

# Advances in Pain and Anxiety Management During Endodontic Therapy in Children

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## ABSTRACT

Pain and anxiety control are essential components of delivering effective endodontic therapy in pediatric patients. Children present unique physiological, developmental, cognitive and psychological characteristics that influence their experience of pain, fear, and cooperation. Endodontic therapy in children (including pulpectomies, pulpotomies, immature permanent teeth treatments, and conventional root canal therapy in cooperative older children) is frequently associated with higher anxiety and greater pain perception compared to less invasive dental procedures. Over the past decade, significant advances have emerged in the fields of behavioural guidance, local anaesthetic pharmacology and delivery systems, sedation and analgesic protocols, and adjunctive non-pharmacologic distraction and coping methods. This narrative review synthesizes current evidence on these advances, highlights their applicability to pediatric endodontic procedures, and identifies gaps and future research directions. It emphasizes a multimodal, developmentally appropriate approach integrating behavioural management, optimised anaesthesia, effective analgesic regimens, and tailored sedation/distraction strategies to improve outcomes in children undergoing endodontic therapy.

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## INTRODUCTION

Pediatric endodontic therapy presents distinct challenges compared to adult endodontics. Children not only suffer from pulpal disease and necrosis but often present with greater anxiety, lower pain-coping thresholds, and variable cognitive understanding of dental procedures. According to the American Association of Endodontists, when treating children, the focus should include supporting the child and fostering an environment centred on learning that minimises anxiety [1].

Pain in children undergoing endodontic therapy can result from multiple sources: the initial injection of local anaesthesia, mechanical instrumentation, irrigation with potentially irritating solutions, or the inherent inflammation of pulpal and periapical tissues. Anxiety often arises from fear of the syringe, the drill, previous negative experiences, or anticipatory fear of pain. If not managed, pain and anxiety can lead to poor cooperation, prolongation of treatment, increased physiological stress responses (heart rate, blood pressure, cortisol), and a negative lifelong attitude toward dental care [2,3].

Therefore, effective management of both pain and anxiety is critical not only for immediate treatment success but also for long-term behavioural outcomes in paediatric dentistry. Endodontic therapy being more invasive than many routine restorative procedures further amplifies the importance of optimised intervention.

In this review, we focus on the key domains of advancement: behavioural techniques, local anaesthetic pharmacology and delivery systems, sedation (inhalational/oral), analgesic protocols (pre-emptive/postoperative), distraction and coping technologies, outcome measurement and special clinical scenarios relevant to paediatric endodontics. Although much of the literature does not focus exclusively on endodontic therapy, the principles are highly relevant and transferrable to this setting [2-6].

### **Behavioural and Communication Techniques**

#### **Principles and taxonomy**

Behavioural guidance remains the cornerstone of paediatric dental care. Techniques such as Tell-Show-Do (TSD), modelling, positive reinforcement, voice control, parental presence/absence decisions, desensitisation and distraction

have long been used [3]. The essence is to adapt communication and procedures to the developmental level of the child (preschooler, school-age, adolescent). For example, professional guidance emphasises the importance of describing the procedure, showing the instruments in a non-threatening way, then proceeding once the child is comfortable [1].

More advanced behavioural frameworks include cognitive behavioural strategies (especially in older children), the CARD™ system (Comfort, Ask, Relax, Distract), and structured coping modules. While such frameworks originate in broader paediatric healthcare, they are increasingly incorporated into dental practice [2,3].

#### **Evidence for effectiveness in endodontic-relevant contexts**

Although the majority of behavioural research in paediatric dentistry focuses on restorative or surgical procedures, the findings are applicable to endodontic therapy. For children undergoing more invasive procedures (e.g., pulpectomy, root canal), higher anxiety is documented; thus behaviour management becomes even more critical [2]. A recent narrative review emphasises that parental anxiety, previous traumatic experiences and neurodiverse conditions are key psychosocial determinants of dental anxiety in children [3].

Distraction techniques such as audiovisual media, virtual reality (VR), music therapy, and interactive play have been studied. A systematic review demonstrated that distraction strategies (audiovisuals, VR, music) significantly reduce anxiety levels in children undergoing dental treatment [4].

