BEYOND THE ACHE: A STAGE-WISE PERSPECTIVE ON ENDODONTIC PAIN

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ABSTRACT: -

Endodontic pain is a significant clinical concern and one of the primary reasons why patients seek dental treatment. The dental pulp, enclosed within rigid dental walls and richly supplied with nerve fibres, exhibits a distinct pain response that varies with the degree of inflammation. The transition from reversible pulpitis to irreversible pulpal damage and eventual pulpal necrosis reflects a dynamic pathological process involving vascular changes, increased intrapulpal pressure and neural sensitisation. A key component in the development of pulpal pain is the release of inflammatory mediators, including prostaglandins, bradykinin and cytokines, which enhance nociceptor responsiveness and contribute to both peripheral and central sensitisation. Understanding these mechanisms is essential for accurate diagnosis and effective clinical management. This article reviews the nature of pulpal pain, its aetiology and progression, along with the role of inflammatory mediators in pain generation. It also highlights the importance of differential diagnosis between pulpal and periodontal conditions and outlines a structured approach to pain control across pre-operative, intra-operative and post-operative phases. Both pharmacological and non-pharmacological strategies are discussed, emphasising their role in improving patient comfort and treatment outcomes. A comprehensive understanding of these factors enables clinicians to deliver effective and predictable endodontic care. An electronic database (Pubmed, Scopus, Research gate, Medline) were screened with key words endodontic pain, pulpitis, inflammatory mediators, pain management, local anaesthesia, NSAIDs and data were collected from the identified articles.

KEYWORDS: - Endodontic pain, Pulpitis, Inflammatory mediators, Pain management, Local anaesthesia, NSAIDs.

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1) INTRODUCTION

1.1) DEFINITION AND CLINICAL RELEVANCE OF PAIN: -

Pain may be described as an unpleasant bodily sensation arising in response to noxious stimulation and associated with actual or potential tissue injury. Its clinical expression may include aching, throbbing or pricking discomfort, and dental pain demonstrates many of these characteristic features [1].

1.2) STRUCTURAL CHARACTERISTICS OF DENTAL PULP: -

The dental pulp is a specialised connective tissue occupying the central cavity of the tooth and maintaining continuity with the periapical tissues through the apical foramen and accessory canals. Its enclosure within mineralised dentinal walls creates a protected environment while preserving vascular and neural communication with the surrounding tissues [2]. The dental pulp possesses a highly organised sensory and vascular network consisting of myelinated A fibres and unmyelinated C fibres that play an important role in pain perception [1].

In normal teeth, the dentinal tubules are occupied by dentinal fluid, and odontoblastic processes are present at the interface between dentin and pulp tissue [3].

1.3) NEURAL RESPONSE AND PAIN PERCEPTION

Pulpal irritation initiates an inflammatory response that alters the local tissue environment and increases intrapulpal pressure, thereby exciting sensory nerve endings and generating pain [1]. Transmission occurs through different populations of pulpal afferent fibres, and the fibres predominantly activated together with the degree of inflammation influence the clinical character of the pain. Consequently, pulpal pain may be experienced as sharp, dull, persistent or throbbing [4]. The character of pain may vary according to the severity of the inflammation, and may be perceived as continuous, dull, sharp or throbbing in nature, depending on the nerve fibres involved [4].

Inflammation within the dental pulp plays a crucial role in the pathogenesis of dental caries and several other pulp and periapical diseases. From a clinical standpoint pain associated with these pathological conditions is one of the most common symptoms reported by patients [3].

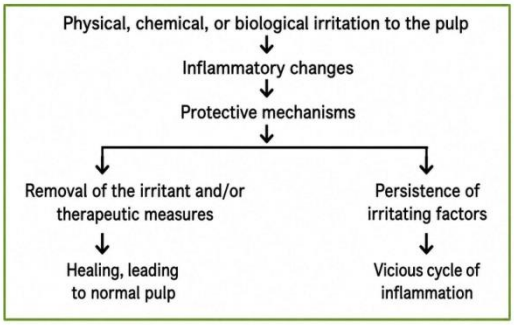
Sensory fibres within the pulp demonstrate considerable plasticity following injury. In areas exposed to microbial irritation, particularly carious lesions, axonal sprouting may increase local neural density and contribute to enhanced pain sensitivity in both acute and chronic pulpal inflammation [5].

