post retention must first be weakened . The core is drilled away (cast core is reduced), leaving just the post extending from the canal. The cement is then broken up with piezoelectric ultrasonic vibration on the post for 10 to 20 minutes. Pointed tips are used to ultrasonically trough around the post.







Extraction of Post

If the post has not been loosened and removed by vibration, it must be extracted with special instruments. The post is bored with a trepan and then tapped and firmly engaged with the matching size extractor. Special pliers are applied to the extractor.



A



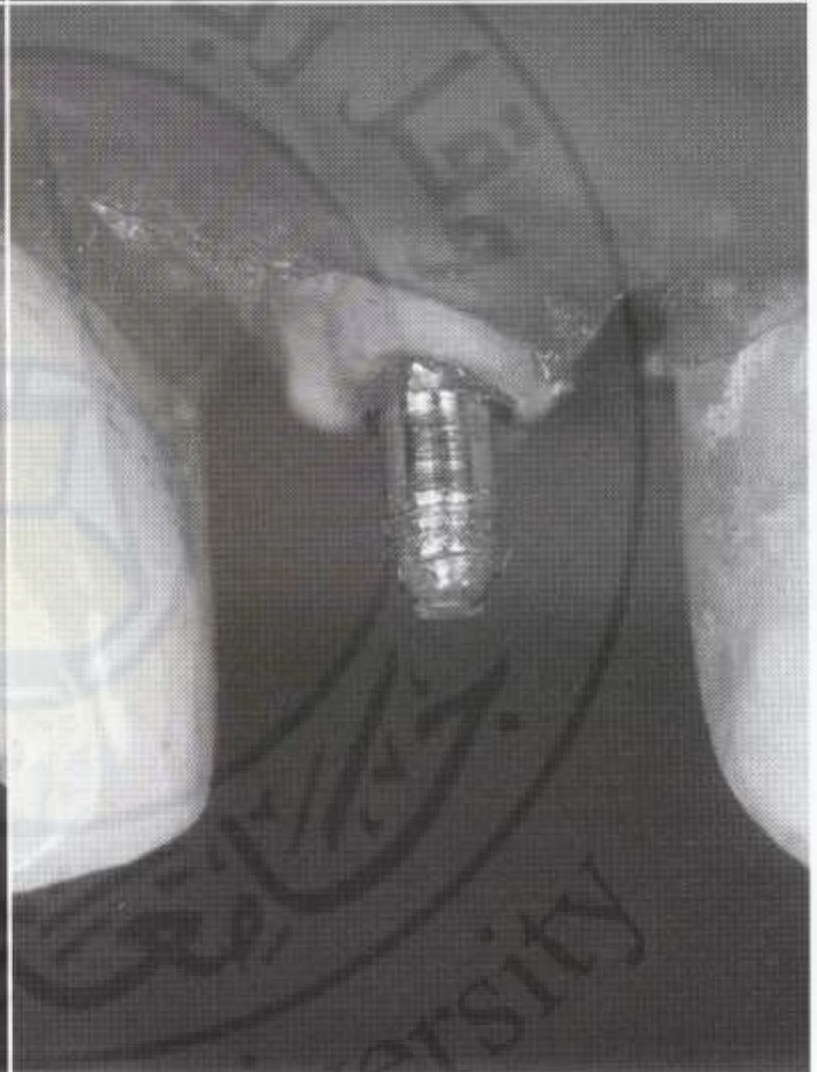
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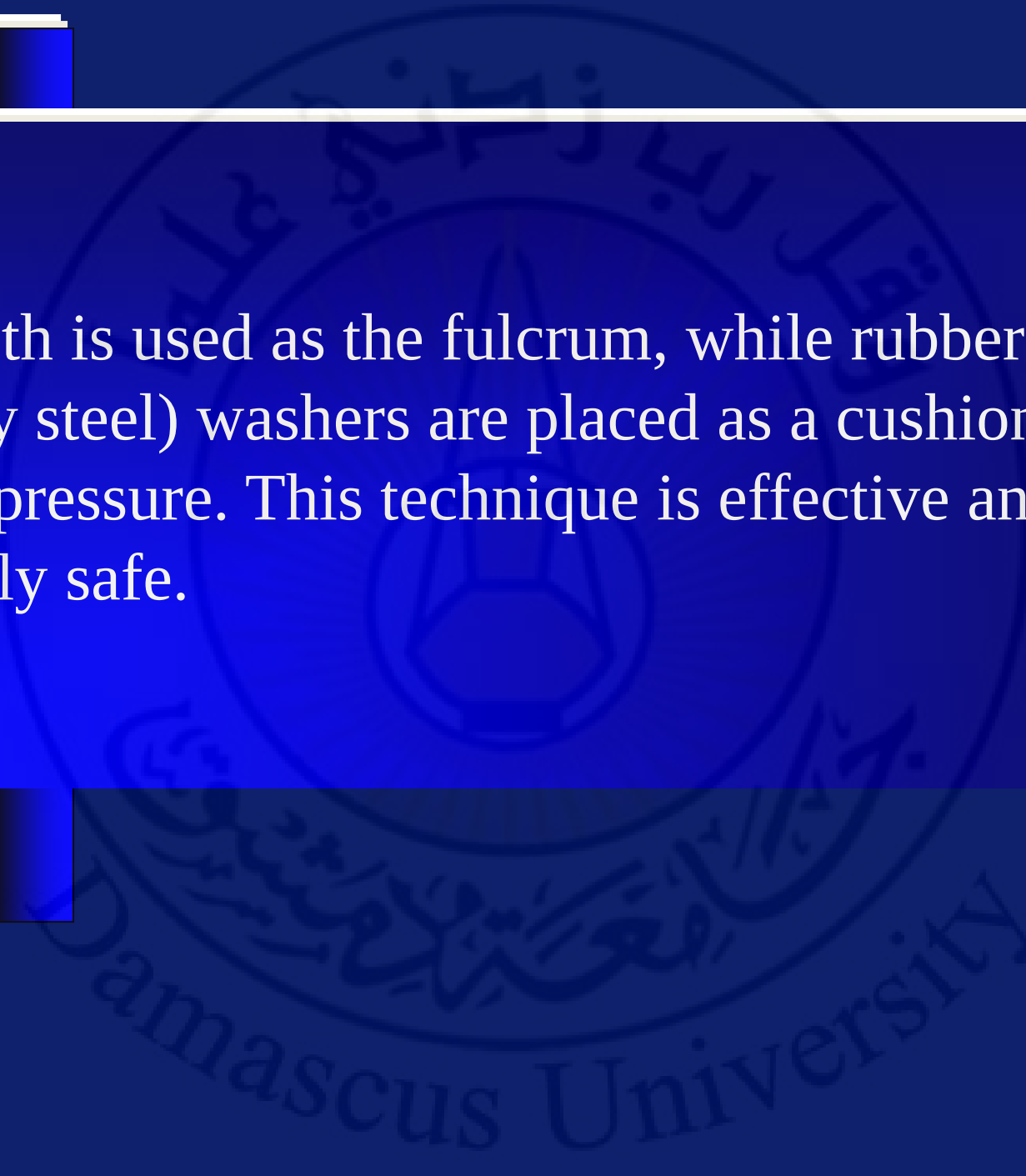


