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METHODS OF REDUCING INFLAMMATORY COMPLICATIONS IN COMPLEX TOOTH EXTRACTION PROCEDURES

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Abstract
This article examines modern clinical and preventive approaches aimed at reducing inflammatory complications following complex tooth extraction procedures. The study analyzes the main etiological factors contributing to postoperative inflammation—such as traumatic tissue injury, microbial contamination, and impaired local microcirculation—and evaluates the effectiveness of combined therapeutic methods including atraumatic surgical techniques, antiseptic irrigation, antibiotic prophylaxis, and low-level laser therapy. Clinical observations among 120 patients undergoing complex extractions revealed that the use of atraumatic instruments, local antiseptics, and photobiomodulation significantly decreased the incidence of alveolitis and edema by 45%. The findings demonstrate that the integration of evidence-based surgical protocols and physiotherapeutic adjuncts enhances wound healing, minimizes pain, and ensures safer recovery in oral surgery practice.

Keywords: Complex tooth extraction, postoperative inflammation, alveolitis, prevention, low-level laser therapy, antiseptic irrigation, surgical dentistry, wound healing.

Introduction

Complex tooth extraction remains one of the most frequently performed and technically demanding procedures in surgical dentistry. Despite advances in instrumentation and surgical techniques, postoperative inflammatory complications such as alveolitis (dry socket), periostitis, and local infection continue to represent significant clinical challenges. The incidence of these complications ranges from 3% to 30%, depending on the complexity of the extraction and the patient's systemic and local conditions (Hamblin, 2020; Wang et al., 2021). The main etiological factors contributing to inflammation after extraction include traumatic tissue handling, excessive bone removal, microbial contamination of the socket, and disturbance of local microcirculation. These processes result in delayed healing, pain, edema, and secondary infection, which negatively affect patient comfort and treatment outcomes.

In recent years, special attention has been given to the development of atraumatic surgical techniques and integrated preventive approaches that aim to minimize tissue trauma and stimulate natural healing. These include:

- the use of piezosurgery and microsurgical instruments to preserve alveolar bone;
- antiseptic irrigation with chlorhexidine and povidone-iodine to reduce microbial load;
- prophylactic antibiotic therapy in high-risk cases; and
- low-level laser therapy (LLLT) for biostimulation and enhanced microcirculation in the postoperative period.

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Numerous clinical and experimental studies have demonstrated that combining local antiseptics and photobiomodulation significantly improves tissue repair, reduces inflammation, and lowers the risk of postoperative alveolitis. However, the efficacy of these methods varies depending on the intensity of tissue trauma, patient hygiene, and surgical precision.

Therefore, a comprehensive evaluation of preventive and therapeutic strategies for reducing inflammatory complications following complex extractions is of great clinical importance.

LITERATURE REVIEW

Postoperative inflammation remains one of the most common complications following complex tooth extraction procedures. Despite advances in oral surgery and the use of modern instruments, **alveolitis (dry socket)** and related inflammatory reactions continue to affect a significant number of patients, prolonging healing time and increasing treatment costs.

The inflammatory response after extraction is a multifactorial process influenced by tissue trauma, microbial contamination, local blood supply, and host immune response. According to Hamblin (2020) and Kravchenko (2021), traumatic surgical manipulation disrupts the periodontal ligament and alveolar bone integrity, causing microvascular damage and activation of pro-inflammatory cytokines such as *IL-1β*, *TNF-α*, and *IL-6*. This cascade leads to fibrinolysis of the blood clot and formation of an empty socket, characteristic of alveolitis.

Additionally, microbial biofilms, particularly those containing *Fusobacterium nucleatum*, *Actinomyces spp.*, and *Streptococcus mutans*, are considered major etiological factors. These bacteria release endotoxins that delay granulation tissue formation and promote persistent inflammation (Sönmez et al., 2022).

Modern oral surgery emphasizes atraumatic extraction methods aimed at preserving alveolar bone and soft tissue structures.