1.4) INNERVATION OF DENTAL PULP

The dental pulp and periodontal tissues receive extensive innervation from trigeminal sensory neurons and contain one of the highest concentrations of nociceptors found in the human body [5]. These nerve fibres remain closely associated with blood vessels collectively forming the neurovascular bundle. Within the subodontoblastic zone, they branch into a delicate neural network referred to as plexus of Raschkow [2].Nociceptors function as an important, protective surveillance mechanism by detecting harmful stimuli and signalling actual or potential damage of tissue [5].

The sensory innervation of the pulp primarily originates from medium to large-size neurons associated with the second and third divisions of the trigeminal ganglion. Most of these fibres are predominantly nociceptive in function [5]. Apart from sensory innervations, dental pulp also receives sympathetic autonomic fibres derived from the superior cervical ganglion which mainly contributes to vasoconstriction and regulation of pulpal blood flow. A significant proportion of pulpal nociceptors are peptidergic in nature and release various neuropeptides following calcium-mediated neuronal activation [5].

1.5) AETIOLOGY OF DENTAL PAIN



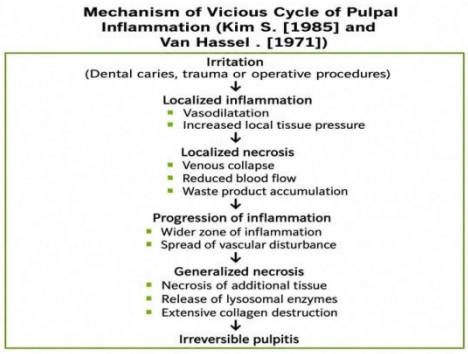
[Figure source: from Grossman's endodontic practice]

Dental pain is a multifactorial condition influenced by several aetiological factors, including microbial infection, dental caries, trauma, periodontal disease, iatrogenic injury, and other local irritants, all of which contribute to its clinical complexity [4].

1.6) DISEASE PROGRESSION

Mild and short-duration irritants, such as cavity preparation procedures and non-luxative traumatic injuries, usually produce acute pulpal inflammation that is followed by healing once the irritant is removed [2].

On the other hand, persistent irritants, including dental caries, defective or loose restorations, tooth cracks, erosion, and luxation-related traumatic injuries may lead to chronic pulpal inflammation. If these conditions remain untreated, continuous irritation, particularly when accompanied byinterruption of the apical blood supply, can eventually result in pulp necrosis [2].



[Figure source: from Grossman's endodontic practice]

1.7) SPREAD OF INFLAMMATION

As pulpal inflammation advances, the increasing tissue pressure within the pulp chamber causes the inflammatory process to extend from the pulp space into the periapical region. This progressive rise in pressure compromises, the structural integrity of the pulptissue, ultimately leading to loss of vitality[2]. At this stage, the tooth may exhibit either partial or complete pulp necrosis, depending on the severity and the rate of bacterial invasion within the pulp. Grossman described a partially necrotic pulp with residual inflamed tissue as necrobiosis [2]. During acute irreversible pulpitis the persistent elevation in intrapulpal pressure drives the inflammatory process through the apical foramen into the periodontal ligament and surrounding Periapical tissues, thereby resulting in apical periodontitis [2].

2.INFLAMMATORY MEDIATORS IN PULPAL PAIN PATHWAY

2.1) PULPAL BLOOD FLOW AND STRUCTURAL IMITATION.

Mature dental pulp demonstrates an estimated blood flow of nearly 40–50 mL/ minute/100 g of tissue, which is relatively greater than that of many oral tissues and skeletal muscles [2]. Since the pulp is confined within rigid dental walls, it is unable to expand in response to increased vascular flow or inflammatory changes within the tissue [2].

2.2) MICROCIRCULATORY CHANGES AND ROLE OF ODONTOBLASTS

Microcirculatory alterations within the dental pulp are considered one of the earliest responses during the onset of pulpal inflammation. Odontoblasts not only contribute to the regulation of pulpal blood flow but also play a crucial role in modulating the inflammatory responses occurring within the pulp tissue [2].

2.3) ROLE OF NITRIC OXIDE AND INITIAL MEDIATOR RELEASE

Odontoblasts contain the enzyme nicotinamide adenine dinucleotide phosphate NADPH-Diaphorase, which is responsible for the production of nitric oxide, a potent vasodilator involved in pulpal inflammatory responses. Nitric oxide further promotes the synthesis of inflammatory mediators, such as prostacyclin (PGI2) leading to stimulation of nerve fibres and brief pain sensations [2].