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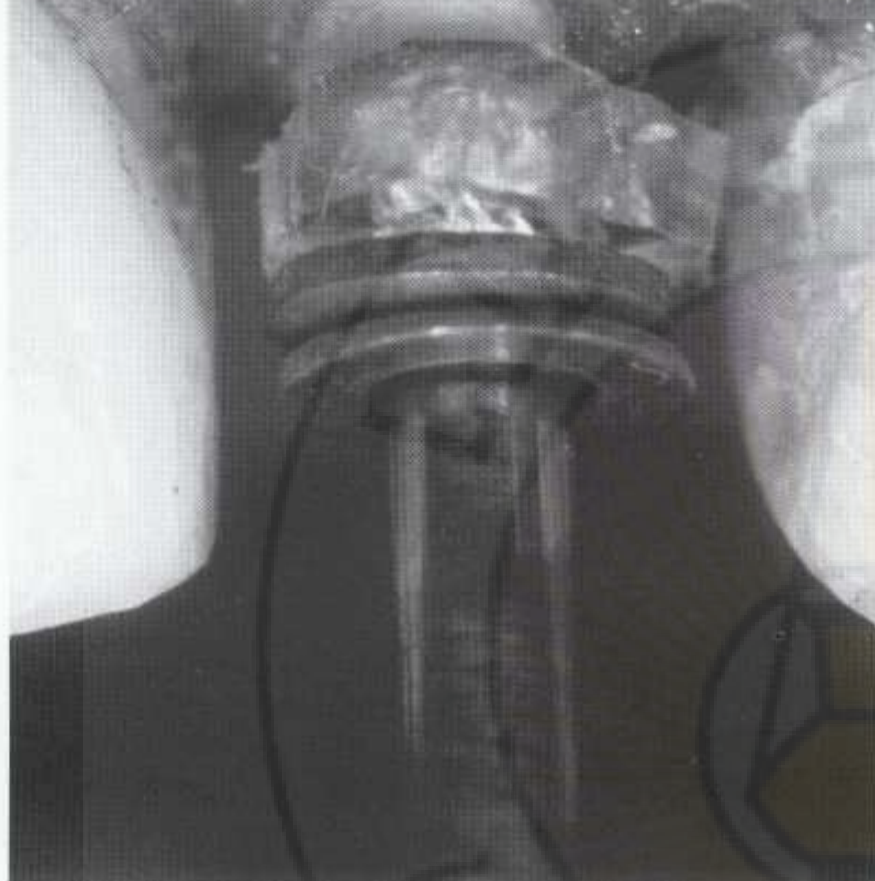
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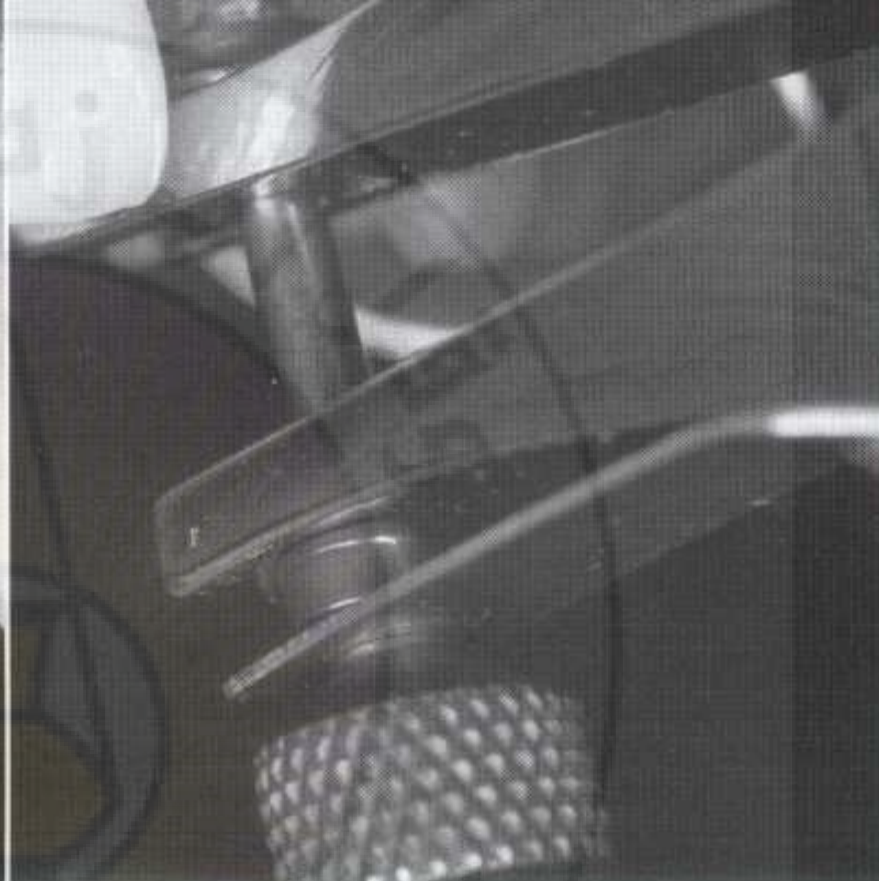
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The tooth is used as the fulcrum, while rubber (and possibly steel) washers are placed as a cushion to reduce pressure. This technique is effective and relatively safe.

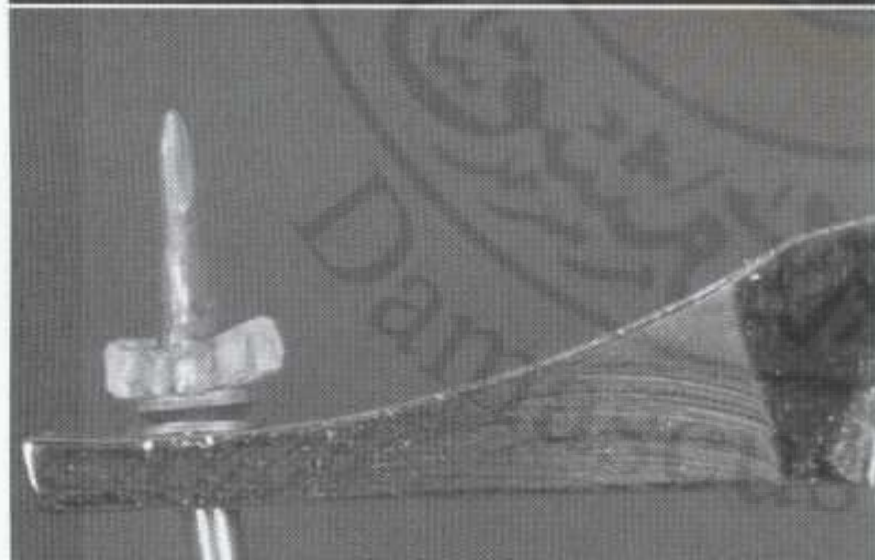
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G



Types of posts removal :

- Eggler.
- Ruddle
- Gonon



All of them work in
a similar manner.



