Impact of Low-Temperature Plasma Radiofrequency Tonsillectomy on Pain, Inflammatory Markers, and Sleep Quality in Adults with Chronic Tonsillitis

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AIM: Chronic tonsillitis (CT) is a very common ear, nose, and throat disease worldwide, and in severe cases it can cause sleep apnea hypoventilation syndrome, which can affect the patient's health and can even be life-threatening. Low-temperature plasma radiofrequency tonsillectomy is one of the commonly used methods for treating CT with remarkable results, but more detailed reports are lacking. In this study, we aimed to explore the impact of low-temperature plasma radiofrequency tonsillectomy on pain, inflammatory markers, and sleep quality in adult CT patients for clinical reference.

METHODS: A retrospective study was performed on adult patients diagnosed with CT at our hospital between June 2019 and October 2023. Patients were categorized into a control group receiving traditional tonsillectomy and a treatment group undergoing low-temperature plasma radiofrequency tonsillectomy. The groups were compared in terms of baseline characteristics, surgical parameters, visual analogue scale (VAS) scores, 36-item short form (SF-36) health survey questionnaire scores, inflammatory markers, and Pittsburgh Sleep Quality Index (PSQI) scores. Group differences in postoperative complications were also analyzed.

RESULTS: There were 160 patients, 80 in the treatment group (50 males and 30 females, mean age 28.90 $\pm$ 2.46 years) and 80 in the control group (46 males, 34 females, mean age 28.89 $\pm$ 2.01 years). Differences between the two groups in terms of age, sex, duration of disease, smoking history, body mass index, and other baseline characteristics were not statistically significant ($p > 0.05$). Operation time, intraoperative bleeding, return to normal diet, and pseudomembrane detachment time in the treatment group were all significantly lower than in the control group ($p < 0.05$). There were no significant differences in VAS or SF-36 scores before treatment ($p > 0.05$). Post-treatment, both groups had lower VAS scores and higher SF-36 scores in the treatment group compared to the control group ($p < 0.05$). There were no significant differences in levels of inflammatory markers before treatment ($p > 0.05$). Both groups showed increased levels of inflammatory markers post-treatment, but the treatment group had lower post-treatment levels of Interleukin-6 (IL-6) and hypersensitive-C reactive protein (hs-CRP) than the control group ($p < 0.05$). No significant difference was observed between the two groups in PSQI scores before treatment ($p > 0.05$). Following treatment, both groups had decreased PSQI scores, with lower scores in the treatment group than in the control group ($p < 0.05$). The complication rate was lower in the treatment group than in the control group, with rates of 8.75% and 23.75%, respectively ($p < 0.05$).

CONCLUSIONS: Low-temperature plasma radiofrequency tonsillectomy for adult CT patients offers advantages such as shorter surgical time, reduced intraoperative bleeding, minimal trauma, and fewer postoperative complications. This procedure significantly alleviates pain, improves quality of life, reduces levels of inflammatory markers, and enhances sleep quality.

Keywords: low-temperature plasma radiofrequency; tonsillectomy; chronic tonsillitis; inflammatory markers; sleep quality

Introduction

Adult chronic tonsillitis (CT) is a prevalent otorhinolaryngological disorder. Clinically characterized by chronic inflammation of tonsillar tissues, it manifests with various discomforting symptoms such as throat pain, difficulty swallowing, fever, and enlarged lymph nodes. The persistent inflammation leads to recurrent throat infections and, and may cause respiratory distress in severe cases, posing a threat to life [1, 2]. Currently, one of the traditional treatment approaches for adult CT is tonsillectomy, a surgical procedure that removes tonsillar tissue to alleviate inflammation and symptoms [3]. Traditional tonsillectomy with ultrasonic knife, high-frequency electric knife, despite the fact that it can completely remove the tonsils, is more traumatic for the patient. Intraoperative hemostasis is very poor, which not only increases the risk of infection in the patient, but also increases postoperative pain [4, 5].

