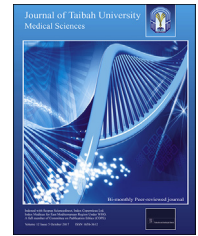




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Review Article

Predictors, prevention, and management of postoperative pain associated with nonsurgical root canal treatment: A systematic review



Mothanna K. AlRahabi, PhD

Department of Restorative Dental Science, College of Dentistry, Taibah University, Almadinah Almunawwarah, KSA

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المخلص

من الممكن إنقاص آلام ما بعد الجراحة لمعالجة القناة الجذرية من خلال تطبيق التطورات الحديثة في التقنيات والمعدات لعلاج الجذور. إن هذه المقالة المرجعية تقدم المعرفة الحالية حول الألم لمعالجة القناة الجذرية غير الجراحية بما في ذلك توقع حدوث، والعوامل المرتبطة، وتأثيرات التطورات الحديثة، والعلاج. روجعت الأدبيات الطبية بين عامي 1990م-2016م باستخدام قواعد البحث PubMed, Cochrane, ScienceDirect. اشتملت الكلمات المفتاحية للبحث ألم ما بعد الجراحة، والعلاج غير الجراحي، وزيارة واحدة، والتطورات الحديثة في علاج الجذور، وعلاج ألم ما بعد جراحة الجذور. كما اشتملت المراجعة على الأبحاث الأصيلة فقط بينما تم استبعاد المقالات الافتتاحية، والمراجعات، والملاحظات المختصرة، ومحاضر المؤتمرات، والرسائل إلى المحرر. وأسفر البحث الأولي عن 4941 مقالة، تم تقييمها وتصنيفها وفقاً لمعايير الاختيار. وتوافقت 65 مقالة مع معايير الاختيار، وتم تضمينها في هذه المقالة المرجعية. أظهرت النتائج حدوث ألم ما بعد معالجة القناة الجذرية غير الجراحية لدى 3-69.3% من المرضى. وتم تحديد الكائنات الحية الدقيقة كمسببات أساسية للألم ما بعد العلاج، ولم يكن هناك فرق في ألم ما بعد الجراحة بين زيارة واحدة وعدة زيارات علاجية. تراوح ألم ما بعد الجراحة لعلاج القناة الجذرية من خفيف إلى معتدل، وحدث حتى عند تنفيذ الإجراءات على النحو الأمثل. وبالإضافة إلى ذلك، يعتبر علاج ألم ما بعد الجراحة غالباً مؤشراً على التميز السريري. قلل تطبيق التقنيات والأجهزة الحديثة في علاج الجذور من ألم ما بعد الجراحة. بالإضافة إلى ذلك، يمكن أن يستعمل وصف الأدوية بشكل مرن بحسب حدة الألم للسيطرة على ألم ما بعد علاج القناة الجذرية. إن تطبيق نتائج هذا البحث سوف يقلل من ألم ما بعد علاج القناة الجذرية ويحسن نتائج المرضى.

الكلمات المفتاحية: المسكنات؛ المعالجة اللبية؛ غير جراحي؛ ألم ما بعد الجراحة؛ القناة الجذرية

Abstract

Postoperative pain after root canal treatment can be reduced by applying recent advances in endodontic techniques and equipment. This systematic review includes current knowledge about pain after nonsurgical root canal treatment, including predictors, related factors, effects of recent advances, and management. A literature search was performed using the PubMed, ScienceDirect, and Cochrane Library databases for articles published between 1990 and 2016. Search keywords included postoperative pain, nonsurgical treatment, single visit, recent advances in endodontics, and management of postoperative pain with endodontic treatment. Only original research studies were included; editorials, reviews, brief notes, conference proceedings, and letters to the editor were excluded. The initial search yielded 4941 articles, which were assessed and filtered using the selection criteria. Sixty-five studies met the inclusion criteria and were included in the review. The findings showed that pain after nonsurgical root canal treatment occurred in 3–69.3% of patients. Microorganisms were identified as the primary contributors to postoperative pain, and there was no significant difference in postoperative pain between single- and multiple-visit treatments. Postoperative pain after root canal treatment ranges from mild to moderate and occurs even after optimally performed procedures. Furthermore, adequate management of postoperative pain is often considered an indicator of clinical excellence. Application of recently developed endodontic techniques and devices will reduce postoperative pain. Furthermore, a flexible, severity-based drug administration plan can be used to control and manage pain after root canal treatment. Application of the current research findings will reduce pain following root canal treatment and improve patient outcomes.

