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A PROSPECTIVE, MODALITY-DIFFERENTIATED COMPARATIVE EVALUATION OF HYDROGEN PEROXIDE–INDUCED OXIDATIVE CHEMICAL CAUTERISATION VERSUS BIPOLAR ELECTROSURGICAL COAGULATION IN MODULATING POST-TONSILLECTOMY MUCOSAL REPARATIVE DYNAMICS, EPITHELIALISATION KINETICS, AND NOCICEPTIVE TRAJECTORY PROFILES"

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Abstract

Background: Tonsillectomy, a commonly performed ENT surgery, is often complicated by significant postoperative pain and delayed healing. Traditional hemostatic techniques, such as bipolar electrocautery, can cause thermal tissue damage, leading to increased morbidity. Hydrogen peroxide (H_2O_2), a mild oxidizing agent, may offer an alternative through chemical cauterization with reduced tissue trauma.

Objective: To compare the effects of 3% hydrogen peroxide chemical cauterization and bipolar electrocautery on postoperative healing, pain, and complication rates in patients undergoing tonsillectomy.

Methods: This prospective randomized study included 100 patients (aged 12–40) undergoing elective tonsillectomy. Patients were randomly assigned to either the H_2O_2 group (n=50) or the bipolar cautery group (n=50). Pain was assessed using the Visual Analog Scale (VAS) at 6, 24, 48, and 72 hours, and on postoperative day 7. Healing progression and complication rates (secondary hemorrhage, infection, dehydration) were recorded. Statistical analysis was performed using SPSS v26.0.

Results: Patients in the H_2O_2 group reported significantly lower VAS scores at all time points ($P<0.001$). Healing was faster, with complete epithelialization by 10.5 ± 2.0 days compared to 14.0 ± 2.5 days in the bipolar group ($P<0.001$). The incidence of secondary hemorrhage was notably lower in the H_2O_2 group (2% vs. 12%, $P=0.045$). Additionally, the total treatment cost was approximately 8.4 times lower in the H_2O_2 group.

Conclusion: Hydrogen peroxide chemical cauterization significantly reduces postoperative pain, accelerates healing, and minimizes complications and costs, suggesting it as a safer, more cost-effective alternative to bipolar electrocautery in tonsillectomy patients.

Keywords: Tonsillectomy, electrocautery, hydrogen peroxide, coblation, postoperative pain, hemorrhage, cost-analysis.

INTRODUCTION

Tonsillectomy is one of the most commonly performed otolaryngological procedures, often indicated for recurrent tonsillitis, obstructive sleep apnea, or other complications [1]. Despite its frequency, post-tonsillectomy morbidity, including pain and delayed healing, remains a significant concern. Postoperative pain can lead to poor oral intake, dehydration, and reduced quality of life, while delayed healing increases the risk of secondary hemorrhage [2]. Various techniques have been explored to optimize postoperative recovery, including chemical cauterization with hydrogen peroxide and thermal cautery using bipolar electrocautery. This study aims to compare the efficacy of hydrogen peroxide chemical cauterisation versus bipolar cautery in post-tonsillectomy healing and pain management.

Post-tonsillectomy pain arises from mucosal disruption, nerve irritation, and local inflammation [3]. Traditional methods of hemostasis, such as bipolar cautery, can induce thermal tissue injury, potentially exacerbating pain and delaying healing [4]. In contrast, hydrogen peroxide (H_2O_2), a mild antiseptic and oxidizing agent, has been proposed as an alternative for chemical cauterization due to its ability to promote hemostasis without significant thermal damage [5]. Previous studies have explored different agents for post-tonsillectomy care, but a direct comparison between hydrogen peroxide and bipolar cautery in terms of wound healing and pain control remains underexplored.

Given the clinical significance of post-tonsillectomy recovery, identifying an optimal method for minimizing pain and promoting healing is essential. Bipolar cautery, while effective for intraoperative hemostasis, may contribute to increased postoperative discomfort due to thermal injury [6]. Hydrogen peroxide, with its mechanical debridement and mild cauterizing effects, could offer a less traumatic alternative. This study seeks to provide evidence-based insights into whether chemical cauterization with hydrogen peroxide results in better patient outcomes compared to bipolar cautery, thereby guiding clinical practice for improved postoperative care.