In recent years, low-temperature plasma radiofrequency tonsillectomy has emerged as a novel therapeutic approach. This technique utilizes low-temperature plasma technology for precise removal of tonsillar tissue, reducing surgical duration, minimizing pain, shortening the recovery period, and promoting better postoperative outcomes. It offers a gentler alternative for the treatment of adult CT [6]. Low-temperature plasma radiofrequency tonsillectomy achieves

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precise excision of tonsillar tissue while minimizing damage to surrounding normal tissues [7]. Traditional surgery was often considered a thorough method for complete removal of tonsillar tissue, but it was associated with a prolonged postoperative recovery period, significant pain, and a higher risk of complications [8]. In contrast, although low-temperature plasma radiofrequency tonsillectomy may not achieve complete excision, it features smaller incisions, shorter postoperative recovery, reduced pain, and a lower risk of complications [9]. Although low-temperature plasma radiofrequency tonsillectomy for CT has been clinically recognized for its effectiveness, previous studies primarily focused on the clinical effects of this procedure and lacked a comprehensive view of patient outcomes [10, 11]. Furthermore, there is limited reporting on the inflammatory response and sleep quality after low-temperature plasma radiofrequency tonsillectomy.

Therefore, the aim of this study was to delve deeper into the role of low-temperature plasma radiofrequency tonsillectomy in adult patients with CT. We assessed its therapeutic efficacy and its impact on pain, inflammatory markers, and sleep quality. We sought to contribute additional evidence to guide the selection of tonsillectomy procedures and provide more suitable methods for the treatment of adult CT.

Materials and Methods

General Information

A retrospective study was performed on adult patients diagnosed with CT at our hospital between June 2019 and October 2023. Patients were divided into a control group and a treatment group based on varying treatment approaches. Inclusion criteria comprised: (1) age $\geq$18 years; (2) clinical diagnosis of CT with indications for tonsillectomy [12]; (3) presence of symptoms of chronic pharyngitis such as throat pain, difficulty swallowing, or persistent cough; (4) bilateral tonsils of grade III enlargement; (5) absence of other serious chronic diseases like heart disease or diabetes; (6) recurrent episodes of tonsillitis, occurring more than three times a year; (7) signed informed consent. Exclusion criteria included: (1) clear surgical contraindications; (2) acute tonsillitis instead of CT; (3) severe immune system disorders; (4) pregnant or lactating women; (5) incomplete case data; (6) patients who had undergone similar surgery previously; (7) individuals with significant organ dysfunction in the heart, lungs, kidneys, etc. Elimination criteria included: (1) occurrence of severe adverse events or complications threatening patient safety; (2) evident efficacy or inefficacy discovered during the study, rendering further scientific rationale for continuation obsolete; (3) voluntary withdrawal from the study by patients; (4) serious breaches of the research protocol or methods. This study was approved by the Ethics Committee of Yuyao People's Hospital (2023-11-001) and all subjects signed an informed consent form. In addition, the study was conducted in strict compliance with the *Declaration of Helsinki*.

Treatment

Control Group

Patients in the control group underwent traditional tonsillectomy. The procedure involved an incision made 1 millimeter outside the free edge of the palatine arch, from the upper to the lower pole of the tonsil, using a tonsil dissector to facilitate separation. The upper pole of the tonsil was exposed, and dissection proceeded along the direction of the capsule from the upper to the lower pole, completing the removal of the entire tonsil using a snare. Hemostasis was achieved by applying gauze balls to areas with bleeding in the tonsillar fossa, employing methods such as ligation or suturing for significant bleeding sites. Postoperative care included intravenous infusion of cefoperazone sodium (Beijing Taiyang Pharmaceutical Co., Ltd., Beijing, China, code number approved by State Food and Drug Administration (SFDA) of China: H20043231), specification: 1 g, combined with normal saline (Hebei Tiancheng Pharmaceutical Co., Ltd., Cangzhou, China, code number approved by SFDA of China: H20143077, Specification: 100 mL) at a rate of twice daily for three consecutive days. On the first day after the surgery, a mouthwash with compound chlorhexidine solution (Jiangsu Chenpai Pharmaceutical Co., Ltd., Nantong, China, code number approved by SFDA of China: H20058018, Specification: 150 mL) was used to clean the surgical cavity three times a day for one week.