Furthermore, surveys of paediatric dentists indicate widespread use of non-pharmacologic behaviour management techniques (Tell-Show-Do, positive reinforcement, distraction) in children with dental fear/anxiety, supporting the practical relevance of these approaches [6].

In the context of endodontics, where instrumentation may last longer and involve more manipulations (including needle injections, file use, irrigation), behavioural techniques must be reinforced throughout the procedure—explaining the stages, giving brief breaks, praising cooperation, allowing child control of micro-choices (e.g., music, colour of rubber dam clamp) and using distraction concurrently with instrumentation [2–6].

#### **Local Anaesthetic Agents and Techniques**

##### **Choice of agent: lidocaine vs articaine and others**

Traditionally, 2% lidocaine with epinephrine has been the standard in paediatric dental local anaesthesia. However, multiple randomized trials and meta-analyses conducted over the last decade suggest that 4% articaine with epinephrine may provide better infiltration and potentially improved pulpal anaesthesia in certain paediatric scenarios, including mandibular primary molars and immature permanent teeth [5]. Although the literature in children specifically undergoing endodontic therapy is sparse, paediatric dentists must be aware of the evolving evidence [2,5].

In inflamed pulpal tissues (common in endodontic cases), the success rate of local anaesthesia declines due to lowered tissue pH, increased blood flow, and sensitised nociceptors. Some clinical reports advocate using articaine infiltration supplemental techniques rather than relying solely on inferior alveolar nerve block (IANB) [2,5].

##### **Techniques to improve anaesthetic success in endodontic procedures**

When treating children with pulpal inflammation (irreversible pulpitis) or necrosis, achieving profound anaesthesia is essential before commencing instrumentation. Strategies include:

- **Supplemental injections:** Intraosseous (IO) injections, PDL/intraligamentary injections and supplemental buccal or lingual infiltrations have shown to increase success in “hot tooth” scenarios [2,5].
- **Buffering local anaesthetic:** Alkalinization (adding sodium bicarbonate to lidocaine) has been shown to reduce pain on injection and improve onset time; in children buffered solutions are associated with lower injection pain [2].
- **Computer-controlled local anaesthetic delivery (CCLAD):** These systems (for example, The Wand®, CompuDent) allow constant flow rate and pressure, reducing tissue distension and associated pain. Meta-analyses report that pain and anxiety levels were significantly lower in children when CCLAD was used compared to conventional syringe [5].

In the specific setting of pediatric endodontics—where the clinician may need to administer repeated injections, invest extra time for instrumentation, and manage anxious children—these techniques can improve patient comfort and cooperation, reduce physiological stress and potentially reduce the need for escalation to sedation [2,5,6].

#### **Adjunctive and Rapid-Onset Techniques**

##### **Topical anaesthetics and cryoanaesthesia**

Topical anaesthetics (e.g., benzocaine gel, lidocaine preparations) remain important adjuncts, especially before palatal, lingual or other painful injections. Cryoanaesthesia (application of ice or cold spray immediately prior to injection) reduces injection pain by numbing the superficial mucosa and activating large-diameter A-fibres (gate control theory)

[1,2]. The professional guidance emphasises the importance of reducing injection pain via distraction, buffering and slow injection [1].

### Novel delivery and rapid-onset strategies

In paediatric endodontics, time is of the essence (especially with uncooperative young children or those with limited attention span). Therefore, techniques that shorten onset time or increase the predictability of anaesthesia are beneficial. These include:

- Using 4% articaine infiltration in certain mandibular cases rather than waiting for IANB onset [5].
  - Using buffering to accelerate onset [2].
  - Slow-rate injection (over 60–120 seconds) to reduce discomfort and psychological shock [1,2].
  - Combining behavioural distraction with anaesthesia delivery (for example, VR or tablet distraction while accessing injection) [4].
- All of these contribute to smoother transitions to instrumentation, reduced need for supplemental injections, and fewer interruptions of treatment due to pain or anxiety [1–6].

