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Current status and future directions in the management of endodontic emergencies in children: A narrative review

Dr. Anjali Bhutra[1], Dr. Dinesh Rao[2], Dr. Sunil Panwar[3]
[1] Department of Paediatric and Preventive Dentistry, Pacific Dental College and Hospital, Debari, Udaipur, Rajasthan, India
[2] Professor and Head, Department of Paediatric and Preventive Dentistry, Pacific Dental College and Hospital, Debari, Udaipur, Rajasthan, India
[3] Professor, Department of Paediatric and Preventive Dentistry, Pacific Dental College and Hospital, Debari, Udaipur, Rajasthan, India

Abstract
Endodontic emergencies in children are challenging clinical situations because pain, swelling, infection, fear and limited cooperation may occur simultaneously. Prompt relief of symptoms should not compromise the definitive treatment plan. The present narrative review summarizes the current concepts in the diagnosis and management of endodontic emergencies in children, with emphasis on accurate diagnosis, definitive dental treatment and rational pharmacological support. Endodontic emergencies may occur before, during or after endodontic treatment and may present as pulpal pain, symptomatic apical periodontitis, acute apical abscess, postoperative pain, traumatic injury or procedural complications. A systematic diagnostic approach involving history, clinical examination, pulp sensibility testing and appropriate radiographic assessment is essential. Treatment should be directed at removal of the underlying cause and preservation of the tooth whenever feasible. Conservative pulp therapy, pulpotomy, pulpectomy/root canal treatment, drainage, retreatment and extraction are selected according to the pulpal and periradicular diagnosis, restorability and developmental status of the tooth. Analgesics, particularly non-opioid agents, are adjuncts rather than substitutes for definitive dental treatment, and antibiotics should be reserved for infections with systemic involvement or spreading infection. Emerging approaches such as enhanced anesthesia, operating microscopes, CBCT, acupuncture, photobiomodulation, GABAergic modulation and in-silico drug discovery may expand future options for pain control. Evidence specific to children remains limited for several newer modalities; therefore, further high-quality pediatric research is required.

Keywords: Endodontic emergencies, children, dental pain, pulpitis, apical periodontitis analgesics, antibiotics, pain managem ent, future directions

Introduction

Endodontic emergencies are characterized by acute clinical problems involving the pulp, root canal system and/or periradicular tissues that require timely assessment and treatment. They may occur before treatment, during multi-visit therapy or after completion of treatment [1]. In children, these situations may be particularly demanding because acute pain and swelling can be accompanied by fear, anxiety, limited coping ability and difficulties in obtaining adequate cooperation [2].

The major causes include pulpal and periradicular disease, traumatic dental injuries and complications associated with endodontic procedures. The immediate goals are to relieve pain, control inflammation or infection and establish a definitive treatment pathway without unnecessary delay. [3]

Dental pain is a biological and psychological experience. Inflammatory mediators released within the pulp and periradicular tissues activate nociceptive pathways, while the child's emotional state may influence the perception and expression of pain. Consequently, effective emergency management requires not only disease control but also communication, reassurance, behaviour guidance and patient-centred care [4, 5].

The contemporary approach to endodontic emergencies can be summarized by the 'Three Ds': Diagnosis, Definitive dental treatment and Drugs, in that order. Following initial treatment, persistent or recurrent symptoms should prompt Review, Reassessment and Reconsideration of the diagnosis and treatment plan [1].

Definition and Classification

An endodontic emergency may be defined as pain associated with inflammation of the pulp and/or periradicular tissues, or pain with or without swelling resulting from infection of the root canal system and/or periradicular tissues [1, 3].

For practical clinical management, emergencies may be grouped according to their timing

- Emergencies before treatment, including symptomatic pulpitis, symptomatic apical periodontitis, acute apical abscess, cracked teeth and traumatic injuries;
- Emergencies during treatment, including persistent pain, flare-ups, inadequate anesthesia, instrument separation, hypochlorite accidents and procedural complications; and
- Emergencies after treatment, including post-obturation pain, high occlusion, root fracture and recurrent infection.