2.4) VASCULAR CHANGES AND TISSUE BREAKDOWN

Disruption of pulp homoeostasis caused by bacterial toxins and inflammatory mediators leads to vasodilation within the pulpal tissue. The subsequent increase in Intrapulpal pressure compresses the delicate blood vessels, leading to localised ischaemia and eventual pulpal necrosis [2].

2.5) ROLE OF INFLAMMATORY MEDIATORS IN PAIN GENERATION

2.5.1) PROSTAGLANDINS

Prostaglandins (PGs) are among the key inflammatory mediators, produced from arachidonic acid through the cyclooxygenase (COX) enzyme pathway. COX exists in two isoforms, COX-1 and COX-2, among which COX2 is inducible and extensively expressed in inflamed tissues including the dental pulp [Reference: Cohen's pathways of pulp].

While prostaglandins do not directly evoke pain, they play a significant role in sensitising peripheral nociceptors and potentiating the effects of inflammatory mediators such as bradykinin and serotonin. Increased concentrations of prostaglandins in inflamed pulp tissue are closely associated with hyperalgesia and enhanced pain sensitivity [Reference: Cohen's pathways of pulp].

Mechanism of action: -

Inflammatory changes within the dental pulp stimulate activation of the cyclooxygenase (COX) system, especially COX-2, which is up-regulated and expressed during pulpal inflammation. (Reference: Cohen's pathways of pulp)

During pulpal inflammation, arachidonic acid is metabolised into prostaglandins (PGs) such as PGE_2 and prostacyclin (PGI_2), both of which play a significant role as inflammatory mediators within the pulp tissue [Reference: Cohen's pathways of pulp].

Prostaglandins enhance the responsiveness of peripheral nociceptors and amplify the pain-producing effects of inflammatory mediators such as bradykinin and serotonin. In addition, they also enhance neuronal excitability by acting on prostaglandin receptors (EP2 and EP3) and modulating ion channels such as voltage-gated sodium channels [Reference: Cohen's pathways of pulp].

2.5.2) BRADYKININ: -

Bradykinin represents a potent plasma-derived inflammatory mediator involved in nociception through direct activation of sensory neurons associated with pain transmission [Reference: Cohen's pathways of pulp]. Mechanism of action: - Bradykinin mediates neuronal hyperexcitability via activation of transient receptor potential channels particularly TRPV1 and TRPA1receptors, thereby potentiating inflammatory pain perception within pulpal tissues [Reference: Cohen's pathways of pulp].

2.5.3) CYTOKINES: -

- Cytokines are regulatory proteins produced by different types of cells and are important in controlling immune and inflammatory reactions [Reference: Cohen's pathways of pulp].
- These small proteins can either stimulate or inhibit the growth, differentiation, and activity of immune cells, helping regulate the body's inflammatory response.
- TNF-α, IL-1, and IL-6 are examples of pro-inflammatory cytokines, while IL-4, IL-5, IL-10, and IL-13 function as anti-inflammatory cytokines [Reference: Grossman endodontic practice]. Mechanism of action: - pro-inflammatory cytokines, notably TNF-α, IL-1β, IL-6, and IL-8, mediate neuroplastic alterations within nociceptors, promoting neuronal sensitisation and exaggerated pain responses in inflamed pulpal tissues [Reference: Cohen's pathways of pulp].

3.DIAGNOSIS AND TREATMENT PLANNING

3.1) IMPORTANCE OF DIAGNOSIS

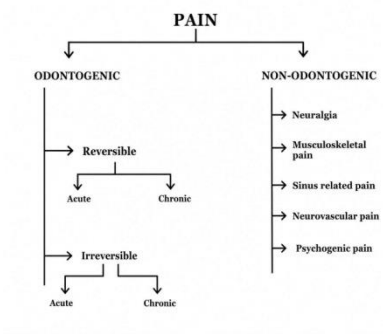
Identification of the cause of pain assists in treatment planning and improves prognosis [2]. Precise diagnosis of pulp and periapical diseases relies on comprehensive clinical and radiographic assessment in conjunction with an in-depth understanding of pulpal pathophysiology and mechanism of pain transmission [2].

3.2) STAGE-WISE MANAGEMENT OF THE PAIN

Management of pulpitis and apical periodontitis should commence with establishment of a working diagnosis, followed by the formulation of a systematic therapeutic plan directed towards disease resolution [6].