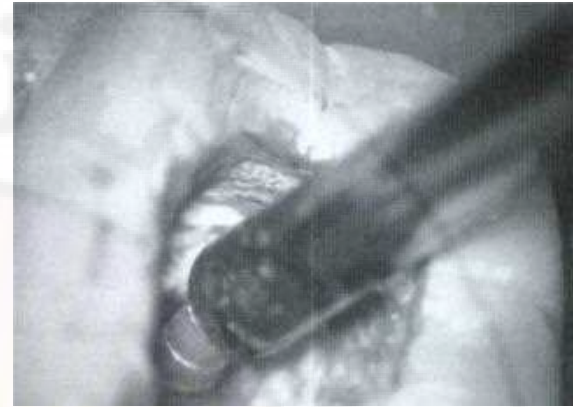
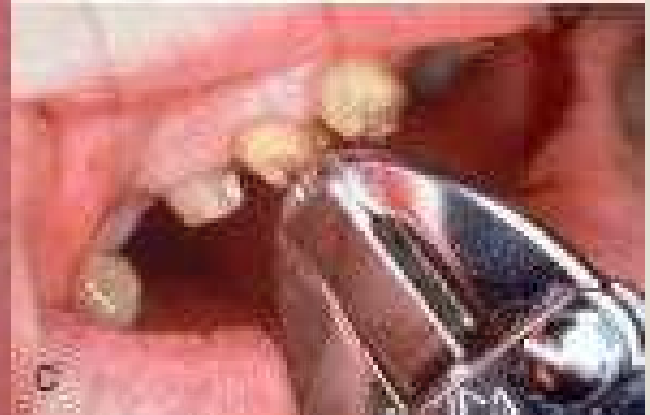
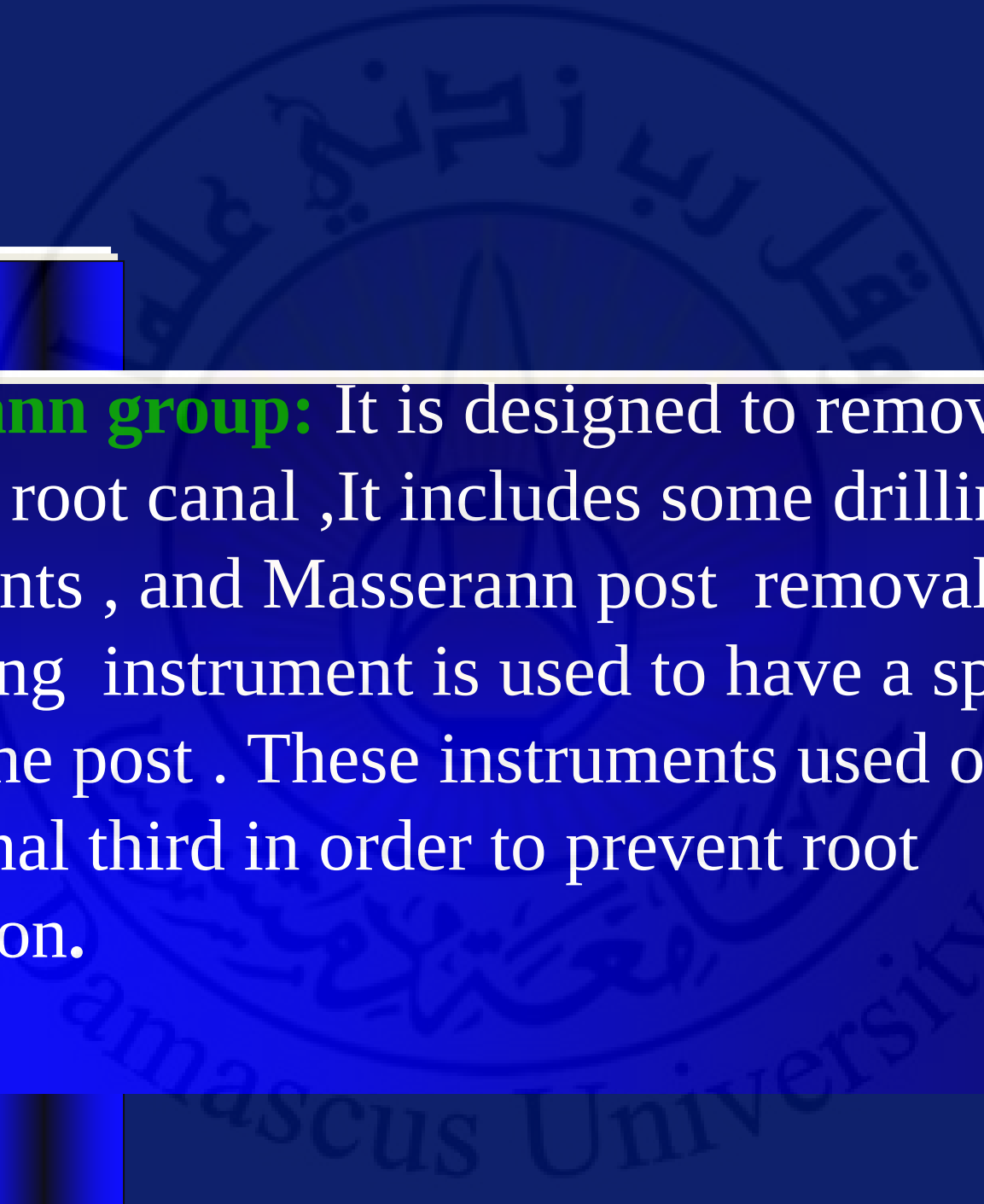


FIG. 8-26: A, Egger Post Remover. B, Post has been contoured with a high-speed bur. C, Egger Post Remover grasping the post. D, Elevating the post. Reprinted with permission from Stancos DE, Gutmann JL: Revisiting the post puller. *J Endod* 17:467, 1991.



تستخدم لإزالة التيجان و إزالة Egger / Post Puller نظامي القلب و الوتد المعدني المصبوبين كقطعة واحدة



Masserann group: It is designed to remove posts from the root canal ,It includes some drilling instruments , and Masserann post removal. the drilling instrument is used to have a space around the post . These instruments used only in the coronal third in order to prevent root perforation.



Removal of cast posts:

We can use ultrasonics tips to dislodge the post or dissolve the surrounding cement, and we can make a groove on the post in order to put the ultrasonic tip on it , and make the tip to vibrate vertically around the post.



Avoiding Post Removal:

In a multirooted tooth, retreatment may indicated in canal(s) other than the one retaining the post.

If post removal is considered risky, access can be established through the core only to the retreated canal(s), without disturbing the post.



CANAL OBSTRUCTIONS:

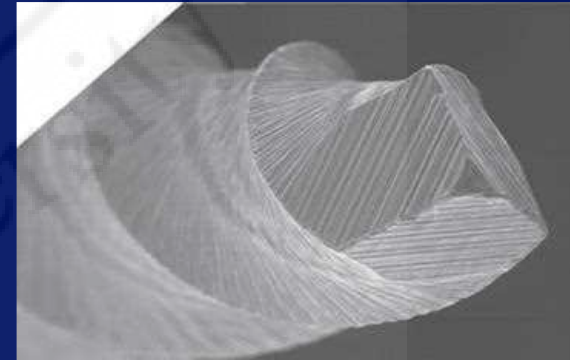
Gutta percha:

Gutta-percha is eliminated with rotary instruments and hand files. Solvent is used selectively. A "crown-down" sequence is Preferable.

Rotary instruments

A variety of instruments can effectively remove gutta-percha, when rotated at 350 to 1000 rpm In the coronal portion of the canal.

wide-taper rotary instruments such as Gates-Glidden burs are used with minimal apical pressure. This forms a receptacle for solvent, and improves access ,Use of heated instruments creates limited space without improving access.