### Sedation for Endodontic Procedures in Children

#### Nitrous oxide–oxygen inhalation sedation (N<sub>2</sub>O/O<sub>2</sub>)

Nitrous oxide remains the most widely used minimal-moderate sedation technique in paediatric dentistry. It provides anxiolysis, analgesia and rapid recovery. Professional guidelines (AAPD and others) recommend its use in children who cannot be managed with behavioural techniques and local anaesthesia alone or where prolonged procedures and anxiety warrant sedation [1]. The key advantages are rapid onset and easy titration; key limitations are the need for patient cooperation (breathing through the nose), equipment, and monitoring [1].

In the context of paediatric endodontics, particularly when the procedure is expected to last longer (e.g., multi-canal instrumentation, irrigation, obturation), N<sub>2</sub>O can improve cooperation, reduce movement, help maintain comfortable posture and reduce overall physiological stress [1,6].

#### Oral (enteral) sedation and other techniques

- **Oral midazolam** or buccal midazolam is frequently used for moderate sedation in paediatric dentistry; systematic reviews have examined its use in dental settings and found it generally safe and effective for anxiolysis and procedural sedation [2,3].
- **Combination sedation:** For uncooperative children, combinations (e.g., ketamine + midazolam) are described in the literature and used selectively in specialised settings [3].
- **Deep sedation / general anaesthesia:** For children with special healthcare needs, extreme anxiety, or when endodontic treatment cannot be completed safely in the office setting, referral to hospital-based general anaesthesia (GA) may be necessary. Such approaches require multidisciplinary care, higher cost, and greater risk; thus optimization of less invasive methods is preferable [1,2].

#### Safety and patient selection

Appropriate patient selection is crucial. Pre-sedation evaluation (medical history, ASA classification, airway assessment, fasting status) is mandatory. Monitoring every sedation case (pulse oximetry, capnography where indicated), having trained staff, emergency equipment and protocols is a professional and ethical obligation [1,2]. In addition, informed consent must cover sedation risks and alternatives, procedure duration, and expected cooperation levels.

For endodontic therapy in children, sedation should be considered when behavioural management plus local anaesthesia are insufficient—especially when pain control is uncertain (e.g., inflamed pulp, immature apex) and when instrumentation time will be extended. Sedation also allows the dentist to perform procedures more efficiently and safely, reducing treatment sessions and thus minimizing repeated anxiety exposures [1–3].

#### Non-Pharmacologic Distraction and Coping Technologies

##### Audiovisual distraction and Virtual Reality (VR)

Distraction techniques aim to divert the patient's attention away from the procedure, thereby reducing perceived pain and anxiety. Audiovisual media (TV cartoons, tablets, interactive games), music therapy and VR headsets have been evaluated in paediatric dental settings. Systematic reviews find distraction strategies (including VR) to be safe and effective in reducing anxiety in children during dental procedures [4].

Recent trials extend the concept further; for example, novel sensory distraction devices combined with calming audio have shown reductions in injection anxiety in paediatric populations [4]. For pediatric endodontics, adopting distraction or immersive VR during long instrumentation or irrigation phases may help maintain calm, reduce movements, and

allow smoother procedure flow. It is particularly useful when children are somewhat anxious but cooperative enough to wear a VR headset or view content [4,6].

### Cognitive coping and structured behavioural programmes

Beyond simple distraction, structured coping programmes (relaxation, guided imagery, breathing exercises) adapted to children’s developmental level can reduce anticipatory anxiety before dental visits. Narrative reviews emphasise that non-pharmacologic strategies, when implemented systematically, can significantly reduce dental fear and improve long-term outcomes [3].