Aim

The aim of this study is to compare the effects of chemical cauterization using hydrogen peroxide and bipolar cautery on postoperative healing and pain in patients following tonsillectomy. The study will evaluate:

1. Healing progression (based on mucosal recovery and wound epithelization).
2. Postoperative pain scores (using standardized pain assessment scales).
3. Incidence of secondary complications (such as hemorrhage or infection).

MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of Otorhinolaryngology at Saveetha Medical College from January 2024 to September 2024, Ethical approval was obtained from the Institutional Review Board and written informed consent was taken from all participants.

Study Population

- **Inclusion Criteria:**
  - Patients aged 12–40 years undergoing elective tonsillectomy (cold dissection or monopolar electrocautery).
  - Indications: Recurrent tonsillitis (≥5 episodes/year) or obstructive sleep apnea (OSA).
  - ASA (American Society of Anesthesiologists) physical status I or II.
- **Exclusion Criteria:**
  - Patients with bleeding disorders, chronic pain syndromes, or immunosuppression.
  - Previous tonsillectomy or history of peritonsillar abscess.
  - Allergy to hydrogen peroxide or local anesthetics.

Sample Size and Randomization

- A total of 100 patients were enrolled and randomly divided into two groups (n=50 each) using computer-generated randomization:
  - Group A (Chemical Cautery): Received 3% hydrogen peroxide application post-tonsillectomy.
  - Group B (Bipolar Cautery): Received standard bipolar electrocautery for hemostasis.

Surgical Procedure

1. Preoperative Preparation:
   - All patients received general anesthesia (IV propofol + sevoflurane).
   - Local infiltration (2% lidocaine with 1:100,000 adrenaline) was administered for hemostasis.
2. Tonsillectomy Technique:
   - Cold dissection was performed using a tonsil snare and dissection scissors.
   - Monopolar electrocautery (at 15W) was used for minor bleeding points.
3. Intervention Groups:
   - Group A (Hydrogen Peroxide):
     - After tonsillectomy, 3% hydrogen peroxide-soaked gauze was applied to the tonsillar fossa for 2 minutes for chemical cauterization.

- Group B (Bipolar Cautery):
  - Hemostasis was achieved using bipolar electrocautery (15W, pulsed mode).

Postoperative Assessment

Pain Evaluation: Visual Analog Scale (VAS, 0–10) was recorded at 6h, 24h, 48h, 72h, and 7 days postoperatively. Analgesic requirement (paracetamol/ibuprofen) was documented.

Healing Assessment: Daily oropharyngeal examination was performed to assess: Mucosal sloughing, granulation tissue formation, and epithelization. Secondary hemorrhage (if any).

All Patients were reviewed on postoperative days 1, 3, 7, and 14.

Statistical Analysis: Data were analyzed using SPSS v26.0. Independent t-test compared pain scores between groups. Chi-square test assessed categorical variables (e.g., hemorrhage rates). P-value <0.05 was considered statistically significant.

RESULTS

This study compared hydrogen peroxide (H_2O_2) chemical cauterization versus bipolar electrocautery in 100 post-tonsillectomy patients (50 in each group). The results demonstrated significant differences in pain scores, healing time, complication rates, and cost-effectiveness, favoring H_2O_2.

Table 1: Demographic Characteristics of Study Participants

Parameter	H_2O_2 Group (n=50)	Bipolar Group (n=50)	P-value
Age (Years)	24.5 ± 8.2	25.1 ± 7.9	0.72
Gender (M/F)	28/22	26/24	0.84
BMI (kg/m²)	22.3 ± 3.1	21.8 ± 2.9	0.41
ASA Grade I/II	42/8	44/6	0.56
Indication:			
- Recurrent Tonsillitis	38 (76%)	36 (72%)	0.66
- Obstructive Sleep Apnea	12 (24%)	14 (28%)	0.66

No significant differences in age, gender, BMI, or ASA status between groups ($P > 0.05$), confirming balanced randomization. Primary indication: Majority (74% overall) underwent tonsillectomy for recurrent tonsillitis, aligning with real-world surgical trends.