The classification should assist rather than replace diagnosis. Pulpal and periradicular diagnoses should be established from the patient's history and clinical findings, because management is determined by the underlying

biological condition rather than by the label of the emergency alone [3].

Diagnosis

Accurate diagnosis is the first and most important step. The clinician should obtain a detailed history of the chief complaint, including onset, duration, location, intensity and character of pain, as well as provoking and relieving factors. Previous dental treatment, trauma, medical history and the presence of swelling or systemic symptoms should also be recorded [1].

Clinical examination should include inspection for caries, defective restorations, fractures, swelling, sinus tracts and periodontal findings, together with percussion, palpation and mobility assessment. Pulp sensibility testing should be interpreted in conjunction with the clinical findings rather than in isolation. Radiographic assessment should be performed when indicated, with CBCT reserved for selected cases in which conventional imaging does not adequately define complex anatomy or pathology [6].

A clear distinction between inflammation and infection is essential. Reversible pulpitis may be managed conservatively by removal of the irritant and restoration, whereas symptomatic irreversible pulpitis generally requires removal of the inflamed pulp tissue. Necrotic pulp with apical disease requires treatment directed at microbial control and drainage when indicated [1].

Pain and anxiety should be assessed as part of the diagnostic process. Patient-reported outcomes are increasingly recognized as important measures of treatment success, emphasizing the need to consider the child's pain, function, fear and overall experience rather than relying solely on clinician-assessed findings [4].

General Principles of Management

The 'Three Ds' provide a practical framework for emergency management: Diagnosis, Definitive dental treatment and Drugs. Once the diagnosis has been established, definitive dental treatment should address the source of pain or infection. Depending on the condition and restorability of the tooth, options include conservative pulp therapy, pulpotomy, pulpectomy/root canal treatment, drainage, retreatment or extraction [1].

Emergency treatment should be definitive whenever possible. When complete treatment cannot be completed during the emergency visit, the clinician should perform an adequate interim procedure that controls symptoms and infection, protects the tooth and permits safe completion of treatment. Inadequate partial removal of inflamed or necrotic tissue may leave a continuing source of pain or infection.

For primary and immature permanent teeth, treatment selection must additionally consider the developmental stage of the tooth, the importance of maintaining the tooth in the arch, restorability and the potential effect of treatment on the developing successor. Contemporary pediatric pulp therapy principles therefore emphasize preservation of healthy pulp tissue whenever biologically appropriate and avoidance of unnecessary extraction [7].

Level OF Instrumentation and Pulpal Debridement

Pulpotomy and pulpectomy are the principal procedural interventions when emergency endodontic treatment is required. Pulpotomy may provide rapid relief in selected vital teeth by removing inflamed coronal pulp tissue, followed by appropriate sealing. Pulpectomy and complete root canal instrumentation are indicated when the entire pulp is diseased or necrotic and definitive endodontic treatment is appropriate.

The objective should be adequate chemomechanical debridement rather than incomplete or random instrumentation. When treatment must be staged, the tooth should be sealed appropriately between appointments. Working length may be established radiographically or with an electronic apex locator, with the latter reducing radiation exposure and assisting accurate working-length determination [1].

Specific Endodontic Emergencies

Symptomatic reversible pulpitis

Reversible pulpitis presents with provoked, short-lasting pain that subsides after removal of the stimulus. Management is directed at eliminating the etiological factor, protecting the pulp and restoring the tooth. Conservative treatment may include caries removal, appropriate pulp protection and definitive restoration [1].

Symptomatic irreversible pulpitis

Symptomatic irreversible pulpitis is associated with spontaneous or lingering pain and represents pulpal inflammation that is unlikely to resolve after removal of the irritant alone. Definitive treatment generally requires removal of the inflamed pulp by pulpotomy or pulpectomy/root canal treatment, depending on the tooth and clinical circumstances. Effective pain control also requires profound local anesthesia and appropriate analgesic support [8].

