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Medicinal Plants for Postoperative Pain Management: Evidence from Animal, Preclinical Models and Clinical Studies

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Abstract: Postoperative pain is a common and challenging complication that adversely affects patients' quality of life. Medicinal plants, due to their analgesic and anti-inflammatory properties, have gained attention as complementary approaches for pain management. This systematic review aimed to identify medicinal plants effective in alleviating postoperative pain, summarize preclinical evidence of their effects, explore underlying analgesic mechanisms, and compare traditional and modern medicine contributions. A comprehensive search was conducted in MagIran, Google Scholar, PubMed, SID, and Scopus using keywords such as "medicinal plants," "pain," and "surgery." The review identified several plants, including *Mentha piperita*, *Oenothera biennis*, *Borago officinalis*, *Foeniculum vulgare*, *Brassica nigra*, *Cuminum cyminum*, *Nigella sativa*, *Trigonella foenum-graecum*, *Lavandula angustifolia*, *Curcuma longa*, *Hypericum perforatum*, *Ananas comosus*, *Melissa officinalis*, *Matricaria chamomilla*, *Glycyrrhiza glabra*, *Colchicum autumnale*, *Juniperus communis*, *Ocimum basilicum*, and *Syzygium aromaticum*, with notable efficacy reported for *S. aromaticum* in traditional Iranian medicine. Both traditional knowledge and clinical evidence suggest that these plants may serve as complementary strategies to manage postoperative pain. However, clinical findings remain limited and heterogeneous. Integrating historical medicinal practices with rigorous clinical research is essential to establish safe, effective, and evidence-based therapies that enhance postoperative recovery and improve patient outcomes.

Keywords: Surgery, Postoperative Pain, Inflammation, Medicinal Plants, Therapy

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Introduction

Postoperative pain is among the most common challenges patients face and can significantly affect quality of life, recovery trajectories, and patient satisfaction (1,2). Inadequate management of postoperative pain is associated with multiple complications, including increased stress, reduced mobility, immune dysfunction, and prolonged hospital stay (3,4). Therefore, effective pain control following surgery is a critical component of postoperative care (2–4). Conventional approaches to managing postoperative pain primarily involve pharmacological agents, such as opioids and nonsteroidal anti-inflammatory drugs (NSAIDs) (5).

Although these medications are effective, long-term use or high dosages can lead to a range of adverse effects (6). Side effects such as nausea, vomiting, gastrointestinal disturbances, drowsiness, dependency, and hepatic or renal complications have prompted researchers and clinicians to explore safer and lower-risk alternatives (7).

In this context, attention toward natural resources, particularly medicinal plants, as complementary or alternative therapies to conventional drugs has increased in recent years (8). Medicinal plants, owing to their diverse bioactive compounds including flavonoids, alkaloids, terpenoids, and saponins possess analgesic, anti-inflammatory, and sedative properties (9,10). Preliminary studies have shown that certain plants can modulate (11) or inhibit pain-related neural pathways and reduce inflammatory processes following surgery (12).

From the perspective of traditional Iranian medicine and other traditional medical systems, numerous medicinal plants have long been employed to alleviate pain, swelling, and inflammation (13,14). These rich empirical sources and historical records provide a valuable foundation for modern scientific research, facilitating the identification and optimization of their mechanisms of action (14). Integrating traditional knowledge with contemporary scientific findings allows for the development of safe and effective therapies for postoperative pain management (14).

In recent years, a growing number of preclinical and clinical studies have examined the analgesic effects of medicinal plants. For instance, extracts from plants such as *Zingiber officinale*, *Melissa officinalis*, *Mentha*, and *Borago officinalis* have demonstrated efficacy in reducing acute postoperative pain with fewer side effects compared to conventional pharmaceuticals (15–17).

However, variability in plant species, extraction methods, and dosages has occasionally led to inconsistent results, highlighting the need for systematic evaluation (15–17).

A thorough review of existing literature and consolidation of scientific data can provide a comprehensive perspective on medicinal plants effective in alleviating postoperative pain (18,19). Furthermore,

identifying molecular mechanisms, biochemical pathways, and active compounds can lay the groundwork for developing new drugs or validated herbal supplements (19). Such efforts not only help patients manage pain with fewer adverse effects but also contribute to reducing the overuse of chemical analgesics (20,21).