A



B



Solvent

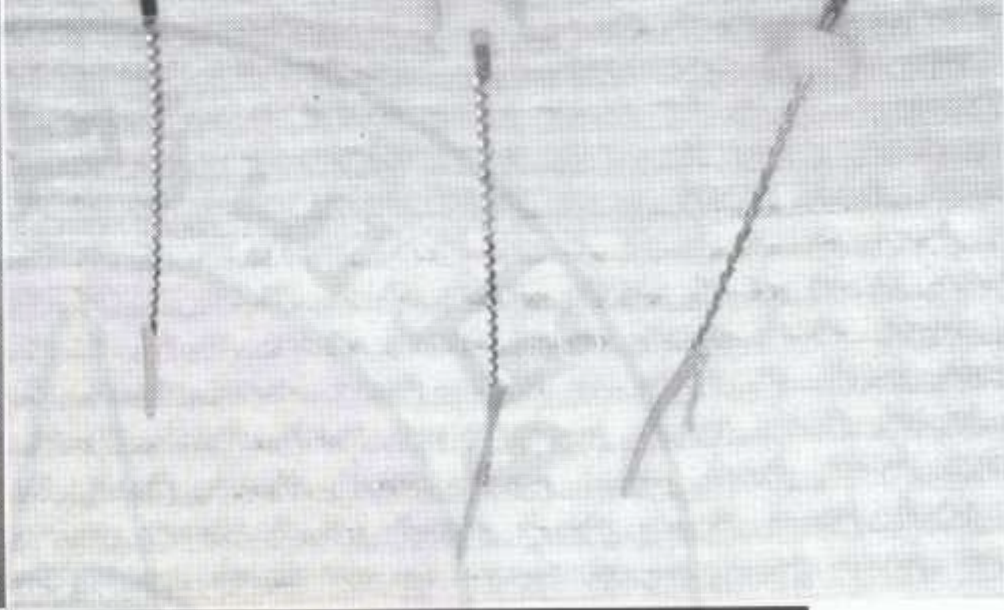
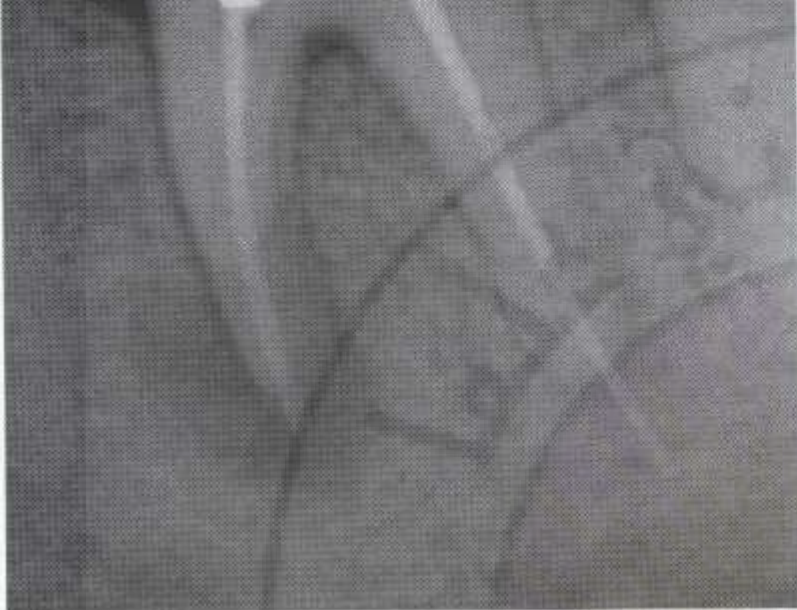
Solvent softens gutta-percha and helps prevent canal transportation. Therefore, it is used for dense root fillings and curved canal, However, because of toxicity, solvent must not be extruded periapically.

Gutta-percha and sealers are soluble to a varying degree in many solutions, chloroform is the most effective.

Hand files

They are used mainly in the apical portion of the canal. When gutta-percha cones are poorly condensed or overextended, solvent is avoided. A reamer or file is used first to negotiate a pathway along the root filling. A larger file is then carefully "screwed" into the filling mass and pulled back, the file may have to be extended periapically to avoid separation of the cone at the apical foramen. Overextended cones may separate at the apex and cannot be retrieved.