Comprehensive pain management protocols include preoperative, intraoperative, inter-appointment and postoperative measures aimed at achieving successfulclinical outcomes [1].

4) PAIN CLASSIFICATION AND DIAGNOSIS: -



4.1) NATURE OF PULPAL PAIN: -

- Pulpal pain is generally stimulus induced and commonly triggered by thermal changes.
- Reversible pulpitis produces brief pain relieved by removal of the stimulus while irreversible pulpitis causes lingering or spontaneous pain.
- Pain may occurspontaneously and be intermittent or continuous
- As the disease advances, the pain may become more intense, throbbing, piercing, or prolonged lasting for minutes.

[Reference: Grossman endodontic practice]

4.2) Reversible pulpitis: -

Reversible pulpitis represents a mild inflammatory response of the pulp to harmful stimuli with the potential for

complete recovery following elimination of the causative factor.

The condition may arise due to several factors, including:

- Mechanical trauma or disturbed occlusion.
- Thermal injury caused by prolonged instrumentation or overheating during restorative procedures.
- Dehydration of cavity preparation or a dentinal surface.
- Galvanic irritation resulting from newly placed amalgam restoration opposing metallic restorations
- Chemical and bacterial rehabilitation associated with restorative material, dietary substances or dental caries.

[Reference: from Grossman's endodontic practice]

SYMPTOMATIC OR ACUTE REVERSIBLE PULPITIS	ASYMPTOMATIC OR CHRONIC REVERSIBLE PULPITIS
• Acute reversible pulpitis represents an acute inflammatory exacerbation of the pulp induced by trauma or early dentinal tubular exposure. • Clinical presentation commonly includes sharp, shooting pain precipitated by cold or sweet stimuli. • Pain is transient and resolves promptly following elimination of the causative stimulus.	• Chronic reversible pulpitis is typically associated with low-grade discomfort during mastication or thermal stimulation. • Histologically, the pulp may remain clinically normal while demonstrating varying degrees of fibrosis secondary to repeated irritation. • Symptoms are generally mild and persistent in nature.
• Symptomatic reversible pulpitis is distinguished by brief, sharp, stimulus-specific pain episodes.	

[Reference: from Grossman's endodontic practice]and [2]

4.3) Irreversible Pulpitis: -

Irreversible pulpitis is defined as a persistent inflammatory condition of the pulp that may present with or without symptoms and is incapable of healing [Reference: from Grossman's endodontic practice].

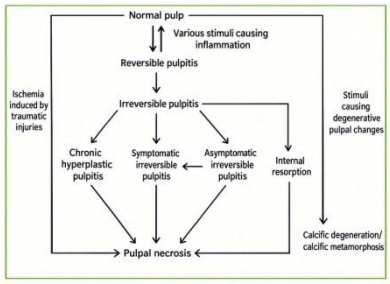
Bacterial involvement, secondary to caries represents the most common aetiological factor; however, thermal injury, chemical irritation and mechanical trauma may also induce pulpal inflammation. Untreated reversible pulpitis can subsequently develop into irreversible pulpitis [Reference: from Grossman's endodontic practice].

SYMPTOMATIC OR ACUTE IRREVERSIBLE PULPITIS	ASYMPTOMATIC OR CHRONIC IRREVERSIBLE PULPITIS
• Symptomatic irreversible pulpitis is characterised by intermittent or spontaneous episodes of pain • Exposure to thermal stimuli, especially cold produces exaggerated, and lingering pain responses, even after elimination of the stimulus • Pain may be sharp, dull, diffuse or localised in nature. [Reference: Cohen's pathways of pulp]	• Asymptomaticirreversible pulpitis represents the clinical condition in which the inflamed pulp is incapable of healing, despite absence of symptoms • Deep carious involvement may extend into the pulp without producing noticeable clinical symptoms. • Without any treatment, the condition may advance to symptomatic pulpitis or pulpal necrosis. Prompt endodontic management is advised to avoid disease progression and severe patient discomfort [Reference: Cohen's pathways of pulp]

4.4) PULP NECROSIS: -

- Pulp necrosis refers to death of the dental pulp, resulting in loss of pulpvitality, and absence of response to pulp testing.
- It is the only pulpal diagnostic category that attempts to describe the histological condition of the pulpal tissue.