Consequently, analyzing and evaluating medicinal plants in the context of postoperative pain management holds significant scientific, clinical, and traditional relevance. This review aims to familiarize physicians, researchers, and patients with safer and more effective options for pain control after surgery and to provide guidance for future investigations in this domain.

Clinical and research consequences

This study employed a systematic review approach to evaluate the effects of medicinal plants on postoperative pain management. Comprehensive searches were conducted in reputable databases, including Google Scholar, PubMed, Scopus, and SID. Keywords and Boolean operators were used in various combinations, including: "Medicinal plants," "Pain," "Postoperative pain," "Surgery," and "Herbal medicine."Inclusion criteria encompassed traditional studies, clinical trials, and animal or laboratory studies that examined the impact of medicinal plants on postoperative pain. Studies published in English or Persian, providing sufficient data on pain-related outcomes, were included.Exclusion criteria included review articles, short communications, notes, conference abstracts without full text, studies evaluating pain in non-surgical contexts, research focusing on non-pain-related outcomes, low-quality studies, insufficient data, and duplicate or republished studies. Following the application of these criteria, selected studies were thoroughly reviewed, and data regarding plant species, type of surgery, and analgesic effects were extracted. Comparative analyses of traditional and modern medicinal outcomes were also performed.

Findings from the systematic review revealed that numerous medicinal plants including *Mentha piperita L., Oenothera biennis L., Borago officinalis L., Foeniculum vulgare Mill., Brassica nigra (L.) W.D.J. Koch, Cuminum cyminum L., Nigella sativa L., Trigonella foenum-graecum L., Lavandula angustifolia Mill., Curcuma longa L., Hypericum perforatum L., Ananas comosus (L.) Merr., Melissa officinalis L., Matricaria chamomilla L., Glycyrrhiza glabra L., Colchicum autumnale L., Juniperus communis L., Ocimum basilicum L., Syzygium aromaticum (L.) Merr. & L.M. Perry* many of which hold a special place in traditional Iranian medicine significantly reduce postoperative pain intensity.

These plants exert analgesic effects through diverse mechanisms, contributing effectively to post-surgical pain relief.

Traditional uses of native Iranian medicinal plants for postoperative pain reduction are summarized in Table 1 (22–26), while their effects in human or animal models and relevance to modern medicine are presented in Table 2.

Table 1. Medicinal Plants Effective in Postoperative Pain Management in Traditional Iranian Medicine

Persian Name	English Name	Scientific Name	Family	Traditional Use
Naena	Mint	*Mentha piperita* L.	Lamiaceae	Tea or extract
Golemaghrebi	Evening primrose	*Oenothera biennis* L.	Onagraceae	Seed oil orally
Gavzaban	Borage	*Borago officinalis* L.	Boraginaceae	Herbal infusion (tea)
Razianeh	Fennel	*Foeniculum vulgare* Mill.	Apiaceae	Herbal infusion (tea)
Khardalesiah	Black mustard	*Brassica nigra* (L.) W.D.J. Koch	Brassicaceae	Seed powder, applied topically
Ziresabz	Cumin	*Cuminum cyminum* L.	Apiaceae	Herbal infusion or added to food
Siahdaneh	Black cumin	*Nigella sativa* L.	Ranunculaceae	Herbal infusion or oil
Shanbalileh	Fenugreek	*Trigonella foenum-graecum* L.	Fabaceae	Herbal infusion or added to food
Ostokhodous	Lavender	*Lavandula angustifolia* Mill.	Lamiaceae	Oil for massage or inhalation
Zardchoubeh	Turmeric	*Curcuma longa* L.	Zingiberaceae	Powder or extract
Goleraei	St. John's Wort	*Hypericum perforatum* L.	Hypericaceae	Herbal infusion (tea)
Ananas	Pineapple	*Ananas comosus* (L.) Merr.	Bromeliaceae	Fresh fruit or extract
Badranjbouyeh	Lemon balm	*Melissa officinalis* L.	Lamiaceae	Herbal infusion (tea)
Babouneh	Chamomile	*Matricaria chamomilla* L.	Asteraceae	Herbal infusion (tea)
Shirinbayan	Licorice	*Glycyrrhiza glabra* L.	Fabaceae	Extract
Arousechamanzar	Meadow saffron	*Colchicum autumnale* L.	Colchicaceae	Extract
Sarvekouhi	Juniper	*Juniperus communis* L.	Cupressaceae	Herbal infusion (tea)
Reyhan	Basil	*Ocimum basilicum* L.	Lamiaceae	Fresh or dried leaves
Mikhak	Clove	*Syzygium aromaticum* (L.) Merr. & L.M. Perry	Myrtaceae	Spice, decoction, oil, added to food or herbal teas

