Radiofrequency tonsil reduction in pediatric obstructive sleep apnea: impact on quality of life assessed by the OSA-18

Original Article

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Abstract

Objective: To evaluate the impact of radiofrequency tonsil reduction combined with adenoidectomy on the quality of life of children with obstructive sleep apnea syndrome using the OSA-18 questionnaire.
Materials and Methods: Prospective study including 44 children (2–15 years) with OSA who underwent adenoidectomy and radiofrequency tonsil reduction. Quality of life was assessed preoperatively and 3–6 months after surgery using the Portuguese version of the OSA-18 questionnaire.
Results: The OSA-18 score decreased from 71.02 to 35.16 ($p < 0.001$), with improvement observed across all domains, particularly in sleep disturbance and caregiver concern. Obesity was associated with a smaller magnitude of improvement ($p = 0.015$) and higher postoperative scores ($p = 0.028$).
Conclusion: Radiofrequency tonsil reduction combined with adenoidectomy significantly improves quality of life and represents an effective alternative to tonsillectomy for the treatment of pediatric OSAS. Obesity was identified as an independent factor associated with poorer outcomes.

Keywords: obstructive sleep apnea; child; radiofrequency; OSA-18; quality of life; obesity.

Introduction

Obstructive sleep apnea (OSA) is a respiratory disorder characterized by recurrent episodes of partial or complete upper-airway obstruction during sleep, resulting in altered ventilation and disruption of normal sleep patterns.[1] It is a predominant disorder in the pediatric population, affecting approximately 1%–5% of children, most frequently between 2 and 8 years of age, as this is the period during which the most Waldeyer's ring hypertrophy occurs.[2–4] Adenotonsillar hypertrophy is considered the most common cause of childhood OSA because it contributes to airway narrowing, especially during sleep-related muscle relaxation.[5,6] The clinical manifestations of pediatric OSA vary and may include nocturnal symptoms such as snoring, breathing pauses, predominant mouth breathing, restless sleep, or night sweats as well as daytime symptoms such as excessive daytime sleepiness, behavioral changes, and difficulty concentrating.[2,7] When untreated, OSA is associated with several comorbidities, including growth delay, behavioral changes, neurocognitive dysfunction, poor school performance, hyperactivity, and cardiovascular complications.[8–11] Polysomnography (PSG) is considered the *gold-standard* test for diagnosing OSA because it provides objective data on disease severity.[7] However, its limited accessibility and high cost hinder widespread use.[7,12,13] Therefore, alternative methods - such as clinical history, physical examination, nocturnal oximetry, and/or clinical evaluation questionnaires - are frequently used to diagnose this syndrome.[3,14,15] Early identification and suitable treatment are crucial to mitigate the potential consequences of OSA. Adenotonsillectomy is considered an effective first-line treatment, or an option after the failure of medical therapy.[6,16] Although total tonsillectomy has historically been the most common method, less invasive techniques such as radiofrequency tonsillar reduction have been gaining popularity.[17] Studies show that this technique can be as effective as total tonsillectomy in improving obstructive symptoms, with advantages such as lesser postoperative pain, a lower risk of hemorrhage, and a faster return to normal activities.[18,19]

Considering the clinical relevance of pediatric OSA and limited access to objective diagnostic methods such as PSG, it is important to evaluate the impact of alternative strategies on these children's quality of life. Therefore, the present study aimed to evaluate the efficacy of radiofrequency tonsillar reduction combined with adenoidectomy in improving the quality of life in children with suspected OSA, using the validated Portuguese version of the OSA-18 questionnaire as the evaluation tool, and to identify predictors of clinical improvement.