- This condition most commonly develops secondary to symptomatic or asymptomatic irreversible pulpitis.
- Following complete necrosis, the affected tooth generally becomes asymptomatic until progression of the pathological process into the periradicular tissues occurs. Necrotic teeth typically exhibit negative responses to electric pulp testing and thermal stimulation with cold
- Despite loss of pulpal vitality, prolonged heat application may occasionally evoke a response potentially due to thermal expansion of residual intracanal fluids or gaseous contents extending into the periapical tissues.



[Figure source: from Grossman's endodontic practice]

5) DIFFERENTIAL DIAGNOSIS

5.1) PULP VS PDL

PULP	PDL
pain originating from pulp is generally poorly localised	periodontal pain is usually more precise and easily localised
localisation of the offendingtooth is often difficult in pulp pain	the offending tooth can usually be identified by the patient
thermal stimulation, frequently elicits pulpal pain.	the involved tooth commonly exhibits tenderness on percussion or mastication
pain may be present as sharp throbbing or piercing in character	pain is generally dull, persistent and continuous
symptoms may occur, intermittently or continuously and may persist following the removal of the stimulus	patient may experience a sensation of the tooth being high in occlusion

[Reference: Grossman's endodontic practice]

5.2) REVERSIBLE VS IRREVERSIBLE PULPITIS

REVERSIBLE PULPITIS	IRREVERSIBLE PULPITIS
Pain is usually triggered by stimuli such as cold water or air exposure.	Pain may arise spontaneously without any identifiable stimulus.
Pain is mild and transient.	Pain is more intense and prolonged.
The pain is sharp and shooting type in nature.	The pain is more severe and persistent.
Pain occurs only in response to stimulation.	pain may occur spontaneously or continuously.
Represents a mild and reversible pulp condition.	Represents a severe in progressive pulpal condition.

[Reference: Grossman's endodontic practice] and [2].

6) PRE-OPERATIVE PAIN CONTROL

6.1) Patient assessment and diagnosis

Preoperative evaluation of a patient's existing disease status and implementation of measures to control any present infection are essential components of effective pain management [1]. Comprehensive understanding of pain pathogenesis significantly simplifies treatment planning and enhances clinical prognosis. Accurate diagnosis of pulpal and periapical diseases requires meticulous history taking, clinical and radiographic assessment, as well as detailed knowledge of pulpal pathophysiology and pain pathways [2]. Progressive elevation of pulpal tissue pressure may facilitate extension of the inflammatory processes from the pulp chamber into the periapical tissues ultimately resulting in disruption of pulpal structural integrity and loss of vitality [2]. Depending on the extent of bacterial progression within the pulp space, the tooth may undergo partial or complete pulpal necrosis, a condition Grossman described as necrobiosis when residual inflamed pulpal tissue remains [2].

6.2) Patient related factors influencing pain

The perception of pain is closely associated with emotional and cognitive variables such as prior dental experiences, patient awareness of the proposed procedure, and sensitivity to procedural sounds and movements [7].

Adequate control of pain during endodontic therapy is crucial for ensuring positive outcomes for both the patient and the clinician [8].

6.3) Pharmacological management of fear and anxiety

- Agents employed for anxiety reduction are categorised as anxiolytics, whereas medications primarily intended to induce sleep are classified as hypnotics
- Pharmacological anxiolysis may be indicated in the patients exhibiting significant dental anxiety and behavioural interventions and effective clinician, patient communication fails to achieve adequate emotional control.
- Benzodiazepines constitute the principal pharmacological agents utilised in contemporary dental practice for the management of anxiety related responses and also, they are contraindicated during pregnancy, owing to their potential teratogenic and foetal depressant effects.
- These medications help reduce anxiety, produce sedation, relax muscles, and control convulsions.
- Their effect is achieved by increasing the activity of gamma-aminobutyric acid (GABA) and inhibitory neurotransmitter in the central nervous system, thereby reducing neuronal stimulation
- Smaller doses, mainly relieve anxiety, whereas larger doses may induce sleep or deepen sedation.
- Commonly prescribed benzodiazepines dental anxiety include:
  - Lorazepam
  - Triazolam
  - Alprazolam
- While short-term use is considered relatively safe, prolonged use may cause dependence and cognitive disturbances.
- Flumazenil may be used to reverse benzodiazepine overdose [Reference: Cohen's pathways of pulp].

6.4) Pharmacological pain control

Effective pain management in endodontics involves behavioural approaches, non-narcotic pharmacological therapy, and the achievement of profound anaesthesia. In selected cases, opioid analgesics may be considered after assessing the associated risks and benefits [1].