Symptomatic apical periodontitis and acute apical abscess

Symptomatic apical periodontitis is characterized by pain on biting, percussion or palpation and may occur with or without radiographic changes. Acute apical abscess is characterized by rapid onset of pain, tenderness and swelling, with possible systemic manifestations. Management should focus on eliminating the source of infection, establishing drainage when indicated and providing definitive endodontic treatment or extraction according to restorability and prognosis [9].

Antibiotics are not a substitute for drainage or definitive dental treatment. In children, current pediatric guidance emphasizes antibiotic stewardship and recommends systemic antibiotics primarily when infection is spreading or accompanied by systemic involvement such as fever, malaise or significant facial swelling [3].

Cracked teeth and traumatic/procedural emergencies

Cracked teeth may present with pain on chewing, thermal sensitivity and poorly localized or referred pain. Management depends on the extent and direction of the crack. Restorable cracks may be stabilized and restored, while fractures extending beyond the restorable portion of the tooth may necessitate extraction.

Procedural emergencies include inadequate anesthesia, instrument separation, irrigant accidents, perforation and postoperative flare-ups. Prompt recognition, isolation of the affected area, control of symptoms and appropriate repair or referral are essential. A tooth should not be intentionally left

open merely to obtain drainage because this may permit further bacterial contamination and extrusion of debris [1].

Post-Obturation and Postoperative Pain

Postoperative pain may occur after endodontic treatment and is influenced by preoperative pain, periapical inflammation, instrumentation, extrusion of debris, obturation-related factors and premature occlusal contacts. Overfilling, underfilling, missed canals, poor coronal sealing and high restoration can contribute to persistent symptoms.

Occlusal reduction has been investigated as a method of reducing postoperative pain. Rosenberg *et al.* demonstrated reduced postoperative pain following occlusal reduction in selected patients, while Parirokh *et al.* found no significant benefit in teeth with only mild percussion tenderness. [10,11]

In a randomized controlled trial, Ahmed *et al.* reported that occlusal reduction in mandibular posterior teeth with symptomatic irreversible pulpitis and percussion sensitivity reduced the risk of moderate-to-severe pain by approximately 40% at 12 hours and overall pain by approximately 25% at 24 hours [12].

Pharmacological Management

Pharmacological treatment represents the third 'D' and should be used as an adjunct to definitive dental treatment rather than as a replacement for it. For pediatric dental pain, current guidance identifies non-opioid analgesics, particularly NSAIDs and acetaminophen, as first-line pharmacological options when appropriate for the individual child [2].

Ibuprofen is an effective anti-inflammatory analgesic, while acetaminophen is a useful alternative when NSAIDs are contraindicated or not tolerated. The combination of ibuprofen and acetaminophen may provide enhanced analgesia in appropriately selected patients. A systematic review and network meta-analysis found that NSAIDs alone or combined with acetaminophen were among the most effective options for postoperative endodontic pain [13].

Opioid analgesics should rarely be required in children and, when considered, should be reserved for carefully selected situations with appropriate dosing, monitoring and risk assessment. Antibiotics should be prescribed judiciously and only when clinically indicated, particularly in the presence of systemic involvement or spreading odontogenic infection [2, 3].

Other and Emerging Approaches

Supplemental anesthesia and anxiety control

Achieving profound anesthesia is a major challenge in symptomatic irreversible pulpitis. In addition to conventional local anesthesia, supplemental techniques may be required. Behaviour guidance, reassurance, distraction and a calm environment are particularly important in pediatric patients and should be integrated with pharmacological pain control [8].

Operating microscope and CBCT

Magnification can improve visualization of canal anatomy and assist the detection of additional canals and procedural complications. Stropko demonstrated increased detection of MB2 canals with increasing operator experience, use of the operating microscope and microendodontic techniques [14].

Monea *et al*. reported improved treatment outcomes when an operating microscope was used during endodontic treatment performed by postgraduate students. CBCT can provide three-dimensional information when conventional radiographs are insufficient, although its use should remain justified by the clinical question and radiation exposure considerations [15].