Treatment Group

Patients in the treatment group underwent tonsillectomy using a low-temperature plasma radiofrequency knife. The procedure involved setting the temperature of the low-temperature plasma radiofrequency knife between 40 °C and 70 °C. The tonsil was pulled downward with forceps, and an incision was made on its mucosa 2 millimeters outside the lateral aspect of the palatopharyngeal arch, completely exposing the upper pole capsule of the tonsil. The capsule was incised from top to bottom, and the tonsil was dissected and removed within the capsule and its surrounding interstitial space, with hemostasis achieved using electrocoagulation. The cutting energy of the low-temperature plasma system was set to level 7, and the coagulation energy was set to level 4. Postoperatively, both groups of patients received intravenous hemostatic treatment for one day. Patients were instructed to use saline mouthwash regularly to maintain cleanliness of the surgical cavity.

Observation Indicators

Surgical Parameters

Surgical parameters were documented for both groups, including operation time, intraoperative blood loss, time until resuming a regular diet, and pseudomembrane shedding time.

Table 1. Patient baseline comparison.

Groups	Control group (n = 80)	Treatment group (n = 80)	t/χ^2	p
Age (years), mean ± SD	28.89 ± 2.01	28.90 ± 2.46	0.035	0.972
Sex (male/female)	46/34	50/30	0.417	0.519
Duration of illness (years)	5.74 ± 1.89	6.11 ± 1.65	1.334	0.184
Smoking history (yes/no)	52/28	48/32	0.427	0.514
Body mass index (kg/m^2), mean ± SD	24.71 ± 1.90	25.11 ± 2.09	1.265	0.208
Family history of disease (yes/no)	12/68	8/72	0.914	0.339
Drinking history (yes/no)	34/46	28/52	0.948	0.330
Place of residence (urban/rural)	49/31	52/28	0.242	0.623
History of conservative treatment (yes/no)	59/21	64/16	0.879	0.349

SD, standard deviation.

Pain

The pain was assessed preoperatively and one month postoperatively using a visual analogue scale (VAS) [13]. Scores were recorded along a 10 cm line on paper, segmented into 10 sections, each denoting a pain level. Scores for mild, moderate, and severe pain were 0–3, 4–7, and 8–10, respectively.

Quality of Life

Quality of life was assessed using the 36-item short form (SF-36) health survey questionnaire [14]: which evaluates vitality, mental health, and physical functioning, with a maximum of 100 points for each dimension. Higher scores indicate better quality of life. Evaluation was conducted by a qualified attending physician.

Inflammatory Markers

Fasting venous blood (4 mL) was collected from adult patients preoperatively and 1 month postoperatively. The blood was centrifuged at 3000 rpm for 10 minutes and stored at –80 °C for analysis. Interleukin-6 (IL-6) and hypersensitive-C reactive protein (hs-CRP) levels were measured using an enzyme-linked immunosorbent assay (ELISA) kit from Shanghai Jianglai Biotechnology Co., Ltd. (Shanghai, China).

Sleep Quality

Sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI) [15]: an 18-item questionnaire categorized into six sections: sleep quality, sleep onset latency, sleep duration, sleep efficiency, and sleep disorders. The PSQI has a total score of 21, with higher scores indicating poorer sleep.

Prognostic Follow-up

Follow-up was conducted for all patients. Postoperative complications documented for both groups included: Infections, fever, cough, and uvula edema. The follow-up period was June 1, 2019, to October 30, 2023, the interval between each recurrence did not exceed 3 months.

Statistical Analyses

The statistical analyses were conducted using statistical software SPSS 23.0. (SPSS Inc., Armonk, NY, USA) Continuous measurements (including age, duration of disease, body mass index, operation time, intraoperative bleeding, time to return to normal diet, pseudomembrane detachment time, VAS and SF-36 scores, inflammatory indices, and PSQI scores) were presented as mean ± standard deviation ($\bar{x} \pm S$) and differences between groups were assessed using t-tests. Categorical measurements (gender, smoking history, and postoperative complications) were presented as count and percentage (%) and associations were assessed using the χ^2 test. Statistical significance was indicated by p values < 0.05.