Corresponding address: College of Dentistry, Taibah University, P O Box 344, Almadinah Almunawwarah, KSA.

E-mail: mrahabi@taibahu.edu.sa

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Keywords: Analgesic; Endodontic; Nonsurgical; Postoperative pain; Root canal

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Introduction

Pain is a critical factor in dentistry because it is the primary cause of dental anxiety.¹ Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage or a sensation described in terms of such damage.² Odontogenic pain is generated through complicated pathways; tissue damage results in action potential generation towards the central nervous system, which occurs in conjunction with inflammatory reactions at the affected site.³

It is a common belief that root canal treatment is the most painful type of dental treatment,⁴ and fear of postoperative pain affects many patients. Therefore, accurate knowledge regarding pain after root canal treatment and related factors will enable clinicians to predict and effectively manage postoperative pain.⁵ Furthermore, knowledge regarding the prevalence, severity, and management of postoperative pain after nonsurgical root canal treatment will reduce the occurrence of tooth removal and enable evidence-based guidelines for general practitioners to manage postoperative pain.⁴ Although root canal treatment alleviates long-term pain, postoperative pain immediately following root canal treatment is commonly reported.^{6–8} Therefore, effective prevention and management of such pain is essential to improve patient outcomes.

The present study aimed to determine the effects of nonsurgical root canal treatment on postoperative pain and to determine predictive and related factors. We also assessed the effects of recent advances in postoperative pain management using a systematic review approach. To achieve these aims, the following specific questions were addressed in relation to the effects of nonsurgical root canal treatment on postoperative pain in adult patients.

- 1) Does root canal treatment produce postoperative pain, and if so, what are the prevalences, severities, possible causes, and related factors?
- 2) Are there relationships between recent advances in endodontics and postoperative pain?
- 3) How can postoperative pain be prevented, reduced, and managed?

Materials and Methods

An electronic literature search was performed using the PubMed, ScienceDirect, and Cochrane databases to identify relevant peer-reviewed articles published between 1990 and 2016. Search keywords included “postoperative pain”, “nonsurgical treatment”, “single visit”, “recent advances in

endodontics”, and “management of postoperative pain of endodontic treatment.” We included original studies published in English. Editorials, reviews, brief notes, conference proceedings, and letters to editors were excluded (Table 1). The initial search identified 4941 articles, which were then assessed for eligibility and filtered using the selection criteria (Figure 1). Sixty-five studies met the inclusion criteria and were included in the present review.

Table 1: Article inclusion and exclusion criteria.

Inclusion	Exclusion
Article published in English	Systemic review
Study conducted using permanent teeth with fully formed apexes	Case report or expert opinion
Clinical trial that randomly evaluated the influence of several factors on pain after root canal treatment	Study based on endodontic retreatment cases

Developed search keywords (postoperative pain, nonsurgical treatment, single visit, recent advances in endodontics, and management of postoperative pain of endodontic treatment)

Searched the PubMed, ScienceDirect, and Cochrane databases for articles published between 1990 and 2017

Identified publications (N = 4941)

Assessed articles for eligibility and filtered articles using the selection criteria (N = 65)

Figure 1: Article selection process.