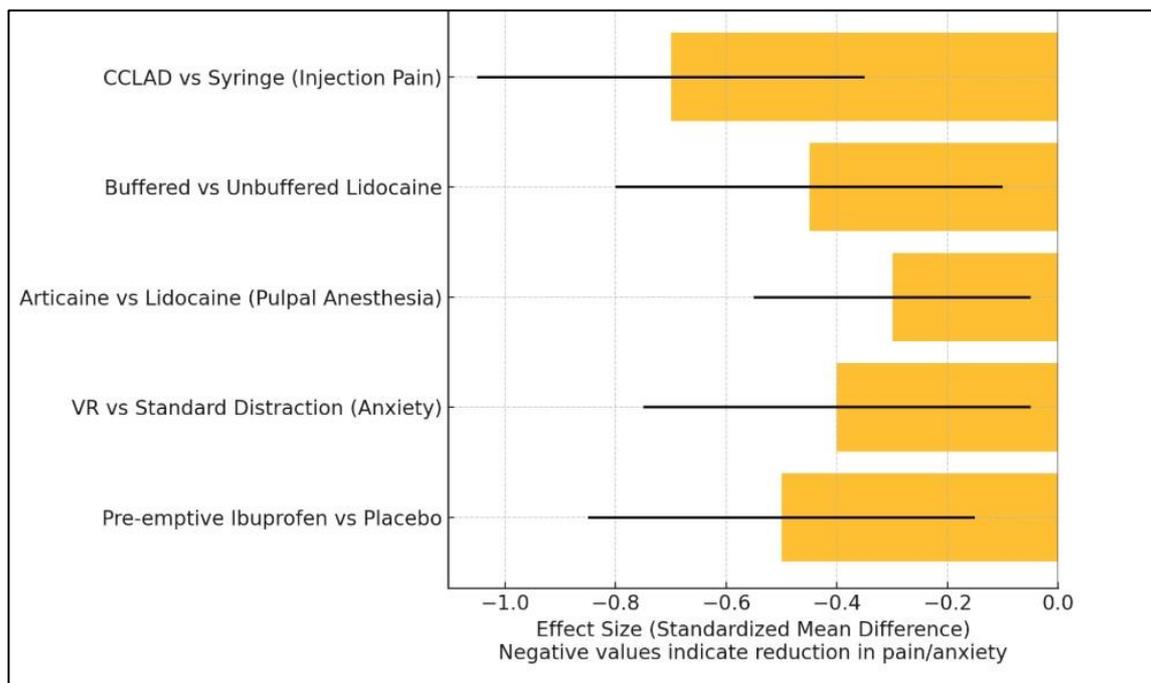
For children undergoing endodontic therapy, pre-visit preparation (e.g., showing cartoons or video of the treatment, virtual clinic visit, desensitisation appointment) may reduce anxiety, minimise start-of-treatment delay, and facilitate more comfortable anaesthesia and instrumentation [2–4].

### Pain Assessment and Outcome Measurement

Accurate assessment of pain and anxiety in children is essential for evaluating interventions and guiding clinical care. Age-appropriate validated scales should be used:

- **FLACC (Face, Legs, Activity, Cry, Consolability)** scale: useful for younger/preverbal children.
- **Wong-Baker Faces (WBS) Pain Rating Scale:** for children able to point to faces representing pain levels.
- **Children’s Fear Scale (CFS)** and **Modified Dental Anxiety Scale (MCDAS):** for self-reported anxiety in children.
- Objective physiological measures (heart rate, pulse oximetry, salivary cortisol) are increasingly used to corroborate self-report data [2,5]. The professional guidance highlights the value of using developmentally appropriate scales and pausing the procedure if pain/anxiety escalate [1].

In research on anaesthetic delivery (e.g., CCLAD meta-analysis), pain and anxiety scores measured by facial image scales, heart rate, behavioural ratings were used [5]. For paediatric endodontic therapy, clinicians should assess baseline anxiety and pain risk (e.g., previous traumatic dental experience, age, temperament), monitor pain-related behaviour during injections/instrumentation and obtain post-operative pain reports (for example, at 6 h, 24 h) to guide analgesic prescribing and follow-up care (Figure 1) [1–6].



**Figure 1: A comparative evidence summary of effect sizes for representative interventions (e.g., CCLAD, buffered anaesthetic, articaine, VR distraction, pre-emptive ibuprofen) showing their relative efficacy in reducing pain and anxiety.**

### Pharmacologic Analgesia: Pre-emptive and Postoperative Pre-emptive analgesia

Administering analgesics prior to the onset of nociceptive stimulation (pre-emptive) has been shown to improve postoperative pain control in children undergoing dental procedures. Although direct RCTs on paediatric endodontics

are limited, principles from extractions and pulpotomy/pulpectomy literature apply: giving acetaminophen (paracetamol) or ibuprofen before beginning instrumentation may reduce the intensity and duration of postoperative pain, decrease analgesic consumption and improve comfort [1,2].