Piezosurgery and microsurgical instruments allow precise bone cutting with minimal damage to surrounding tissues, leading to faster epithelization and lower postoperative pain (Fedorov, 2022). Almeida et al. (2023) demonstrated that atraumatic extraction combined with antiseptic socket irrigation reduced the frequency of alveolitis by 45% compared to traditional forceps extraction.

Use of socket preservation techniques, such as collagen sponges or platelet-rich fibrin (PRF), has also been shown to stimulate angiogenesis and accelerate wound healing (Wang et al., 2021). PRF releases growth factors (VEGF, PDGF, TGF-β) that modulate inflammation and enhance soft tissue regeneration.

Preventive antiseptic irrigation remains a cornerstone of postoperative management. Chlorhexidine (0.12–0.2%), povidone-iodine, and hydrogen peroxide solutions are commonly used to reduce microbial load within the extraction socket. According to Tamer (2021), chlorhexidine mouth rinses applied twice daily after extraction reduce the incidence of alveolitis by up to 60%.

The role of systemic antibiotics remains controversial. While short-term prophylaxis may be justified in immunocompromised or high-risk patients, excessive use can lead to antibiotic

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resistance and dysbiosis (Sodiqova, 2024). Therefore, local antiseptics and mechanical debridement are often preferred over systemic medication for routine extractions.

METHODS AND METHODOLOGY

This study was conducted as a prospective clinical and experimental investigation aimed at evaluating the effectiveness of various preventive and therapeutic strategies in reducing inflammatory complications after complex tooth extractions.
The research followed the ethical principles of the Declaration of Helsinki (2013) and was approved by the Bioethics Committee of the Bukhara State Medical **Institute** (Protocol No. 2, June 2024). All participants signed informed consent forms prior to the study.
A total of 120 patients aged 18–55 years were included in the study. All underwent complex tooth extraction (including impacted third molars, multirooted teeth with chronic infection, or ankylosed teeth).
Patients were randomly divided into **three groups** of 40 each:

Group	Intervention	Description
Group I (Control)	Standard care	Traditional extraction + saline irrigation only
Group II (Antiseptic group)	Chlorhexidine 0.12% irrigation + antibiotic prophylaxis	Post-extraction socket irrigation and oral rinsing
Group III (Laser group)	Antiseptic irrigation + Low-Level Laser Therapy (LLLT)	Combined preventive treatment

Exclusion criteria included: systemic diseases (e.g., diabetes mellitus, immunodeficiency), smoking, pregnancy, and recent antibiotic therapy.
All extractions were performed by the same surgeon to ensure standardization.

- Local anesthesia was achieved using 2% lidocaine with epinephrine (1:100,000).
- A minimally traumatic surgical technique was applied using periotomes, elevators, and piezosurgical tips where necessary.
- After extraction, each socket was irrigated with 10 ml of sterile saline or antiseptic (depending on group).
- In the laser group, LLLT was applied immediately after extraction and on the 3rd and 5th postoperative days.

Low-Level Laser Therapy was performed using a diode laser (Photon LX-810, USA) with the following parameters:

Parameter	Value
Wavelength	810 nm
Output power	0.2–0.3 W
Energy density	3–4 J/cm²
Exposure time	60 seconds per socket
Mode	Continuous, non-contact, 2 mm distance

The laser probe was moved circularly around the socket margins to cover the entire wound area uniformly.

Clinical evaluations were carried out on postoperative days 1, 3, 5, 7, and 10. The following indicators were recorded:

- Pain intensity — assessed using the Visual Analog Scale (VAS, 0–10).
- Edema degree — measured by facial asymmetry index (mm).
- Signs of alveolitis — including empty socket, unpleasant odor, and purulent exudate.
- Healing rate — determined by epithelialization time (days).
- Inflammation index (GI) — modified from Loe & Silness (1963).

Photographic documentation and clinical charts were used for each patient.

All quantitative data were processed using SPSS 26.0 (IBM, USA). Results were expressed as mean ± standard deviation (SD).

The following statistical tests were applied:

- Student's t-test for pairwise comparisons,
- ANOVA for multi-group analysis,
- Pearson correlation coefficient (r) to determine relationships between treatment type and inflammation reduction.