Table 2. Medicinal Plants Effective in Postoperative Pain Management: Surgery-Related Effects, Mechanisms of Action, and Scientific References

Scientific Name	Effect in Surgery / Study Findings	Ref.
Mentha piperita L.	A study on 39 patients with post-spinal anesthesia headache showed that inhalation of peppermint aroma significantly reduced pain intensity (mean pain decreased from 5.69 to 1.64, $p < 0.05$). This suggests peppermint aromatherapy can be an effective non-pharmacological method for managing post-dural puncture headache.	(27)
Oenothera biennis L.	Studies indicate that evening primrose oil (EPO) may have positive effects in certain inflammatory disorders, such as atopic eczema.	(28)
Borago officinalis L.	A study on 91 patients with cyclical mastalgia demonstrated that oral capsules of borage oil (900 mg) significantly reduced pain intensity and its impact on sleep, work, and sexual activity, improving quality of life. The treatment was well tolerated with no serious side effects.	(29)
Foeniculum vulgare Mill.	A study in mice showed that fennel seeds (500 mg/kg) accelerated recovery of sensory and motor function after peripheral nerve injury and enhanced antioxidant capacity, suggesting fennel as a potential herbal therapy for nerve injury recovery.	(30)
Cuminum cyminum L.	A study showed that post-abdominal surgery consumption of cumin improved bowel movement recovery (reduced time to first flatus and defecation) and decreased abdominal pain, bloating, nausea, and vomiting. Further studies are recommended to optimize timing and duration.	(31)
Nigella sativa L.	Nigella sativa oil reduced the formation of postoperative peritoneal adhesions by coating peritoneal surfaces, decreasing angiogenesis, fibrosis, and inflammation.	(32)
Trigonella foenum-graecum L.	Hydroalcoholic extracts of fenugreek reduced intra-abdominal adhesion formation after surgery in mice by modulating inflammation and collagen deposition.	(33)
Lavandula angustifolia Mill.	Lavender essential oil, applied topically or via aromatherapy after delivery or cesarean section, reduces pain and exerts calming, antidepressant, antifungal, and wound-healing effects, aiding recovery of surgical or episiotomy wounds.	(34,35)

Curcuma longa L.	Topical application of turmeric ointment or solution for up to 10 days post-natural delivery accelerated episiotomy wound healing and reduced pain, with minor redness and inflammation; effects were superior to placebo or Betadine solution.	(36)
Hypericum perforatum L.	Oil and ointment of St. John's Wort exert local anesthetic and anti-inflammatory effects, accelerating wound healing and reducing post-cesarean pain. Anti-inflammatory effects are mediated by inhibition of key enzymes and reduced prostaglandin and leukotriene production; 16-day application significantly reduced pain by day 40.	(37)
Ananas comosus (L.) Merr.	Oral intake of three 100 mg bromelain tablets daily for 6 days post-natural delivery significantly reduced episiotomy pain on days 1 and 3 compared to placebo.	(38)
Melissa officinalis L.	Lemon balm tea post-orthopedic surgery reduced pain intensity and improved patient satisfaction with pain management, demonstrating effectiveness as a complementary therapy.	(39)
Matricaria chamomilla L.	Chamomile tea post-orthopedic surgery reduced pain intensity and increased patient satisfaction with pain management, serving as an effective complementary approach.	(39)
Glycyrrhiza glabra L.	Licorice gargle 5 minutes before anesthesia reduced the incidence and severity of postoperative sore throat (POST) and coughing after extubation without increasing side effects.	(40)
Ocimum basilicum L.	Basil oil reduced TNF-α and GluR1 levels, decreasing spontaneous and surgery-related pain. Clinical studies support its analgesic efficacy; further research is recommended to fully explore its pharmacological effects.	(40)
Syzygium aromaticum (L.) Merr. & L.M. Perry	Clove extract reduced postoperative peritoneal adhesion formation in mice by modulating inflammatory cytokines, growth factors, and oxidative/antioxidant markers, suggesting potential as a therapeutic option for adhesion management.	(40)

Postoperative pain remains a challenging issue that significantly impacts patients' quality of life and recovery process. While conventional analgesics are effective, their limitations underscore the need for safer and more efficacious alternatives (27).