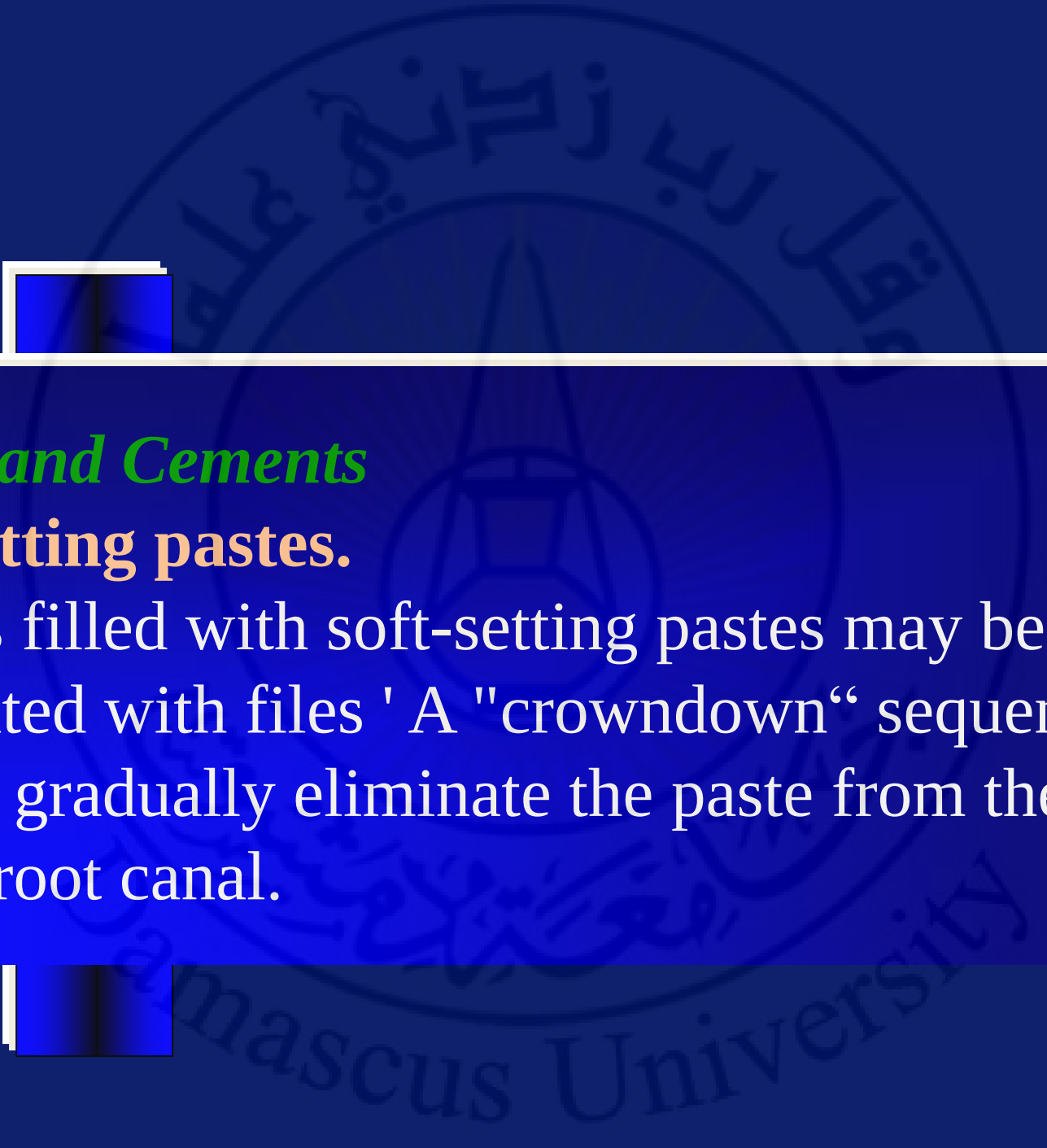
A



C



D



Pastes and Cements

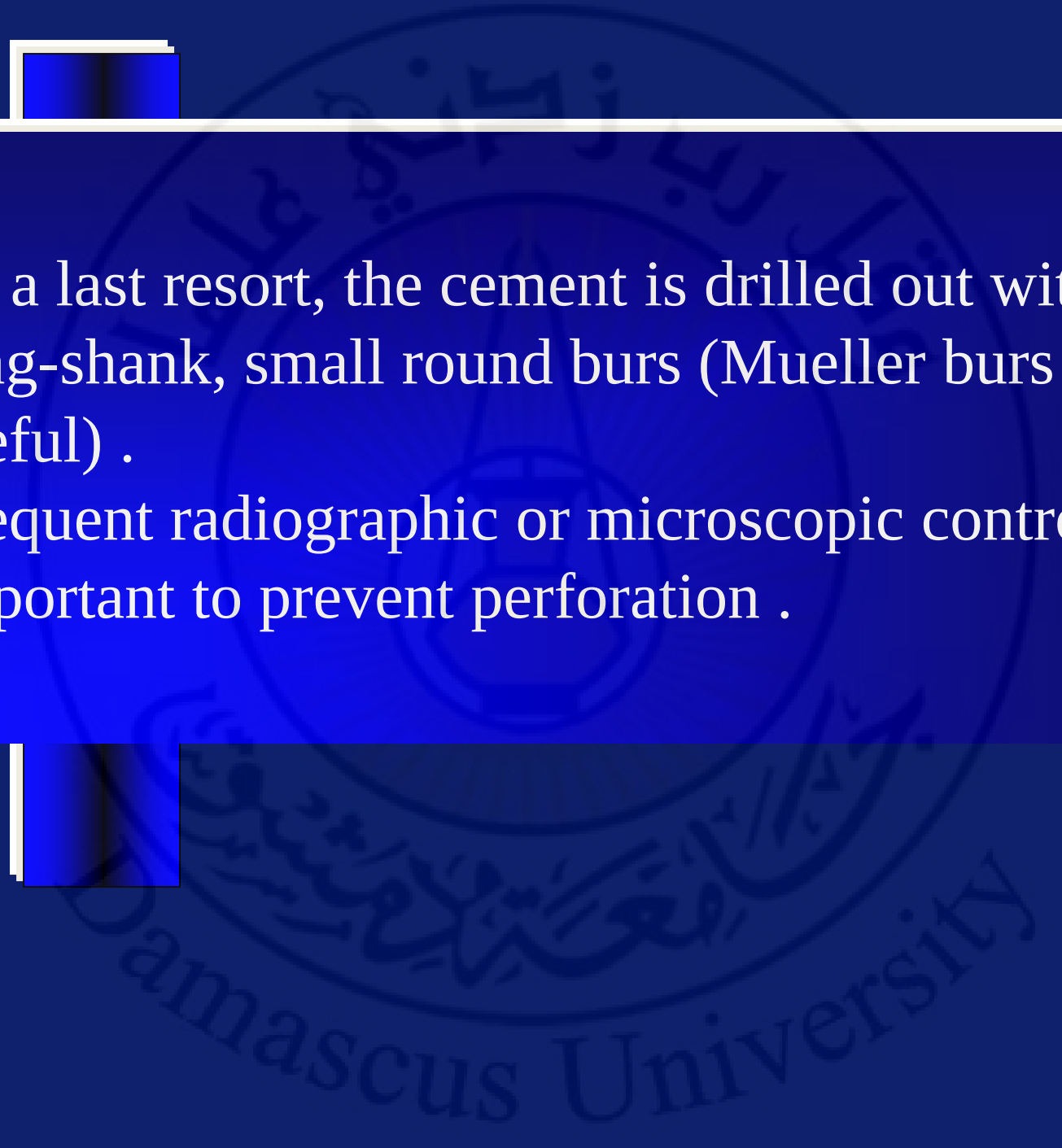
Soft-setting pastes.

Canals filled with soft-setting pastes may be penetrated with files ' A "crowndown" sequence is used to gradually eliminate the paste from the entire root canal.

Hard-setting cements:

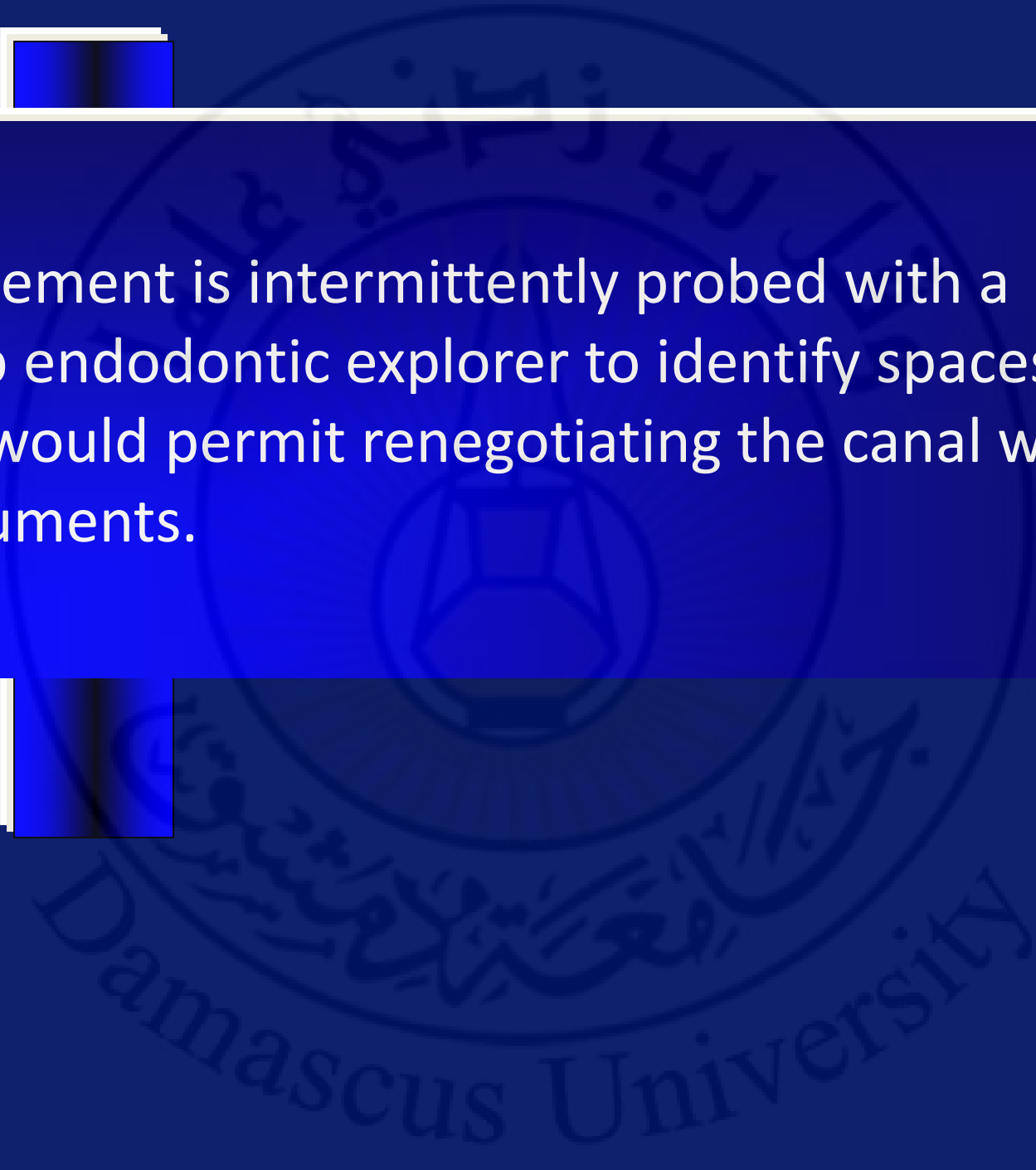
Resin-type cements should be exposed to solvents such as tetrachlorethylene, eucalyptol, or eugenol . If softened, the cement is managed like soft-setting pastes . If not, the cement is broken down with moderate ultrasonic vibration, using special pointed tips under light apical pressure.



The background of the slide features a large, faint watermark of the Damascus University logo. The logo is circular, containing Arabic calligraphy and the English text "Damascus University" at the bottom. The text on the slide is white and positioned over a dark blue rectangular area.

As a last resort, the cement is drilled out with long-shank, small round burs (Mueller burs are useful) .