Results

Patient Baseline Comparison

There were 160 patients in the study, 80 in the treatment group (50 males and 30 females, mean age 28.90 ± 2.46 years) and 80 in the control group (46 males, 34 females, mean age (28.89 ± 2.01 years). Differences between the two groups in terms of age, sex, duration of disease, smoking history, body mass index, and other baseline characteristics were not statistically significant ($p > 0.05$) (Table 1).

Comparison of Surgery-Related Indicators

Operation time, intraoperative bleeding, return to normal diet, and pseudomembrane detachment time in the treatment group were all significantly lower than in the control group ($p < 0.05$) (Fig. 1).

Comparison of VAS and SF-36 Scores

There were no significant differences between groups before treatment ($p > 0.05$). Both groups had significantly lower post-treatment VAS scores and higher SF-36 scores compared to pre-treatment. Comparison of post-treatment scores indicated significantly lower VAS scores and higher SF-36 scores in the treatment group compared to the control group ($p < 0.05$) (Fig. 2).

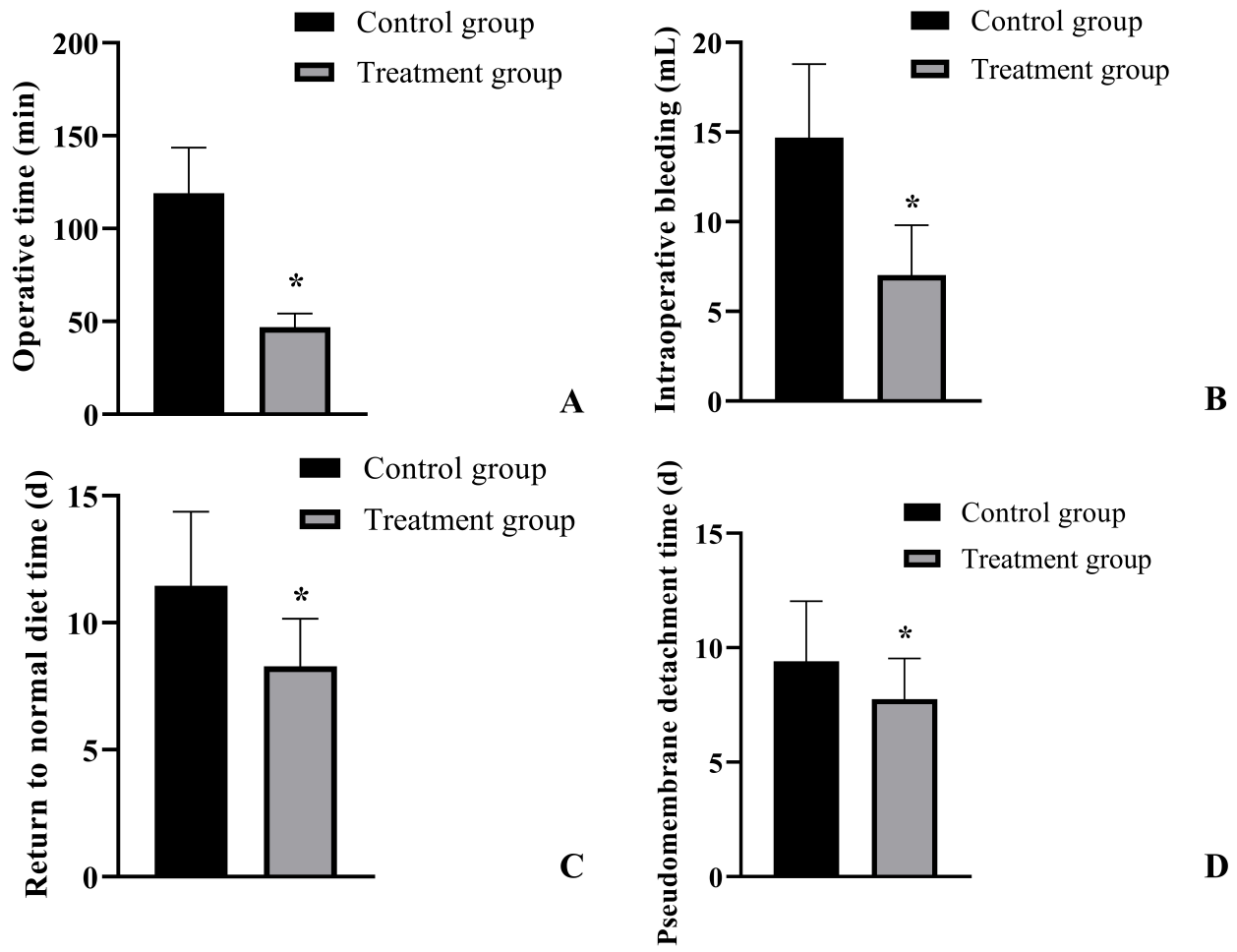

Fig. 1. Comparison of surgery-related indicators ($\bar{x} \pm S$). (A) Operative time. (B) Intraoperative bleeding. (C) Time to return to normal diet. (D) Time to pseudomembrane detachment. Comparison with control group: * $p < 0.05$.

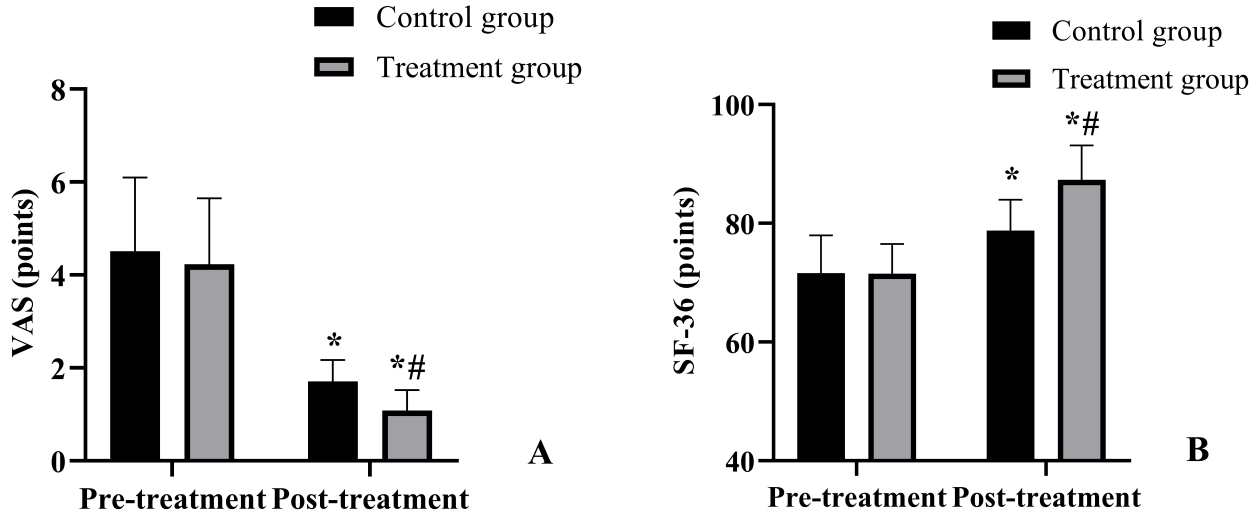

Fig. 2. Comparison of VAS and SF-36 scores ($\bar{x} \pm S$, points). (A) Visual analogue scale (VAS) scores. (B) 36-item short form (SF-36) health survey questionnaire scores. Comparison with pre-treatment: * $p < 0.05$; with control group post-treatment: # $p < 0.05$.

Comparison of IL-6 and hs-CRP Levels

There were no significant differences between groups before treatment ($p > 0.05$). Both groups showed increased levels of inflammatory markers post-treatment, and the treatment group had lower IL-6 and hs-CRP levels than the control group ($p < 0.05$) (Fig. 3).