Administration of ibuprofen at doses greater than 400 mg has demonstrated significant efficacy as premedication for enhancing anaesthetic success [8].

6.5) Pre-anaesthetic considerations

Inflammation-induced sensitisation of nociceptors adversely affects the success of nerve block anaesthesia. Consequently, controlling inflammation before local anaesthetic administration plays a key role in improving anaesthetic outcomes [8].

7) INTRA-OPERATIVE PAIN CONTROL ;

In endodontic practice, efficient intraoperative pain control is essential for ensuring patient comfort and improving treatment outcomes [9].

7.1) Local anaesthetic techniques

Local anaesthetics and analgesic medications are routinely administered to control pain associated with endodontic treatment during both intraoperative and postoperative periods [10]. A range of local anaesthetic techniques are available to achieve effective pulpal anaesthesia and facilitate comfortable endodontic treatment. The success of profound anaesthesia is influenced by several factors, including the dental arch involved, the pulpal status of the affected tooth, the anaesthetic technique selected and the type and quantity of anaesthetic solution administered. In addition, patient related factors such as anxiety and perception of pain may also significantly affect and anaesthetic efficacy during endodontic procedures [10]. Intrapulpal anaesthesia (IPA) is generally employed as a final anaesthetic approach in cases where adequate anaesthesia cannot be achieved using conventional or adjunctive anaesthetic techniques [10].

Although infrequently encountered accidental injury to the inferior alveolar nerve (IAN) during endodontic procedures is considered an important clinical concern because of its potential neurological consequences [11]. In cases where achieving adequate anaesthesia is challenging, supplementary methods, such as intra-ligamentary or intraosseous injections can be used to obtain profound anaesthesia, before initiating endodontic treatment thereby ensuring patient comfort facilitating effective treatment outcomes [9].

7.2) Pharmacological methods

Intracanal medicaments play a crucial role in pain modulation during endodontic therapy. Calcium hydroxide, one of the most extensively used intracanal agents, contributes to pain control through its anti-inflammatory action and its ability to create an alkaline environment hostile to bacteria, thereby reducing the bacterial load [4].

7.3) Non-Pharmacological methods

Contemporary research has led to development of several non-pharmacological interventions aimed at the effective management of anxious dental patients before and during treatment procedures. Commonly employed approaches include music therapy, hypnosis, cognitive–behavioural therapy (CBT), enhanced patient education, and relaxation strategies [12].

7.4) Procedural considerations

Conventional root canal treatment was traditionally carried out over multiple appointments to facilitate adequate cleaning, shaping and disinfection of the canal system. Nevertheless, single-visit root canal therapy has gained increasing acceptance owing to its efficiency and greater patient convenience [13].

8) POST-OPERATIVE PAIN CONTROL

8.1) Aetiology of post-operative pain

8.1.1) General aetiology

Postoperative endodontic pain arises from multiple aetiological factors and is associated with acute inflammation of the periapical tissues caused by chemical, mechanical, microbial, or host-related injury during treatment [14].

A principal mechanism underlying endodontic pain involves the release of inflammatory mediators that activate sensory nociceptors in the periradicular tissues surrounding the affected tooth [15].

8.1.2) Incidence and time course

Post-operative pain represents a common sequela of endodontic treatment with prevalence rates ranging from 2.5% to nearly 60%. Clinical evidence indicates that pain intensity tends to increase between 6 and 12 hours post-treatment reaches peak prevalence within 24 hours and subsequently declines to approximately 11% after one week [14].

8.2) Pharmacological management

8.2.1) Analgesics and NSAIDs

Analgesics have traditionally played an important role in endodontic therapy and are frequently administered following treatment procedures [15].

NSAIDs have been widely employed in dental practice for long-term management of pain and inflammation [15].

NSAIDs constitute a diverse class of medications with analgesic, antipyretic, and anti-inflammatory effects. They are widely available as over-the-counter drugs with

relatively fewer side effects. Their principal mechanism involves competitive inhibition of cyclooxygenase (COX) enzymes responsible for the metabolic conversion of arachidonic acid into prostaglandins (PGs) and thromboxanes [15].

8.2.2) Corticosteroids

Evidence from systematic reviews and meta-analyses indicates that corticosteroids are highly beneficial in controlling postoperative pain and inflammatory responses [4].