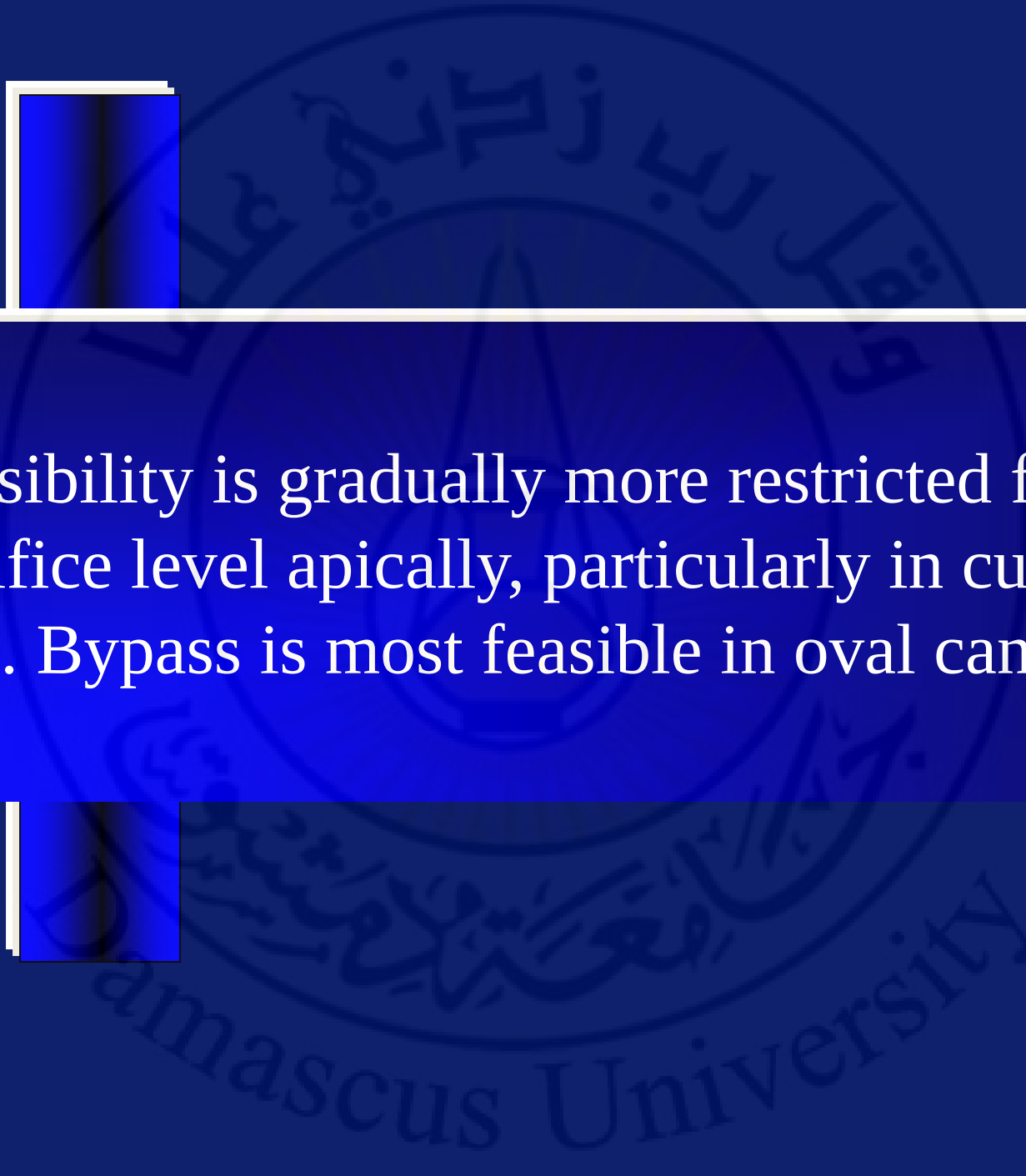
Frequent radiographic or microscopic control is important to prevent perforation .

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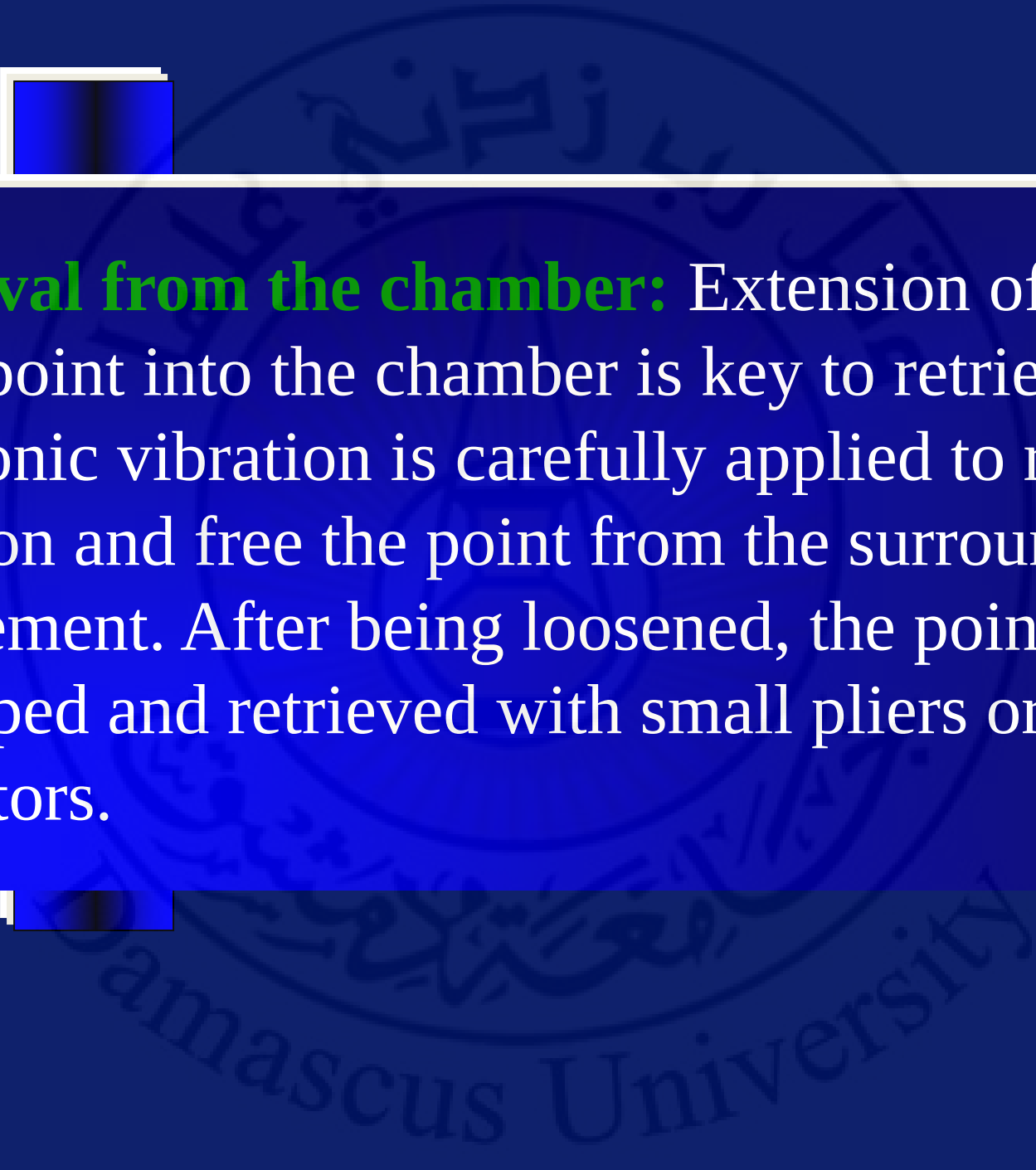
The cement is intermittently probed with a sharp endodontic explorer to identify spaces that would permit renegotiating the canal with instruments.

Metallic Objects-Silver Points and Separated Instruments

Metallic objects may often be retrieved or bypassed ,These procedures depend on accessibility and canal anatomy.

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Accessibility is gradually more restricted from the orifice level apically, particularly in curved canals. Bypass is most feasible in oval canals.



Retrieval from the chamber: Extension of the silver point into the chamber is key to retrieval. Ultrasonic vibration is carefully applied to reduce retention and free the point from the surrounding core cement. After being loosened, the point is grasped and retrieved with small pliers or special Extractors.