Results

The results of this systematic review revealed that the incidence of postoperative pain during the first 24–48 hours ranges from 3 to 69.3%.^{1,8–19} Mild to moderate pain has been observed in some studies,^{1,12,13,17–21} and moderate to severe pain has been observed in other studies.^{1,8,11,22} A strong relationship exists between preoperative and postoperative pain. Patients with acute preoperative pain are likely to experience more severe postoperative pain.^{16,23,24} The majority of studies revealed that patient age is not related to pain after nonsurgical root canal treatment;^{12,16,25,26} women experience more pain after this treatment than men.^{21,23,27,28} The incidence of pain after nonsurgical root canal treatment is also higher in the mandibular arch and in molar teeth.^{5,27} Intracanal medication is also related to pain after root canal treatment. No definitive evidence exists indicating that there are significant differences in postoperative pain between single-visit and multiple-visit root canal treatments. Recent advances in endodontics have resulted in reduced postoperative pain in terms of both intensity and duration.^{29–31} Providing patients with information regarding expected postoperative pain and managing pain using prescription medications are methods to improve patient confidence, increase patients' pain thresholds, and improve their perspective regarding future dental treatments.^{32,33} Pretreatment analgesia administered 30 minutes before root canal treatment reduces postoperative pain and may be useful, especially in patients with low pain thresholds.³⁴ NSAIDs are most commonly used to control pain after root canal treatment.³⁵ A flexible drug

administration plan for pain control is recommended (Figure 2) and should be determined according to pain severity.³⁶

Discussion

Postoperative pain prevalence and severity

The incidence of postoperative pain during the first 24–48 h ranged from 3% to 69.3%.^{1,8–19} Mild to moderate pain was observed in some studies,^{1,12,13,17–21} and moderate to severe pain was observed in other studies.^{1,8,11,22} In addition, several studies have reported severe postoperative pain after 12–24 h.^{14,16,23,24} Pain typically lasts for 24–48 h, although some patients report pain that continued for 3–9 days following root canal treatment.^{5,12,13,21} The variability in results can be explained by the use of different criteria to assess postoperative pain, the use of different materials and techniques for root canal treatments, and failure to consider preoperative pain as a variable.²⁵

Factors resulting in postoperative pain

Microorganisms are the most common factor associated with postoperative pain after nonsurgical root canal treatment,^{1,26} as pain typically results from the acute inflammation of periradicular tissues. Other causes of postoperative pain include mechanical or chemical damage to periradicular tissues.^{17,27} Specifically, mechanical factors such as overinstrumentation or extrusion of root canal obturation materials are associated with pain after

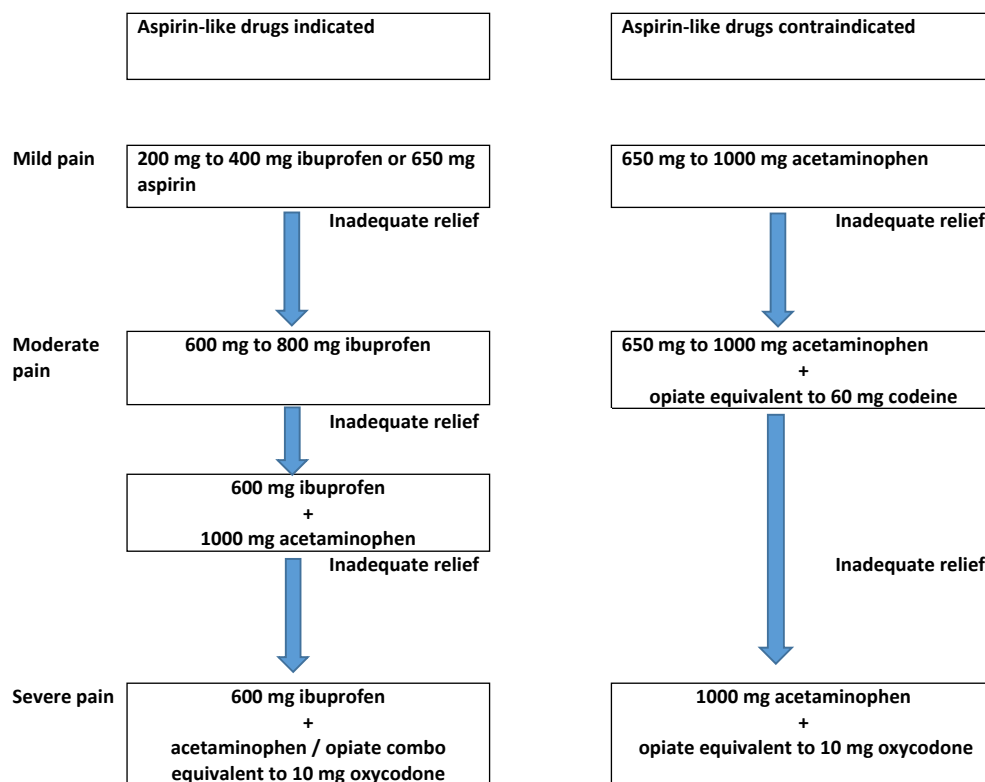


Figure 2: Drug administration protocol for postoperative pain management.