Owing to their anti-inflammatory and immunosuppressive actions, corticosteroids have demonstrated considerable effectiveness in the management of endodontic pain. A systematic review and meta-analysis titled Efficacy of Corticosteroids on Postoperative endodontic Pain concluded that these agents significantly reduce pain intensity while also highlighting the influence of different drug regimens on treatment outcomes over time [1].

8.2.3) Adjunct pharmacological agents

Trypsin-chymotrypsin, due to its potent anti-inflammatory and antioxidant activities, has demonstrated effectiveness in controlling postoperative oedema and alleviating severe pain [1].

Valacyclovir, a commonly used antiviral medication, has shown promising results in the treatment of acute apical abscesses within endodontic practice. One study evaluated the combined use of valacyclovir and amoxicillin in 20 patients experiencing moderate-to-severe pain [1].

8.3) Non-pharmacological management

8.3.1) Cryotherapy

Recent studies indicate a growing interest in non-pharmacological interventions, as supportive or substitute therapies for conventional treatment methods. Among this intracanal cryotherapy has shown promising effectiveness in reducing postoperative pain through reduction in intracanal temperature and inflammatory reactions [4].

Intraoral and extraoral cryotherapy techniques demonstrate significant analgesic and anti-inflammatory effects. Within endodontic practice, the therapeutic use of low temperatures has emerged as a complementary strategy for reducing post-treatment pain and discomfort [4].

During root canal treatment, cryotherapy employs cold irrigating solutions, such as chilled saline or cryo-treated sodium hypochlorite. The beneficial effects of this technique are mainly due to lowering of tissue temperature, which leads to vasoconstriction, reduced metabolic activity and decreased release of inflammatory mediators. Together, these effects help lessen oedema, slow nerve conduction and reduce pain perception [4].

8.3.2) Advanced therapeutic approaches

Advanced therapeutic approaches such as low-level laser therapy (LLLT) and photobiomodulation have demonstrated promising outcomes in pain reduction and tissue healing. Furthermore, studies have also investigated nano-pulsed magneto-infrared laser therapy, which has shown promising efficacy in the management of post-endodontic pain when used alongside oral analgesics [4].

8.4) Flare-ups and their management

8.4.1) Pathophysiology of flare-ups

An endodontic flare-up develops when treatment-associated irritation of the periradicular tissues initiates an acute inflammatory response, clinically presenting as an exacerbation of pain, with or without swelling [16].

8.4.2) Risk factors

The risk factors responsible for flare-up development after endodontic treatment can be categorised into two major groups: patient-related and treatment-related factors. Patient related variables include demographic profile, systemic health status, pulpal and periapical tissue condition, existing clinical symptoms, and the specific tooth undergoing treatment. Treatment related variables encompass the number of treatment sessions, retreatment procedures, and the application of intracanal medicaments [16].

8.4.3) Mechanical factors and flare up initiation

Procedural irritation may occur when instrumentation carries intracanal contents beyond the apical confines. Extruded infected debris, pulpal remnants, microorganisms or irrigating agents can irritate periradicular tissues and provoke an inflammatory response, thereby increasing postoperative pain and potentially disturbing tissue repair [16].

8.4.4) Management of flare-ups

The use of antimicrobial intracanal medicaments in combination with a well-executed endodontic treatment contributes to improved clinical outcomes and reduced post-operative pain [16].

Trephination is a therapeutic endodontic procedure in which an opening is created through the alveolar cortical plate or the apical foramen to establish drainage of inflammatory exudate. This decompress approach helps alleviate periapical pressure and has been reported to provide immediate relief from pain and discomfort [1].

9) PHARMACOLOGICAL APPROACH TO PAIN MANAGEMENT

9.1) Analgesics

9.1.1) Types of analgesics

CATEGORY	EXAMPLE
NON-OPIOID ANALGESICS	Acetaminophen
NSAIDs (NON-STEROIDAL ANTI-INFLAMMATORY DRUGS)	ibuprofen, flurbiprofen, ketorolac tromethamine, etodolac, tenoxicam, and naproxen
OPIOID ANALGESICS	tramadol and codeine
STEROIDAL ANTI-INFLAMMATORY DRUGS	prednisolone
COMBINATION THERAPY	Combination of above-mentioned drugs

table reference [1]

Non-opioid agents, particularly NSAIDs and acetaminophen, are generally preferred as initial pharmacological options for dental pain because they provide effective analgesia with an established safety profile when appropriately prescribed [17].