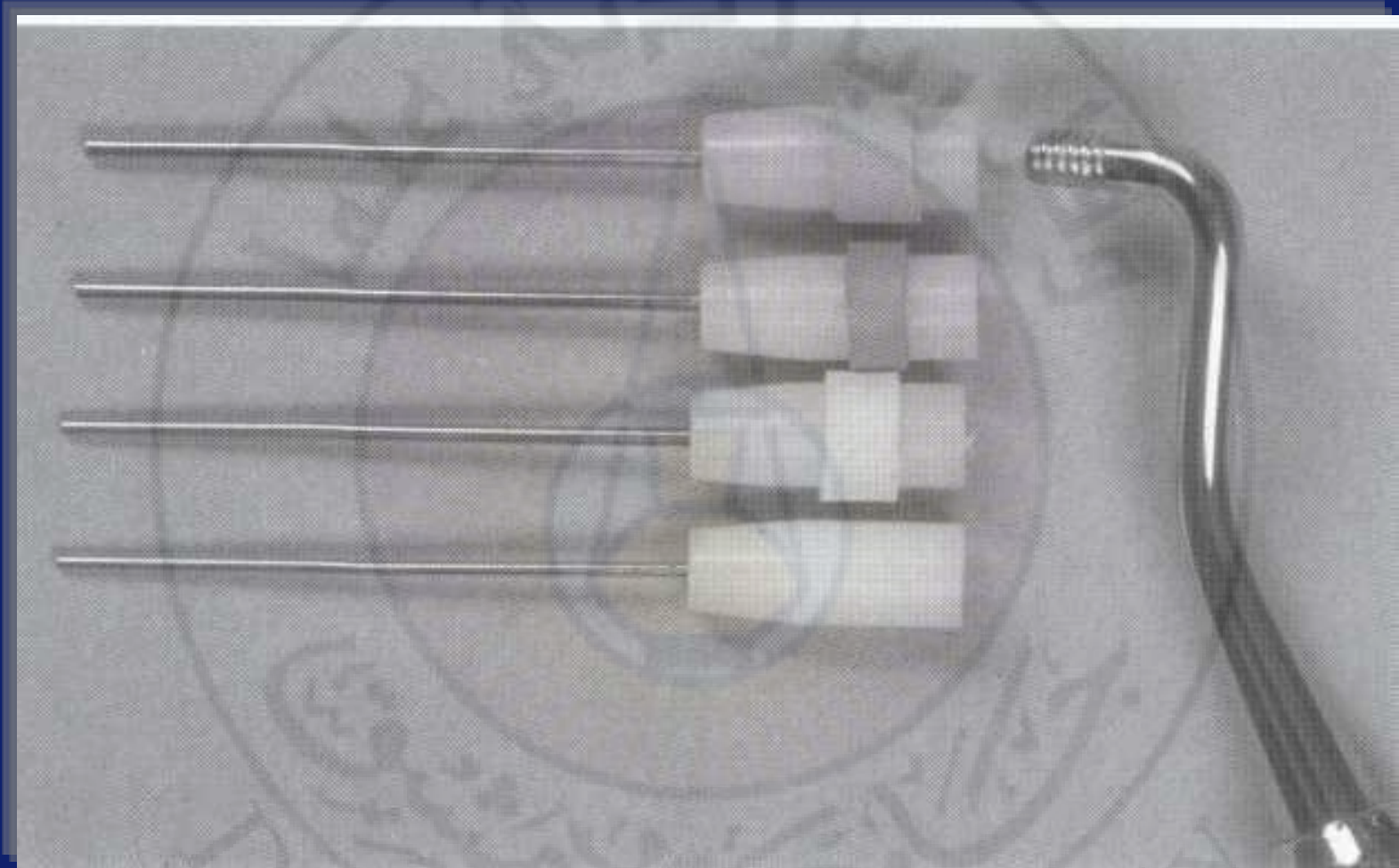
Bypass

The canal is flared with Gates-Glidden burs. Hand files are then used with solvent to prepare a pathway around the metallic object and possibly retrieve it. Ultrasonic files can be used to vibrate the object.

This procedure can be very time consuming and complicated by additional file separation, perforation, or apical displacement of the object. Visualization is optimized with the operating microscope.

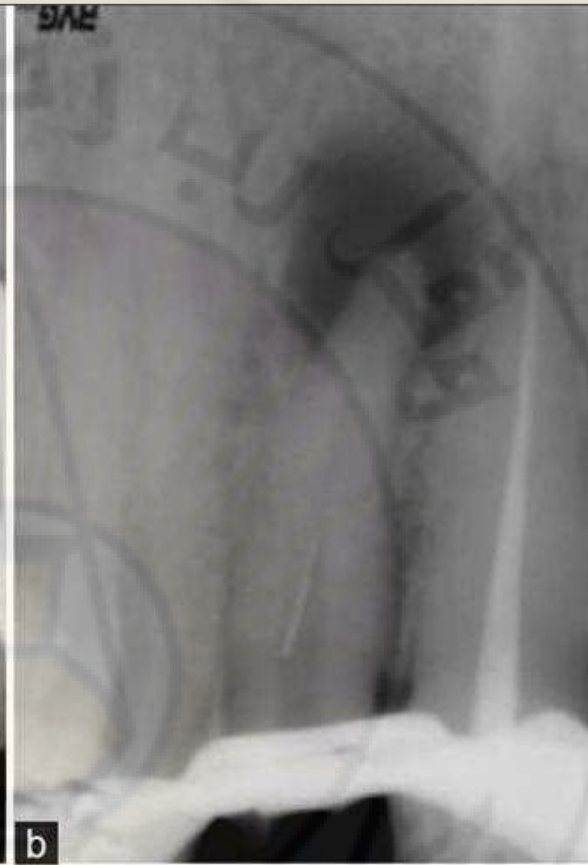
Extraction from the canal

Objects can be extracted with special devices. Most available devices include end-cutting trepans and extracting tubes, with or without a locking mechanism, A trough is cut around the object with ultrasonic tips or the trepans. A matching extracting tube is applied, locked, ultrasonically vibrated, and withdrawn. Frequent radiographic or microscopic control is imperative to prevent perforation.



Hollow tubes to extract separated silver points and instruments from root canals.