endodontic treatments,⁶ and sodium hypochlorite (NaOCl) extrusion produces severe pain, swelling, and tissue injury when used as an irrigant for the periapical tissues.²⁸

Factors related to postoperative pain

Postoperative pain following nonsurgical root canal treatment is a multifactorial phenomenon and is related to the presence of periapical pathosis, missed canals, inadequate cleaning and shaping, apical extrusion of debris, apical patency during instrumentation, irrigant and intracanal medication extrusion, and overbite restorations,²⁹ as well as tooth type^{5,30} and gender.³¹

There is a strong relationship between preoperative and postoperative pain. Patients who have acute preoperative pain are likely to experience more severe postoperative pain.^{16,32,33}

However, there are inconsistent findings regarding the relationship between pulpal status and postoperative pain. Several studies have reported that pulpal status contributes to postoperative pain,^{25,34} whereas other studies have not demonstrated an influence of pulpal status.^{32,35} Peripheral and central sensitization resulting from inflammatory mediators during pulpitis and apical periodontitis may also increase pain severity.³⁶

The majority of studies have found that patient age was not related to pain after nonsurgical root canal treatment.^{12,16,37,38} However, other studies have indicated a negative correlation between increasing age and treatment outcome,³¹ with patients >35 years of age experiencing less pain than younger patients.³⁴ There is no definitive evidence to prove that increasing age is associated with progressive loss of nociceptive sensitivity.³⁹ Thus, decreased pain sensitivity with increasing age is not related to changes in physiological pain systems. However, pulp chamber recession complicates root canal treatment in older patients and results in more severe postoperative pain.⁵

Women experience more pain after nonsurgical root canal treatment than men.^{21,25,32,40} The biological differences between men and women resulting from changes in serotonin and non-adrenalin hormones may underlie gender differences.⁴¹ Similarly, cortisol modulates pain sensation and is secreted in higher quantities in men than in women.^{42,43} Other factors such as oestrogen, the menstrual cycle, lifestyle, and societal expectations may also contribute to gender differences in physiological reactions to pain.⁴⁴

The incidence of pain after nonsurgical root canal treatment is also higher in the mandibular arch and in molar teeth.^{5,40} This difference may result from the dense trabecular pattern of the mandibular bone, which decreases blood circulation and concentrates infection, thereby delaying healing.³² Similar effects are associated with the complex anatomy of the lower molars.^{31,45} The maintenance of apical patency during root canal instrumentation had no significant influence on pain after root canal treatment.^{46,47} However, apical foramen enlargement due to over instrumentation during root canal treatment may increase the incidence and intensity of postoperative pain.⁴⁸

Intracanal medication is also related to pain after root canal treatment. Compared to when no dressing is used, dressing the necrotic canals with chlorhexidine alone or with calcium hydroxide plus chlorhexidine reduces postoperative

pain.⁴⁹ In addition, postoperative pain associated with acute apical periodontitis is effectively managed by intracanal dressing with Ledermix paste, which is a mixture of a glucocorticoid (triamcinolone) and an antibiotic (demeclocycline).⁵⁰ Ledermix efficiently and quickly relieves pain and is superior to calcium hydroxide for pain relief.⁵¹