From guiding documents, non-opioid analgesics remain first-line in paediatrics; opioids are seldom indicated for routine dental pain. Professional guidance recommends non-opioid, age-appropriate dosing, parent education on dosing and safe storage [1].

#### **Choice of agent for postoperative dental pain**

Systematic reviews in children show that both acetaminophen and ibuprofen are effective for moderate dental pain; ibuprofen may provide modestly better analgesia in some inflammatory conditions [2].

In paediatric endodontics, postoperative pain may derive from instrumentation, irrigation, extrusion of debris, periapical inflammation and occlusion changes. Therefore, an analgesic protocol might include:

- Weight-based NSAID (e.g., ibuprofen) given at the end of the appointment and repeated as needed (every 6–8 h) for 24–48 h.
- If NSAID contraindicated, acetaminophen may be used.
- If moderate-to-severe pain is anticipated (e.g., large periapical lesion, symptomatic necrosis), consider scheduled analgesic rather than “as needed,” and educate parents for anticipatory guidance [1,2].

Combination or alternating ibuprofen-acetaminophen regimens have been explored and may have applicability to dental pain, but paediatric dental RCTs are few; careful dosing and parental education are essential [1,2]. Emerging fixed-dose combinations and extended-release formulations are under investigation but are not yet standard in paediatric dental practice [2,4].

#### **Special Clinical Scenarios in Paediatric Endodontics**

##### **Inflamed pulp/endodontic “hot tooth”**

One of the most challenging situations is treating a child with irreversible pulpitis or necrotic pulp and periapical involvement: achieving profound anaesthesia may be difficult due to lowered pH, high blood flow, increased nociceptor sensitisation. The clinician must plan for advanced analgesia and behaviour management. Recommended steps:

- Use pre-operative analgesia (NSAID) if no contraindication.
- Consider articaine infiltration in addition to standard IANB or infiltration (if age and indication permit).
- Use buffered lidocaine for injection.
- Use CCLAD for injection if available.
- Consider sedation (N<sub>2</sub>O or oral) if anxiety or complexity high.
- Plan for the possibility of needing supplemental injections (IO, PDL).
- Behaviourally prepare child/parent for the possibility of additional injection(s) and reassure [1–5].

These methods correlate with recent reviews of new approaches in paediatric pain management [2].

##### **Very young children, special-needs patients or uncooperative children**

For very young children (preschool age) or those with developmental/behavioural disabilities who require endodontic therapy, behavioural approaches alone may be insufficient. Minimally invasive alternatives (e.g., pulpotomy, interim treatments) and sedation or GA referral may be necessary. Surveys show many paediatric dentists use GA when non-pharmacologic/anaesthesia techniques are insufficient [6].

In endodontic therapy, where instrumentation may be lengthy, and patient movement is problematic, sedation (N<sub>2</sub>O or oral) helps achieve safety, efficiency and reduced psychological trauma. Careful planning with an experienced paediatric dental anaesthesia team is critical [1–3,6].

##### **Safety, Guidelines and Ethical Considerations**

Professional guidelines (e.g., AAPD, AAE) emphasise a safety-first approach: ensuring sedation protocols are in accordance with training, monitoring guidelines, emergency preparedness, parental informed consent and tailoring approaches to the child’s health status and anxiety/behavioural profile [1].

From an ethical standpoint, children undergoing endodontic therapy deserve the same standard of pain control and anxiety management as adults. There is also an imperative to avoid creating or reinforcing negative dental experiences which may lead to long-term dental avoidance. Pre-treatment counselling, realistic expectation-setting and involving parents are essential [2,3].

Behaviour management, anaesthesia and analgesia must be documented systematically—including baseline anxiety/pain assessment, intra-operative monitoring of impacts, analgesic prescriptions, and follow-up pain outcomes. This improves care quality and supports future research [1–6].