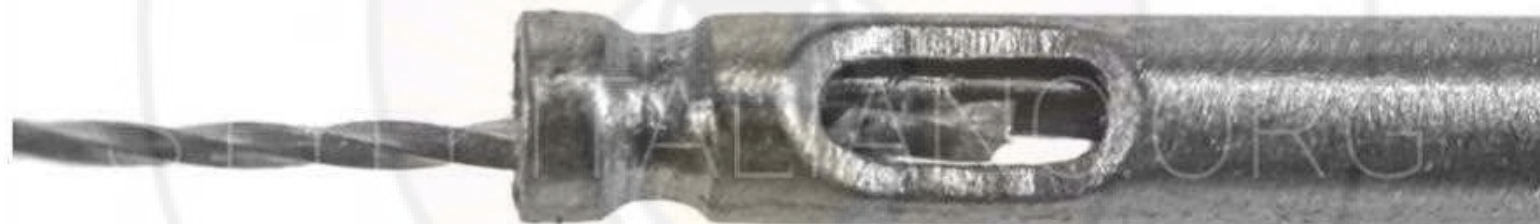




1



2



3





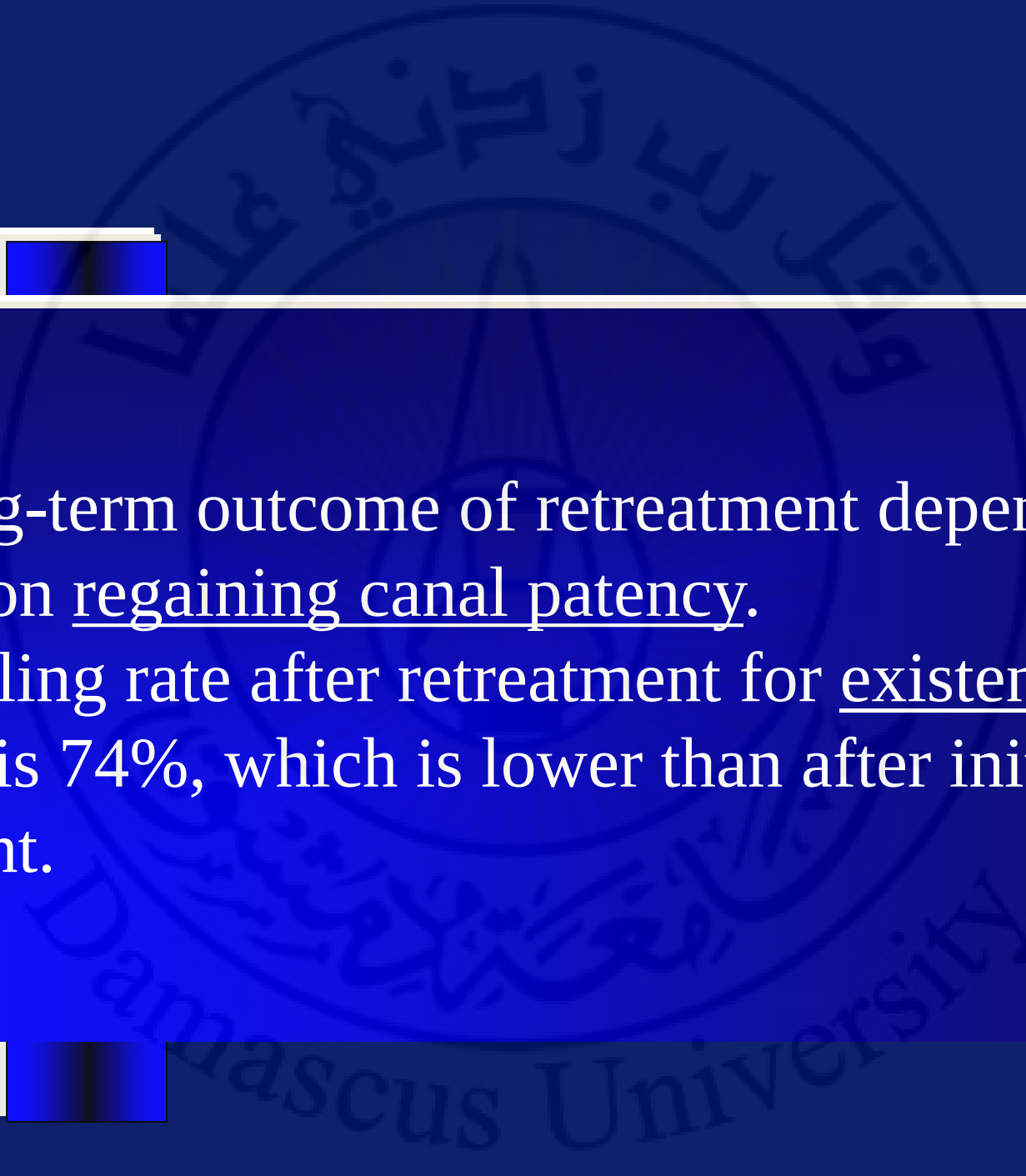
COMPLETION OF RETREATMENT

The following are important for management of post-treatment disease:

1. A wide, direct access is needed for better instrumentation.
2. The canal is enlarged beyond its previous size to reduce residue of root filling materials.
3. Calcium hydroxide is used for canal disinfection.

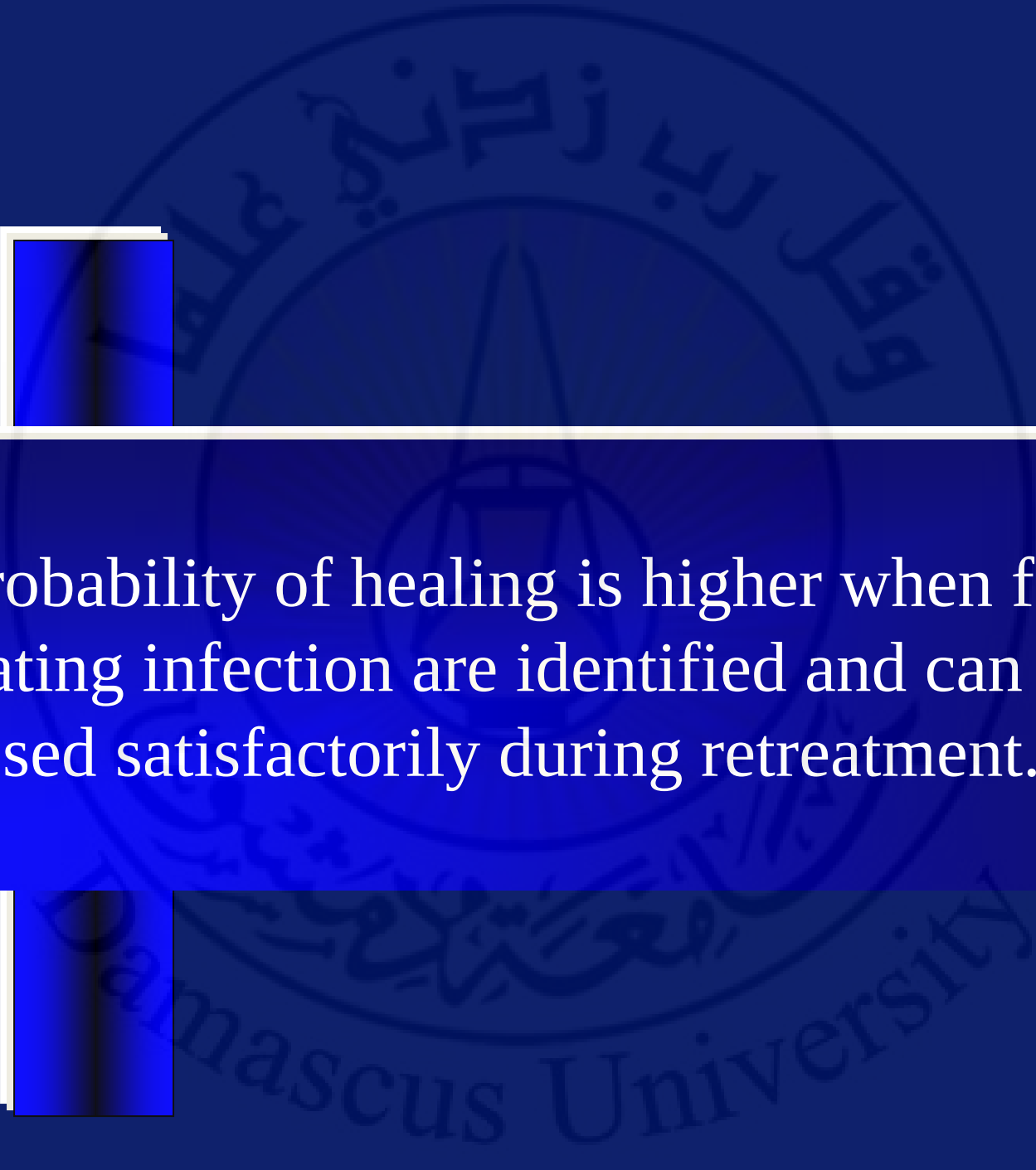
Short-Term and Long-Term Treatment Outcome

In the short term, retreatment with existent post treatment disease may be associated with postoperative discomfort, including pain and swelling. *This is an additional reason why retreatment for existent disease should not be completed in one visit.*

The background of the slide features a large, faint watermark of the Damascus University logo. The logo is circular, containing Arabic calligraphy at the top and the words "Damascus University" at the bottom. In the center of the logo is a stylized representation of the Dome of the Rock.

The long-term outcome of retreatment depends largely on regaining canal patency.

The healing rate after retreatment for existent disease is 74%, which is lower than after initial treatment.

The background of the slide features a large, faint watermark of the Damascus University logo. The logo is circular, containing Arabic calligraphy at the top and the words "Damascus University" at the bottom. In the center of the logo is a stylized building or dome. The entire slide has a dark blue background with vertical stripes.

The probability of healing is higher when factors facilitating infection are identified and can be addressed satisfactorily during retreatment.