Number of clinic visits and postoperative pain

For the last few decades, more than 70% of dental schools have recommended single-visit root canal treatment.^{52,53} Recent advances in endodontics, such as nickel titanium rotary instrumentation, reliable apex locators, ultrasonics, microscopic endodontics, digital radiography, newer obturation systems, and biocompatible sealing materials, have facilitated more efficient endodontic procedures and enabled single-visit rather than multiple-visit root canal treatments.^{54,55} However, some studies report that many clinicians perform root canal treatments over multiple visits.^{16,38} Although single-visit root canal treatment is an efficient and clinically effective procedure, the incidence of postoperative pain is concerning,⁵⁶ even though the majority of studies found no significant differences in postoperative pain between single-visit and multiple-visit root canal treatments.^{1,32,33,57,58} However, other studies have reported that postoperative pain increased for single-visit root canal treatments,^{59,60} which contrasts with reports that postoperative pain is reduced for single-visit root canal treatments.^{61,62} These discrepancies may result from differences in sample size, treatment techniques (such as rotary instrumentation vs. manual instrumentation or lateral condensation vs. vertical condensation obturation), pulp status, whether teeth are single- or multi-rooted, and pain measurement techniques.

Table 2 Summarizes the relationship between the number of clinic visits and pain after root canal treatment.

Effects of recent advances in postoperative pain management

Recently, the practice of endodontics has benefitted from several new technologies that have improved treatment efficiency, safety, and quality.^{55,66} In addition, recently developed endodontic techniques and devices, such as operative microscopes, electronic apex locators, and rotary nickel titanium systems, have reduced procedure durations and increased the success rates of endodontic treatments.^{67,68} For example, the crown-down technique for cleaning and shaping root canal systems, which approaches the apical end starting from the coronal third and progressing towards the apical third, reduces extrusion of debris through the apical foramen. This reduction is significant because periapical debris extrusion is a major contributor to pain after root canal treatment.^{69,70} In addition, nickel–titanium engine-driven instrumentation extrudes less debris than manual stainless steel K-files.⁷⁰ Hence, these instruments have dramatically decreased the incidence of postoperative pain.^{71–73} Similarly, advances in root canal instrumentation reciprocating systems have resulted in less postoperative pain in terms of both intensity and duration.^{70,74,75}

Irrigant activation is an effective method to reduce postoperative pain,⁷⁶ and the use of a negative apical pressure

Table 2: Summary of the relationship between the number of clinic visits and pain after root canal treatment.

Study and reference no.	Type of tooth	Pulp status	No. of teeth or patients	Percentage of cases		Incidence of postoperative pain
				Single	Multiple	
Patil et al. ⁶³	Maxillary central incisor	Vital and nonvital	66 teeth	100%	n/a	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Onay et al. ⁶²	All types	Vital and nonvital	1819 teeth	31%	69%	The incidence of postoperative pain was minimal after single-visit root canal treatments
Wong et al. ⁶⁴	All types	Vital and nonvital	538 teeth	51%	49%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Prashanth et al. ⁵⁷	All teeth	Vital and nonvital	32 patients	50%	50%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Singh et al. ³⁴	Single-rooted teeth	Vital and nonvital	200 teeth	50%	50%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Wang et al. ³⁵	Permanent anterior teeth	Vital	100 teeth	50%	50%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
El Mubara et al. ¹⁶	All types	Vital and nonvital	230 patients	50%	50%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Bayram et al. ¹	All types	Vital and nonvital	306 patients	50%	50%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Risso et al. ¹³	Molars	Pulp necrosis	118 teeth	48%	52%	Postoperative pain was greater after 2-visit root canal treatment compared to single-visit treatment, although the differences were not statistically significant
Al-Negrish et al. ²¹	Central incisor teeth	Nonvital	120 teeth	50%	50%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Oginni et al. ⁵⁹	All teeth	Vital and nonvital	107 teeth	45.8%	5.2%	Pain after single-visit root canal treatment was greater than pain after multiple-visit root canal treatment
DiRenzo et al. ⁶⁵	Permanent molars	Vital and nonvital	72 patients	54%	46%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments
Imura and Zuolo ⁶¹	All types	Vital and nonvital	1012 patients	57.5%	42.5%	Pain after multiple-visit root canal treatment was greater than after single-visit root canal treatment
Fava 1994 ⁵⁸	Maxillary central incisors	Vital	60 patients	50%	50%	There was no significant difference in postoperative pain between single- and multiple-visit root canal treatments

irrigation device can significantly reduce postoperative pain.⁶ However, one study found that there were no significant differences in postoperative pain between the use of 2% chlorhexidine and 5.25% sodium hypochlorite irrigating solutions.^{77,78}