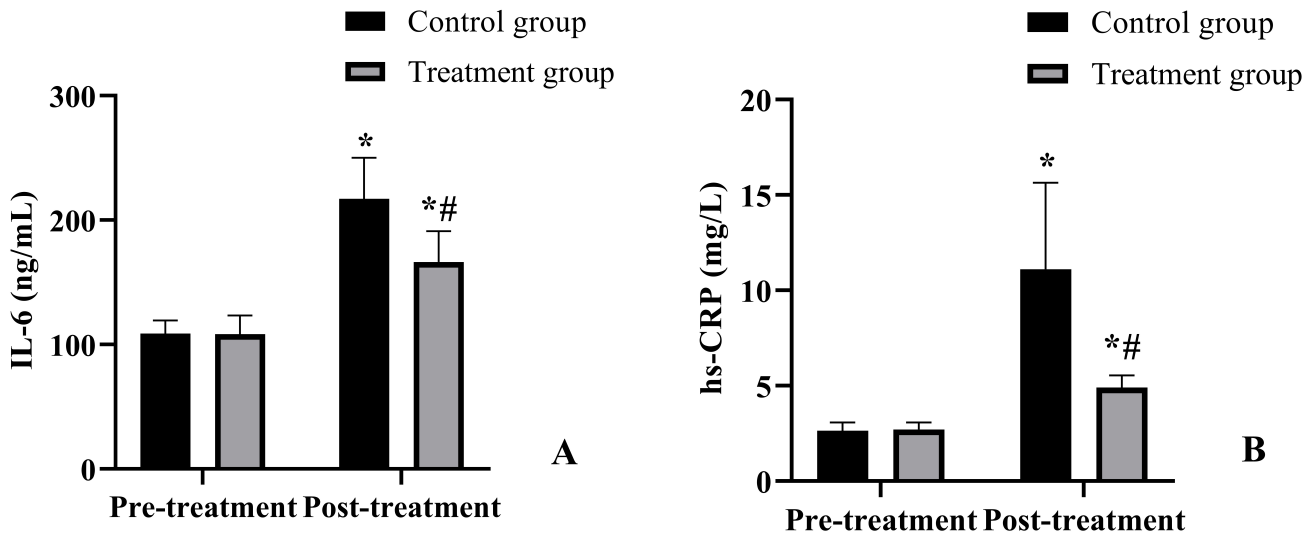

Fig. 3. Comparison of IL-6 and hs-CRP levels ($\bar{x} \pm S$). (A) Interleukin-6 (IL-6) levels. (B) hypersensitive-C reactive protein (hs-CRP) levels. Comparison with pre-treatment: $^{*}\ p < 0.05$; with control group post-treatment: $\#\ p < 0.05$.