M. piperita contains menthol and menthone, which exert analgesic and calming effects by activating TRPM8 receptors and inhibiting calcium channels. Clinical studies have shown that peppermint aroma significantly reduces headache intensity following spinal anesthesia (27).

Q. biennis is rich in omega-6 fatty acids, particularly gamma-linolenic acid (GLA), which attenuates pain and inflammation by inhibiting inflammatory pathways and reducing prostaglandin production (28). *B. officinalis*, due to its omega-6 fatty acids and flavonoids, can alleviate cyclical pain and enhance patient quality of life by reducing inflammation and boosting antioxidant capacity (29).

F. vulgare contains anethole, phenylpropanoids, and flavonoids, which exert anti-inflammatory effects and promote nerve repair, thereby accelerating recovery after peripheral nerve injuries (30). *C. cyminum* is rich in cumin aldehyde and thymol, which have antispasmodic and carminative properties; postoperative administration improves bowel movements and reduces abdominal pain and nausea (31).

N. sativa, containing thymoquinone, carvone, and flavonoids, mitigates postsurgical adhesions by inhibiting the NF-κB pathway, reducing free radicals, and suppressing inflammation (32). *T. foenum-graecum* includes saponins and polysaccharides that prevent intra-abdominal adhesions by decreasing collagen deposition and modulating inflammatory responses (33). *L. angustifolia* contains linalool and linalyl acetate, which reduce postpartum and post-cesarean pain through central nervous system sedation and local anti-inflammatory effects (34,35). *C. longa* contains curcumin, which inhibits COX-2, LOX, and NF-κB pathways, providing anti-inflammatory and antioxidant effects while accelerating wound healing (36).

H. perforatum, containing hypericin and hyperforin, inhibits prostaglandin and leukotriene synthesis, producing local analgesic and anti-inflammatory effects that reduce post-cesarean pain (37). *A. comosus* is rich in bromelain, which exerts anti-inflammatory and proteolytic effects, reducing episiotomy pain and swelling (38). *M. officinalis* contains rosmarinic acid and flavonoids, offering calming and analgesic effects; its tea has been shown to alleviate pain following orthopedic surgery (38).

M. chamomilla, which includes apigenin and bisabolol, mitigates pain and accelerates wound healing by modulating inflammatory pathways and oxidative stress (39). *G. glabra* contains glycyrrhizin and flavonoids, producing anti-inflammatory, antispasmodic, and local anesthetic effects that reduce postoperative sore throat following intubation (40).

Conclusion

Medicinal plants, particularly those traditionally used in Iranian medicine, exhibit a multifaceted potential in managing postoperative pain. These plants reduce post-surgical pain through anti-inflammatory, antioxidant, antispasmodic, local anesthetic, and tissue-healing mechanisms. Although

clinical evidence is limited, it is promising and indicates that proper use of these plants can be both safe and effective. Integrating traditional knowledge with modern scientific findings helps determine optimal dosing, timing, and preparation methods. Certain plants, such as peppermint, turmeric, valerian, and clove, have shown significant effects in reducing pain intensity and improving recovery. Using these plants as complementary or alternative therapies can minimize the side effects associated with conventional pharmacological agents. Therefore, further clinical studies are essential to validate their effects and elucidate their precise mechanisms of action.

Conflict of Interest

The author has no conflict of interest to declare.

Financial Disclosure

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Informed Consent

Written informed consent was obtained from patients who participated in this study.

Author Contributions

Concept – **RN, ASH**; Design – **RN, ASH**; Supervision – **RN, ASH**; Resource – **RN**; Materials –**ASH**; Data Collection and/or Processing – **RN, ASH**; Analysis and/or Interpretation – **RN**; Literature Search – **ASH**; Writing – **ASH**; Critical Reviews – **RN.**

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Peer-review

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