Preventive management of postoperative pain

Pain relief is often more important to patients than successful root canal treatment.⁷⁹ Therefore, the prevention and management of postoperative pain after nonsurgical root canal treatment is a component of successful outcomes. Providing patients with information regarding expected postoperative pain and managing pain by prescribing medications improves patient confidence, increases patients' pain thresholds, and improves patients' views of future dental treatments.^{80,81}

Pretreatment analgesia administered 30 min before root canal treatment reduces postoperative pain and may therefore be useful, especially in patients with low pain thresholds.⁸² Pretreatment analgesia with nonsteroidal anti-inflammatory drugs (NSAIDs) before endodontic treatment blocks the cyclooxygenase (COX) pathway and may therefore block pain signals prior to sensation.⁸³ One study found that premedication with a single dose of ibuprofen did not relieve postoperative pain after root canal treatment.⁸⁴ However, the study sample was small (39 patients), and information was not provided regarding whether the pulp was vital or necrotic. Furthermore, a preoperative single oral dose of prednisolone (30 mg) or dexamethasone (4 mg) substantially reduces postoperative pain.^{85,86} Administration of an enduring local anaesthetic (bupivacaine) during treatment can also significantly reduce postoperative pain after nonsurgical root canal treatment,^{87,88} and this effect is hypothesized to occur by blocking nociceptive impulses for a long enough duration of time to prevent central hyperalgesia in the early stages of inflammation after root canal treatment.⁸⁹ Intracanal cryotherapy using 2–4 °C saline irrigation for 5 min as the final irrigant may significantly reduce postoperative pain.^{90,91} Cryotherapy restricts tissue metabolism and blood flow to tissues, thereby producing vasoconstriction.⁹²

The resulting decreased external root surface temperature may constrain inflammatory reactions, reduce the release of pain-producing substances, and reduce edema in the periapical region. Localized inflammation has a crucial role in odontogenic pain development,³ and pain after root canal treatment results from periapical tissue inflammation.¹⁷ NSAIDs, including ibuprofen, aspirin, flurbiprofen, ketorolac, and etodolac,⁹⁴ are most commonly used to control pain after root canal treatment.⁹³ Prostaglandin synthesis is prevented by NSAIDs by reducing the enzyme activities of COX 1 and 2.⁴⁶ Furthermore, moderate to severe pain is ideally managed using a combination of 2 or more drugs to enable a lower dose of each drug, which minimizes side effects.⁹⁵ For example, the combination of an NSAID and acetaminophen can improve analgesia for dental pain.⁹⁶ Similarly, a combination of ibuprofen and paracetamol effectively reduces pain following root canal treatment when taken immediately following the procedure.⁹⁷ However, when NSAID combinations are not effective

pain management strategies, a narcotic analgesic should be considered.⁹⁸ Therefore, a flexible drug administration plan for pain control is recommended (Figure 2) and should be determined on the basis of pain severity.⁹⁹ Furthermore, drugs should be administered four times per day until the pain subsides.

The effects of reducing occlusion to relieve postoperative pain after root canal treatment are inconclusive. In teeth with symptomatic apical periodontitis, reducing occlusion did not have any effect on pain after root canal treatment.^{100,101} However, another study revealed that occlusal reduction of teeth with tenderness on biting effectively reduced postoperative pain.¹⁰² Pain on biting may result from inflammatory mediators stimulating periradicular nociceptors, and occlusal reduction may disrupt the continuous mechanical stimulation of the sensitized nociceptors.¹⁰³

Conclusions

Pain after root canal treatment typically ranges from mild to moderate and can occur even after optimally performed root canal treatments. Recent advances in endodontics have reduced the incidence of pain after root canal treatment and improved patient satisfaction regarding postoperative pain. The effective management of postoperative pain is often considered an indicator of clinical excellence. However, further research is required to understand the physiology of pain and the mechanisms of relief associated with drugs and therapy.

Conflict of interest

The authors declare that there are no conflicts of interest regarding this article.

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