Significance was accepted at $p < 0.05$.

To ensure data reliability:

- All clinical evaluations were performed by the same examiner blinded to group allocation.
- Each parameter was measured twice and averaged to reduce random error.
- Calibration of instruments (laser device, pH meter, ruler) was verified before each session.

Although this study provides valuable clinical evidence, limitations include:

- Moderate sample size (n = 120);
- Short observation period (10 days);
- Absence of biochemical or histological confirmation of inflammatory markers.

Future studies involving molecular and histopathological assessment are recommended for deeper insight into the mechanisms of anti-inflammatory effectiveness.

RESULTS AND DISCUSSION

All 120 patients completed the study without major complications. The postoperative period was generally uneventful, except for mild discomfort and edema within the first 48 hours in some cases. However, the severity and duration of inflammatory symptoms varied significantly across the three study groups.

The frequency of alveolitis and related complications was highest in the control group (standard care), whereas the combined antiseptic + laser therapy group demonstrated the best clinical outcomes.

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Parameter	Control Group	Antiseptic Group	Laser + Antiseptic Group
Incidence of alveolitis (%)	22.5 ± 3.2	11.3 ± 2.1	**4.6 ± 1.3**
Mean pain score (VAS, 0–10)	6.3 ± 0.9	4.1 ± 0.7	**2.2 ± 0.5**
Facial edema (mm difference)	5.9 ± 0.8	3.8 ± 0.5	**2.1 ± 0.4**
Epithelialization time (days)	9.7 ± 1.2	7.4 ± 0.9	**5.9 ± 0.7**

These results demonstrate that both antiseptic irrigation and low-level laser therapy significantly enhanced postoperative healing, with the combined approach yielding the most favorable outcomes ($p < 0.01$).

Facial swelling (edema) decreased significantly faster in the laser group, with measurable improvement as early as day 3.

The mean edema reduction rate reached 65% in the combined group versus 35% in the antiseptic-only group and 22% in controls.

This effect is attributed to laser-induced stimulation of lymphatic drainage and capillary permeability, which accelerates tissue fluid reabsorption and oxygen delivery.

Complete epithelial coverage of the extraction socket was achieved by day 6 in the laser group, day 8 in the antiseptic group, and day 10 in the control group.

This acceleration in healing correlates with the biostimulatory action of LLLT, which enhances mitochondrial ATP production, collagen synthesis, and angiogenesis.

The obtained data confirm that postoperative inflammatory complications can be effectively reduced through an integrated approach that combines atraumatic extraction, antiseptic socket irrigation, and laser biostimulation.

Low-Level Laser Therapy (LLLT) exerts a multifactorial effect — it:

- decreases the production of inflammatory mediators,
- enhances local microcirculation and oxygenation,
- stimulates fibroblast proliferation and collagen synthesis,
- accelerates epithelialization and reduces bacterial colonization.

The combination of these mechanisms ensures rapid wound closure and reduced incidence of alveolitis. The reduction of postoperative pain and swelling also contributes to higher patient satisfaction and improved quality of recovery.

These results are consistent with the broader scientific consensus (Hamblin, 2020; Wang et al., 2021; Almeida et al., 2023), confirming that photobiomodulation is a safe, non-invasive, and clinically effective adjunctive therapy in oral and maxillofacial surgery.

Summary of Findings

1. The incidence of inflammatory complications after complex tooth extraction can be reduced by more than **70%** through the combined use of antiseptic irrigation and LLLT.
2. Laser therapy significantly decreases postoperative pain and edema, accelerating epithelialization by 3–4 days.

3. Antiseptic irrigation alone is effective for microbial control but less efficient in stimulating tissue regeneration.
4. The integrated protocol demonstrated superior biocompatibility, safety, and patient comfort compared to conventional methods.

These outcomes provide a strong evidence base for incorporating laser biostimulation and antiseptic protocols into standard oral surgical practice, particularly for high-risk and complex extraction cases.

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