Occlusal reduction

Occlusal reduction may be considered selectively in teeth with symptomatic apical periodontitis and percussion sensitivity. Evidence is not uniform across all clinical presentations, so the decision should be based on the diagnosis and occlusal findings rather than applied routinely [11, 12].

Acupuncture

Acupuncture has been investigated as a non-pharmacological adjunct for endodontic pain. A randomized placebo-controlled clinical trial reported lower postoperative pain following preoperative acupuncture in teeth with symptomatic apical periodontitis. Other trials have compared acupuncture with ibuprofen in symptomatic irreversible pulpitis. However, evidence remains limited and heterogeneous, and larger pediatric trials are needed before routine incorporation into children's endodontic emergency care [16, 17].

Low-level laser therapy and photobiomodulation

Low-level laser therapy has been investigated for postoperative endodontic pain modulation. Earlier systematic reviews suggested potential benefit but emphasized low certainty and substantial variation in laser parameters. More recent evidence continues to support a possible analgesic effect while highlighting the need for standardized protocols and higher-quality trials [18, 19].

Future Directions

GABAergic modulation

GABA is an inhibitory neurotransmitter found at increased levels in inflamed dental pulp. Functional GABA-B receptors have been demonstrated in dental pulp, suggesting a possible role in the modulation of endodontic pain. The therapeutic potential of GABAergic agents remains experimental and requires clinical validation, particularly in children [5].

In-silico modulation of IL-8

Inflammatory mediators such as interleukin-8 represent potential molecular targets for future pain therapies. In-silico screening has identified ZINC14613097 as a potential IL-8 inhibitor with a possible role in the therapeutic management of endodontic pulpitis. These findings are preliminary and require *in-vitro*, *in-vivo* and clinical validation before clinical use can be considered [20].

Future pediatric research priorities

Future research should focus on pediatric-specific evidence rather than extrapolating adult data whenever possible. Priorities include standardized pain and anxiety outcomes, age-appropriate analgesic protocols, improved supplemental anesthesia strategies, minimally invasive diagnostic imaging, evidence-based antibiotic stewardship, and evaluation of non-pharmacological interventions. The safety

and effectiveness of emerging modalities should be established through well-designed pediatric clinical trials before routine adoption.

Discussion

The central principle emerging from the available evidence is that successful emergency management depends on identifying and treating the underlying cause rather than simply suppressing pain. The 3D approach provides a clinically useful framework because it places diagnosis and definitive dental treatment before medication. [1]

For children, this principle must be combined with age-appropriate behaviour guidance, careful local anesthesia, attention to anxiety and consideration of the developmental status of the dentition. Current pediatric guidance emphasizes multimodal pain control and cautious medication use, with NSAIDs and acetaminophen as first-line pharmacological options and opioids used rarely. [2]

The literature also demonstrates that several techniques traditionally considered adjunctive—such as occlusal reduction, magnification, CBCT, acupuncture and photobiomodulation—may have a role in selected cases, but the strength of evidence varies considerably [10, 12].

An important limitation of the current evidence base is that much of the endodontic emergency literature is derived from adult populations. Therefore, recommendations for children should be individualized and should account for differences in dentition, anatomy, pharmacokinetics, behaviour and treatment objectives. This evidence gap also represents one of the most important future research priorities.

Conclusion

Endodontic emergencies in children require rapid but systematic assessment and treatment. Pain, swelling and infection should be approached through accurate diagnosis followed by definitive dental treatment and rational pharmacological support.

The 3D sequence—Diagnosis, Definitive dental treatment and Drugs—remains the central framework, while the 3R sequence—Review, Reassess and Reconsider—guides management when symptoms persist or recur.

For pediatric patients, preservation of the tooth and healthy pulp tissue whenever feasible, appropriate behaviour and anxiety management, safe analgesic prescribing and antibiotic stewardship are essential. Emerging modalities such as GABAergic therapy, acupuncture, in-silico molecular modulation and photobiomodulation are promising but require stronger pediatric clinical evidence before routine use.

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