### Emerging Technologies and Future Directions

Advances are emerging in several domains:

- **Wearable/biometric monitoring:** real-time monitoring of physiological stress (heart rate variability, galvanic skin response) during injections or instrumentation could allow adaptive distraction or sedation [2].
- **Refined CCLAD devices:** more affordable, ergonomic units specifically designed for paediatric patients may allow wider uptake [5].
- **Personalised analgesic regimens:** as pharmacogenomics evolve, individual risk stratification for pain/anxiety responses may allow tailored pre-emptive analgesia and behavioural interventions [2].
- **Large multicentre RCTs specific to paediatric endodontics:** many current studies are in general pediatric dentistry or restorative settings—not specific to endodontic therapy. More evidence is needed for children undergoing pulpectomy/pulpotomy or full root canal treatment [2,4].
- **Telehealth/behavioural preparation modules:** gamified apps or virtual clinic visits to prepare children psychologically before their appointment, thereby reducing baseline anxiety and improving cooperation [3].
- **Integration of VR and augmented reality (AR) for distraction and pre-visit desensitisation:** early studies show promise but cost, hygiene, fit for younger children and standardisation remain challenges [4].

Recent narrative and review papers highlight that while techniques are improving, translation into routine paediatric dental practice remains variable [2,4,6].

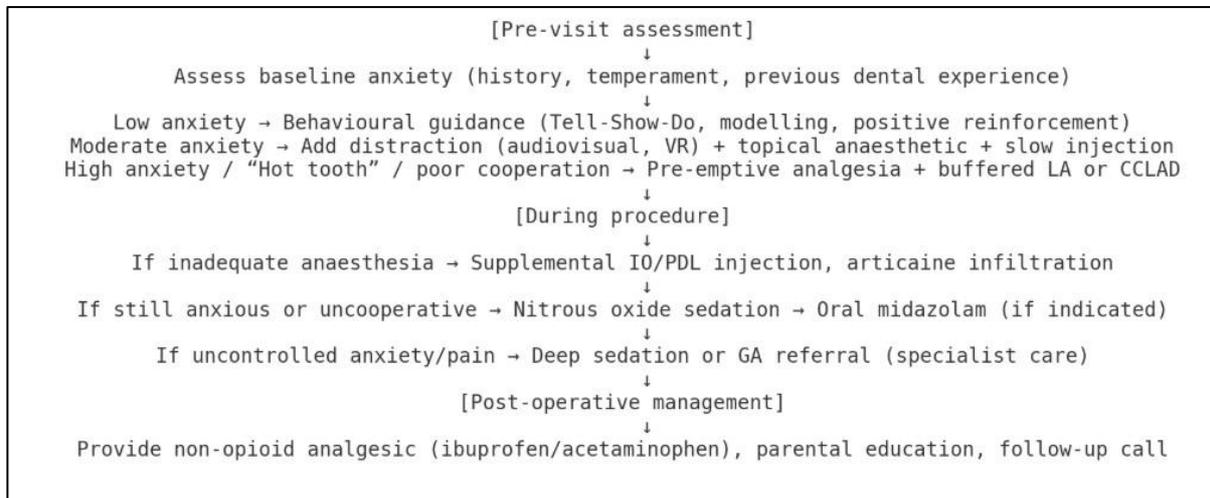
### Practical Clinical Recommendations (Evidence-informed)

Based on the review of evidence and applicable to paediatric endodontic therapy, the following recommendations are suggested (Figure 1):