9.1.2) Mechanism of action of NSAIDs

Ibuprofen reduces inflammatory pain through inhibition of cyclooxygenase-dependent prostaglandin synthesis. Patient-specific renal, cardiovascular and gastrointestinal risk should be considered when selecting an NSAID, while acetaminophen provides an alternative when NSAIDs are unsuitable, although excessive dosing carries a risk of hepatotoxicity [17].
These medications are considered suitable for pain management in patients without renal cardiovascular or gastrointestinal risk factors. Acetaminophen serves as an effective alternative for individuals who are unable to tolerate NSAIDs; however, excessive doses may increase the risk of hepatotoxicity [17]. 9.1.3) Opioid analgesics

Because of their adverse-effect and dependence potential, opioid analgesics such as codeine or hydrocodone should generally be reserved for severe dental pain that remains inadequately controlled with non-opioid therapy [17].

9.1.4) Pre-emptive Analgesia

Pre-emptive analgesia is intended to reduce nociceptive activity before procedural injury occurs and thereby limit subsequent pain. Pre-operative NSAID administration has been investigated for this purpose, with ibuprofen doses of approximately 400–600 mg commonly reported in the reviewed literature [4]. 9.2) Antibiotics

9.2.1) Indications

Antibiotic therapy has a defined but limited role in dental practice and may be indicated for selected odontogenic or non-odontogenic infections as well as particular prophylactic situations [18,19].

Importantly, systemic antimicrobial therapy should not replace definitive treatment directed at eliminating the odontogenic source of infection [19].

9.2.2) Prophylactic use

Prophylactic antibiotic therapy may be indicated for patients who are immunocompromised or have underlying systemic conditions, including a history of cancer, infective endocarditis, diabetes, a history of splenectomy, prosthetic joints, indwelling catheters, neurosurgical shunts, valvular heart disease, surgical pulmonary shunts, hypertrophic cardiomyopathy, mitral valve prolapse and prosthetic heart valves, as discussed in the review [19].

9.3) Local Anaesthesia

Local anaesthesia is fundamental to comfortable dental treatment and permits procedures ranging from endodontic therapy to surgical, periodontal and implant interventions to be performed with minimal procedural pain [17].

The majority of injectable local anaesthetics commonly used in dentistry belong to the amide group. In 2003, the American Dental Association introduced a standardised colour coding system for dental anaesthetic cartridges to minimise Brand related confusion based on the duration of pulpal anaesthesia, Local anaesthetics are broadly classified as short-acting (approximately 30 minutes) intermediate acting (around 60 minutes) and long-acting agents (lasting more than 90 minutes) [Reference: Cohen’s pathways of pulp].

Lidocaine remains an established reference local anaesthetic because of its rapid onset of action, intermediate duration and favourable safety profile. The high lipid solubility of articaine facilitates effective diffusion through both soft and hard tissues, making it particularly suitable for infiltration anaesthesia techniques, whereas the prolonged action of bupivacaine may be advantageous for lengthy procedures and extended postoperative analgesia, although its greater cardiotoxic potential requires appropriate caution [17].

10) NON-PHARMACOLOGICAL APPROACH TO REDUCE PAIN

Medical clowning is a non-pharmacological behavioural approach used in healthcare to create a more reassuring and positive treatment environment and to reduce anxiety and emotional distress. It is also described as hospital clowning, therapeutic clowning or clown-doctor care [20].

Its effects appear to arise through several interacting psychological and behavioural mechanisms rather than through a single process. Humour and laughter may promote endorphin release and reduce stress-hormone levels, while cognitive coping and pleasant imaginative experiences can help children manage the perceived threat associated with treatment. Allowing children to express their emotions freely within a supportive environment may further reduce distress, while diversion of attention away from painful or threatening procedural stimuli can lessen anxiety and pain perception. Together, these mechanisms may increase the pain threshold, encourage more positive behaviour and improve cooperation during dental treatment [20].

CONCLUSION: -

Endodontic pain is a multifactorial condition driven by inflammatory mediators, neural responses and structural changes within the pulp and surrounding tissues. A clear understanding of its pathophysiology and accurate diagnosis is fundamental to successful management.

The integration of stage-wise treatment strategies with proper pharmacological and non-pharmacological interventions is essential for effective pain control. Ultimately, a systematic and informed approach enables clinicians to improve patient comfort and achieve optimal endodontic outcomes.

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