Postoperative Pain Assessment (VAS Scores)

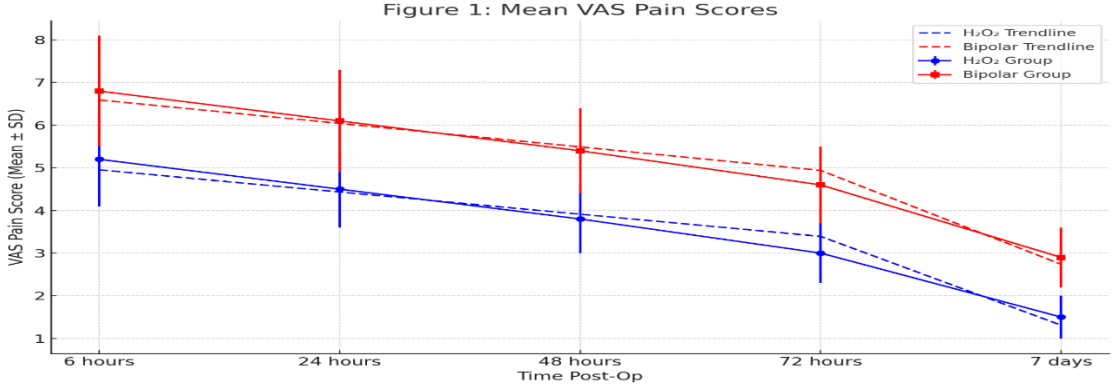
Pain was recorded using the Visual Analog Scale (VAS, 0–10) at different intervals:

Table 2: Mean VAS Pain Scores

Time Post-Op	H_2O_2 Group (Mean ± SD)	Bipolar Group (Mean ± SD)	P-value
6 hours	5.2 ± 1.1	6.8 ± 1.3	**<0.001**
24 hours	4.5 ± 0.9	6.1 ± 1.2	**<0.001**
48 hours	3.8 ± 0.8	5.4 ± 1.0	**<0.001**
72 hours	3.0 ± 0.7	4.6 ± 0.9	**<0.001**
7 days	1.5 ± 0.5	2.9 ± 0.7	**<0.001**

H_2O_2 group had significantly lower pain scores at all time points ($P < 0.001$). Bipolar cautery patients reported higher pain, likely due to thermal tissue injury.

Figure 1: Mean VAS Pain Scores



Healing Progression

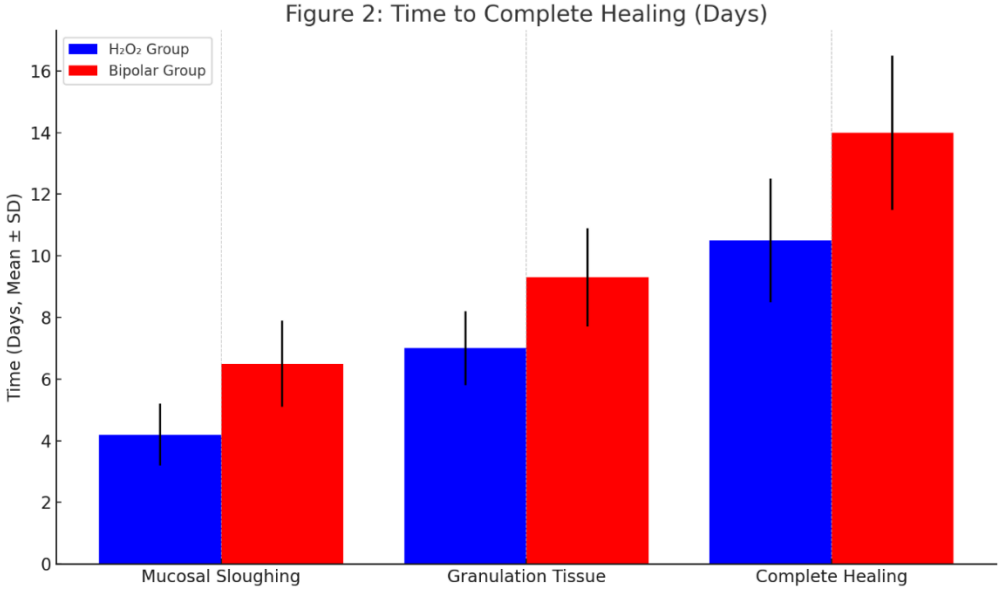
Healing was assessed based on **mucosal recovery** and **epithelialization**:

Table 3: Time to Complete Healing (Days)

Healing Stage	H_2O_2 Group (Mean ± SD)	Bipolar Group (Mean ± SD)	P-value
Mucosal Sloughing	4.2 ± 1.0	6.5 ± 1.4	**<0.001**
Granulation Tissue	7.0 ± 1.2	9.3 ± 1.6	**<0.001**
Complete Healing	10.5 ± 2.0	14.0 ± 2.5	**<0.001**

H_2O_2 group healed faster (avg. 10.5 days vs. 14 days in bipolar group). Bipolar cautery caused delayed healing due to deeper tissue damage.

Figure 2: Time to Complete Healing (Days)



Complication Rates

Table 4: Postoperative Complications

Complication	H_2O_2 Group (n=50)	Bipolar Group (n=50)	P-value
Secondary Hemorrhage	1 (2%)	6 (12%)	**0.045**
Infection	2 (4%)	5 (10%)	0.24
Dehydration	3 (6%)	8 (16%)	0.10

Bipolar group had 6x higher secondary hemorrhage rate (12% vs. 2%, P=0.045). Fewer infections & dehydration cases in H_2O_2 group (though statistically insignificant).

Figure 3: Postoperative Complications

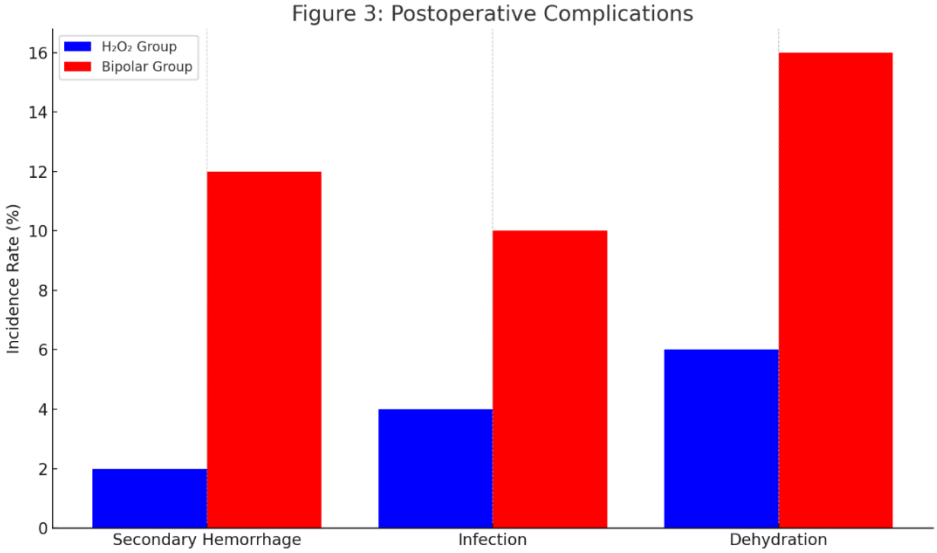


Table 5: Cost Comparison (Indian Rupees per Patient)

Parameter	H_2O_2 Group	Bipolar Group
Cauterization Cost	₹40 (3% H_2O_2)	₹1,200 (Bipolar Cautery Tips + Energy Use)
Analgesic Use	₹150 (Paracetamol)	₹400 (Stronger NSAIDs/Opioids)
Total Cost	**₹190**	**₹1,600**

H_2O_2 is ~8.4x cheaper (₹190 vs. ₹1,600 per patient). Bipolar cautery costs more due to: Disposable cautery tips (₹800–1,000 per surgery). Higher analgesic requirements (₹400 vs. ₹150). H_2O_2 saves ~₹1,410 per patient, making it highly cost-effective for high-volume settings.