1. **Pre-visit preparation**
  - At scheduling, provide age-appropriate explanation of the procedure using TSD.
  - Offer children a choice (e.g., rubber dam colour, music or video) to enhance sense of control and reduce anxiety [1–3].
  - Assess baseline anxiety (e.g., ask about prior dental experiences, needle fears) and select behavioural strategies accordingly.
2. **Behavioural guidance during treatment**
  - Use TSD, modelling, positive reinforcement, voice control as needed.
  - Employ distraction (audiovisual/VR) during injection and instrumentation, particularly for longer sessions [4].
  - Use micro-breaks and offer real-time feedback to maintain cooperation.
3. **Optimised local anaesthesia**
  - Use topical gel before injection.
  - If available, buffer the lidocaine to reduce injection pain and speed onset.
  - Use slow injection (over 60–120 s) to reduce discomfort and anxiety [1,2].
  - If available, consider CCLAD for children, especially for anxiety-provoking injections [5].
  - Choose appropriate anesthetic agent: consider articaine 4% with epinephrine for infiltration in selected cases where safe and permitted; otherwise use lidocaine [5].
  - For “hot tooth” cases, anticipate need for supplemental injections (IO, PDL) and plan accordingly [2,5].
4. **Sedation awareness and selection**
  - For children whose anxiety or treatment complexity exceed what can be managed by behaviour and anaesthesia alone, plan for sedation (N<sub>2</sub>O/O<sub>2</sub>) or oral sedation with midazolam with appropriate monitoring and staff training [1–3].
  - Use sedation to facilitate cooperation and reduce physiological stress during instrumentation rather than as a substitute for good behaviour management and anaesthesia.
5. **Analgesic protocol**
  - Prescribe weight-based non-opioid analgesics: e.g., ibuprofen or acetaminophen at the end of treatment, with instructions to continue for 24–48 h as necessary [1,2].
  - Consider pre-emptive analgesia in children with anticipated greater post-operative pain.
  - Educate parents/caregivers regarding dosing schedule, side effects, safe storage, and when to seek dental help [1].
6. **Post-operative management and follow-up**
  - At discharge, set expectations and provide written instructions for analgesic dosing and contact information for pain escalation.
  - Conduct follow-up (phone or clinic) within 24–48 h to assess pain and recall of the experience [1–3].

### 7. Special considerations in paediatric endodontics

- For very young children or special-needs patients where prolonged instrumentation is not feasible, consider minimally invasive alternatives and schedule definitive treatment when appropriate [6].
- For children with previous traumatic dental experiences or high baseline anxiety, allocate additional time for preparation and consider proactive sedation planning [2,3].



**Figure 2: A stepwise clinical algorithm illustrating multimodal pain and anxiety management during pediatric endodontic therapy — showing behavioural, pharmacologic, and escalation steps.**

### Limitations of Current Evidence

Although the field has advanced, several limitations remain:

- Many studies in paediatric dentistry address restorative or extraction procedures rather than specifically paediatric endodontic therapy (pulpotomies, pulpectomies, root canals), limiting direct evidence for endodontic contexts [2,4].
- Sample sizes in paediatric sedation and analgesia studies are often small, with heterogeneity in outcome measures (different pain scales, anxiety scales) and variable reporting of adverse events [2].
- Intervention studies (e.g., distraction or CCLAD) often exclude younger children (<4 yrs) or include only cooperative children, thereby limiting generalisability [5,6].
- Long-term follow-up regarding the impact of improved pain/anxiety management on dental fear and avoidance into adolescence/adulthood is scarce [3].
- Comparative effectiveness trials of newer analgesic combinations in paediatric dental settings remain rare.
- Cost-effectiveness studies and real-world practice uptake (e.g., VR systems, CCLAD in general paediatric dental practice) are limited.

Therefore, while many promising interventions exist, translation into routine paediatric endodontic practice requires more scalable evidence, training, equipment accessibility and cost considerations [1–6].

### CONCLUSION

Paediatric endodontic therapy represents a situation where pain control and anxiety management are especially important. A multimodal approach combining developmentally-appropriate behavioural guidance, optimised local anaesthetic techniques (including buffering and advanced delivery systems), evidence-based analgesic protocols, and judicious use of sedation/distraction can substantially improve the experience and outcomes for children. Advances in non-pharmacologic distraction technologies (e.g., VR), improved analgesic regimens, and personalised behaviour preparation hold promise for the future. However, more high-quality, endodontic-specific paediatric studies are needed to refine protocols and translate innovations into everyday practice. Clinicians should strive to integrate these strategies into their workflow, always mindful of the child's comfort, cooperation, safety and long-term attitude toward dental care.

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