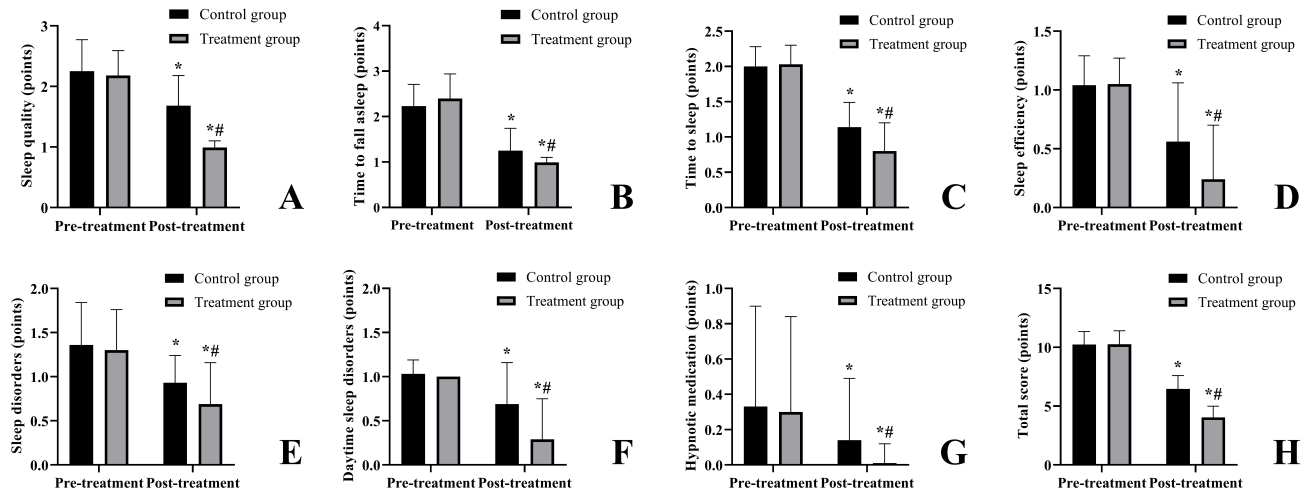

Fig. 4. Comparison of PSQI scores ($\bar{x} \pm S$, points). (A) Sleep quality score. (B) Time to fall asleep score. (C) Time to sleep score. (D) Sleep efficiency score. (E) Sleep disorders score. (F) Daytime sleep disorders score. (G) Hypnotic medication score. (H) Pittsburgh Sleep Quality Index (PSQI) total score. Comparison with pre-treatment: $^{*}\ p < 0.05$; with control group post-treatment: $\#\ p < 0.05$.

Comparison of PSQI Scores

No significant difference was observed between the two groups before treatment ($p > 0.05$). Following treatment, both groups showed decreased PSQI scores, with the treatment group having lower than the control group ($p < 0.05$) (Fig. 4).

Comparison of the Occurrence of Complications between the Two Groups of Patients

The complication rate of the treatment group was lower than that of the control group ($p = 0.010$, $\chi^2 = 6.613$). All complications were manageable, were treated in a timely manner, and did not affect the normal course of treatment and symptomatic relief (Table 2).

Discussion

In this study, we found that low-temperature plasma radiofrequency tonsillectomy for the treatment of adult CT patients is not only safe but also effectively reduces postoperative pain and improves patients' quality of life, which shows that this treatment option has a high value for future application in CT.

The tonsils, enveloped by the tonsillar capsule at the upper end and covered by the palatine arch at the lower end, are lymphoid tissues that play a crucial role in local immune responses [16]. CT in adults refers to the prolonged inflammation of tonsillar tissues, resulting in a chronic inflammatory state [17, 18]. Although tonsillar issues are often associated with childhood ailments, adults are equally susceptible to tonsillitis, potentially leading to various otolaryngological complications [19]. This condition significantly

Table 2. Comparison of the occurrence of complications between the two groups of patients (n [%]).

Groups	Number of patients	Postoperative complication				Total incidence
		Infections	High temperature	Cough	Uvula oedema	
Control group	80	7 (8.75)	4 (5.00)	3 (3.75)	5 (6.25)	19 (23.75)
Treatment group	80	3 (3.75)	1 (1.25)	1 (1.25)	2 (2.50)	7 (8.75)
χ^2						6.613
p						0.010

impairs patients' normal life and work routines, reducing their overall quality of life. Hence, effective treatment for adult CT is essential.

Traditional tonsillectomy, one of the conventional treatments for adult CT, involves the removal of tonsillar tissues through surgery to alleviate inflammation and associated symptoms [20]. While effective in many cases, this method requires general anesthesia, involves considerable postoperative pain, and has a prolonged recovery period, leading to potential complications [21]. In recent years, plasma radiofrequency tonsillectomy has emerged as a novel treatment method. Utilizing low-temperature plasma technology, it offers more precise removal of tonsillar tissues, reducing surgical time, pain, and postoperative complications [22]. Plasma radiofrequency tonsillectomy enables more accurate tissue removal, minimizing damage to surrounding normal tissues [23]. Compared to traditional surgery, it is associated with smaller incisions, reduced bleeding, milder pain, and faster recovery, allowing patients to resume normal life promptly.