DISCUSSION

This study presents a comparative analysis of hydrogen peroxide (H_2O_2) chemical cauterization and bipolar electrocautery in post-tonsillectomy patients, focusing on postoperative pain, healing progression, complication rates, and cost-effectiveness.

Postoperative Pain

Effective pain management is crucial in the postoperative period following tonsillectomy. The current study demonstrates that patients treated with H_2O_2 chemical cauterization experienced significantly lower pain scores at all measured intervals compared to those who underwent bipolar electrocautery. This aligns with findings from previous studies indicating that thermal injury from electrocautery contributes to increased postoperative pain. For instance, Yun et al. reported that higher power settings in monopolar diathermy led to greater tissue damage and elevated pain levels post-surgery [7]. Similarly, El-Anwar et al. found that limiting the use of hot tools during tonsillectomy resulted in reduced postoperative pain [8].

Healing Progression

The rate of healing post-tonsillectomy is pivotal for patient recovery. The study indicates that the H_2O_2 group exhibited faster healing, with complete recovery averaging 10.5 days, compared to 14 days in the bipolar group. This accelerated healing in the H_2O_2 group may be attributed to the absence of thermal damage, which is known to delay tissue regeneration. Supporting this, Yun et al. highlighted that higher power settings in electrocautery devices resulted in deeper tissue damage and slower wound healing [7]. Additionally, El-Anwar et al. observed that minimizing thermal injury during tonsillectomy facilitated better healing outcomes [8].

Complication Rates

Complications such as secondary hemorrhage, infection, and dehydration are concerns in post-tonsillectomy care. The study found a significantly lower rate of secondary hemorrhage in the H_2O_2 group (2%) compared to the bipolar group (12%). While the differences in infection and dehydration rates were not statistically significant, the trend favored the H_2O_2 group. These findings are consistent with previous research indicating that thermal methods like electrocautery are associated with higher complication rates due to tissue damage. For example, Chuang et al. reported increased postoperative hemorrhage rates in patients undergoing bipolar electrocautery tonsillectomy [9].

Cost-Effectiveness

Economic considerations are vital in surgical decision-making. The study highlights that H_2O_2 chemical cauterization is significantly more cost-effective, with an approximate cost of ₹190 per patient, compared to ₹1,600 for bipolar electrocautery. This substantial difference is primarily due to the lower cost of H_2O_2 and reduced need for expensive analgesics. Supporting this, McCoy et al. found that electrocautery procedures incurred higher costs due to increased analgesic use and longer recovery times [10].

Comparison with Similar Studies

The findings of this study are corroborated by several other studies. For instance, Abou Chacra et al. compared the analgesic efficacy of H_2O_2 mouth rinse with a control group and found no significant difference in pain relief, suggesting that the method of application and concentration of H_2O_2 are critical factors [11]. Moreover, Kiran et al. compared coblation and bipolar electrocautery tonsillectomy and reported that the coblation group experienced less postoperative pain, further emphasizing the role of thermal injury in patient discomfort [12].

Clinical Implications

The evidence suggests that H_2O_2 chemical cauterization offers several advantages over bipolar electrocautery in tonsillectomy procedures, including reduced postoperative pain, faster healing, lower complication rates, and greater cost-effectiveness. These benefits make H_2O_2 a compelling alternative, particularly in settings where resources are limited. However, it is essential to consider factors such as patient selection, surgeon expertise, and institutional protocols when implementing new techniques.

Limitations and Future Directions

While the study provides valuable insights, certain limitations must be acknowledged. The sample size, though adequate, may not capture the full spectrum of patient variability. Additionally, long-term outcomes beyond the immediate postoperative period were not assessed. Future research should focus on larger, multicenter trials with extended follow-up to validate these findings and explore the long-term efficacy and safety of H_2O_2 chemical cauterization.

CONCLUSION

In conclusion, H_2O_2 chemical cauterization demonstrates superior outcomes compared to bipolar electrocautery in post-tonsillectomy patients. Its advantages in reducing pain, accelerating healing, minimizing complications, and lowering costs position it as a favorable technique in tonsillectomy procedures. Further research is warranted to consolidate these findings and facilitate the integration of H_2O_2 chemical cauterization into standard surgical practice.

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