In this study, the treatment group had shorter operative time, less intraoperative blood loss, earlier resumption of normal diet, and shorter pseudomembrane detachment time compared to the control group. This suggests that the use of low-temperature plasma radiofrequency technology is more efficient and causes less trauma during surgery, possibly due to its precise tissue handling, reducing heat-related damage to surrounding tissues. Previous research by Puges *et al*. [24] indicated that the formation of pseudomembranes above the tonsillar crypts might impede inflammatory cell infiltration around the tonsils. In our study, patients in the treatment group reported lighter pain sensations, and the pseudomembrane shedding time was significantly reduced. This may be attributed to heat-induced changes in the tonsillar peritonsillar connective tissue or collagen, forming pseudomembranes covering tonsillar crypts, significantly affecting surgical outcomes. Regarding postoperative pain perception and quality of life, the treatment group demonstrated clear advantages in VAS and SF-36 scores. This could be attributed to the minimally invasive nature of the surgery, facilitating a quicker recovery and reduced pain perception. The increase in SF-36 scores also implies substantial improvements in patients' quality of life. CT is a common upper respiratory tract infection, and changes in inflammatory indicators such as IL-6 and hs-CRP play a crucial role in chronic inflammation [25]. IL-6 is a multifunctional cytokine associated with inflammation, infection, and tissue damage. In CT, repeated stimulation of the immune system by bacteria and viruses can lead to an elevation in IL-6 levels [26]. Although an increase in IL-6 is a physiological response to inflammation, prolonged elevation may lead to an overactive immune system, exacerbating inflammation [27]. hs-CRP is a sensitive, improved form of CRP synthesized mainly in the liver. In chronic inflammatory states, especially in bacterial infections, hs-CRP levels increase [28]. In CT, continuous inflammatory stimulation may lead to persistent hs-CRP production. Elevated hs-CRP levels indicate the body's ongoing inflammatory response [29]. In our study, both groups exhibited increased IL-6 and hs-CRP levels after treatment, with the treatment group displaying significantly lower post-treatment levels of both markers. This suggests that low-temperature plasma radiofrequency technology has a certain inhibitory effect on postoperative inflammatory reactions, likely due to the smaller tissue trauma associated with this technique, resulting in a relatively mild inflammatory response. The treatment group demonstrated greater improvement in sleep quality postoperatively. This may be due to the minimally invasive nature of the surgery, making it easier for patients to enter a good sleep state postoperatively. Treatment group PSQI scores were superior to those of the control group, possibly due to reduced pain perception and improved quality of life. Additionally, the treatment group exhibited a lower postoperative complication rate compared to the control group. This may be attributed to the precise tissue handling of the low-temperature plasma radiofrequency knife, reducing the occurrence of complications and providing robust support for the safety of this technology.

This study has some limitations. It only included adult CT patients treated in a specific period at one hospital, and the sample may not comprehensively represent the entire population of CT patients. Results may need careful consideration when extrapolating to other regions or populations due to geographical and demographic variations. In this study, IL-6 and hs-CRP levels were used as inflammatory indicators, but these are only partial indicators of the inflammatory response. Other biomarkers potentially related to inflammation and changes in other aspects of the immune system were not fully considered. Future research could incorporate a more comprehensive evaluation of patients' immune status.

Conclusions

Low-temperature plasma radiofrequency tonsillectomy demonstrates excellent clinical outcomes in treating adult CT. Because it is a minimally invasive technique it optimizes surgical efficiency and also provides significant advantages regarding postoperative pain, quality of life, inflammatory response, and sleep quality.

Availability of Data and Materials

The datasets used or analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

YHG and JNG designed and conducted the experiments, analyzed the data, and contributed to writing and editing the manuscript. JNG performed the research and provided help and advice on the experiments. Both authors revised the manuscript critically for important intellectual content. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Yuyao People's Hospital (2023-11-001) and all subjects signed an informed consent form. In addition, the study was conducted in strict compliance with the *Declaration of Helsinki*.

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Conflict of Interest

The authors declare no conflict of interest.

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