Materials and methods

We conducted a prospective study between September 2023 and September 2024 that included children aged 2 to 15 years with symptoms suggestive of OSA based on caregiver-reported clinical history and physical examination. The inclusion criteria were: (1) grade ≥ II tonsillar hypertrophy (according to the Friedman classification,[20] which grades the palatine tonsil volume on a scale from 0 to IV based on how far the tonsils extend medially in relation to the tonsillar pillars and oropharyngeal midline); (2) habitual snoring reported by caregivers (occurring for most of the night, on ≥ 3 nights per week, for ≥ 3 months); and (3) breathing pauses during sleep observed by caregivers. Children with severe comorbidities or medical conditions that could interfere with the results—such as craniofacial malformations, genetic syndromes, or neuromuscular diseases—and children with a history of adenotonsillar surgery were excluded. All children underwent adenoidectomy and radiofrequency tonsillar reduction under general anesthesia with orotracheal intubation at Hospital Beatriz Ângelo. The surgical procedure began with adenoidectomy by curettage using a Beckmann curette under direct vision, followed by radiofrequency tonsillar reduction (RaVoR technique—Radiofrequency Volume Reduction) with a RaVoR™ bipolar electrode (Sutter Medizintechnik, Freiburg, Germany) and CURIS® 4 MHz radiofrequency generator (Sutter Medizintechnik) in bipolar coagulation mode at a power setting of 10 W.

The quality of life was assessed preoperatively and 3 to 6 months after surgery using the validated Portuguese version of the Obstructive Sleep Apnea-18 questionnaire[21] (OSA-18; Figure 1). The OSA-18 questionnaire is a validated instrument for assessing the quality of life in children with OSA, developed by Franco et al.[22] It consists of 18 questions divided into five domains: sleep disturbance, physical suffering, emotional distress, daytime problems, and caregiver concerns. The questionnaire is completed by caregivers,

Figure 1
Obstructive Sleep Apnea-18 (OSA-18) Questionnaire, validated Portuguese version[21]

Em cada uma das questões seguintes, faça por favor um círculo à volta do número que melhor descreve a frequência de cada sintoma ou problema nas últimas 4 semanas. Assinale apenas um número por questão. Obrigado.							
	Nunca	Quase nunca	Poucas vezes	Algumas vezes	Bastantes vezes	Quase sempre	Sempre
Distúrbio do Sono							
Nas últimas 4 semanas, com que frequência o seu filho teve...							
Ressonar alto?	1	2	3	4	5	6	7
Paragens na respiração durante a noite?	1	2	3	4	5	6	7
Engasgos ou respiração ofegante enquanto dormia	1	2	3	4	5	6	7
Sono agitado ou despertares frequentes do sono	1	2	3	4	5	6	7
Sintomas Físicos							
Nas últimas 4 semanas, com que frequência o seu filho teve...							
Respiração bucal por obstrução nasal?	1	2	3	4	5	6	7
Resfriados ou infeções das vias aéreas superiores?	1	2	3	4	5	6	7
Secreção e congestão nasal?	1	2	3	4	5	6	7
Dificuldade em engolir alimentos?	1	2	3	4	5	6	7
Problemas Emocionais							
Nas últimas 4 semanas, com que frequência o seu filho teve...							
Alterações do humor ou acessos de raiva?	1	2	3	4	5	6	7
Comportamento agressivo ou hiperativo?	1	2	3	4	5	6	7
Problemas disciplinares?	1	2	3	4	5	6	7
Problemas do Quotidiano							
Nas últimas 4 semanas, com que frequência o seu filho teve...							
Sonolência diurna excessiva?	1	2	3	4	5	6	7
Episódios de falta de atenção ou concentração?	1	2	3	4	5	6	7
Dificuldade ao levantar da cama de manhã?	1	2	3	4	5	6	7
Preocupação dos Cuidadores							
Nas últimas 4 semanas, com que frequência os problemas acima descritos...							
Causaram preocupação com a sua saúde?	1	2	3	4	5	6	7
Preocuparam-no pelo seu filho poder não respirar ar suficiente?	1	2	3	4	5	6	7
Interferiram com as suas atividades diárias?	1	2	3	4	5	6	7
Deixaram-no frustrado?	1	2	3	4	5	6	7

and each item is scored on a scale of 1 to 7, reflecting the frequency of symptoms during the previous 4 weeks. The total OSA-18 score ranges from 18 to 126 points: values below 60 indicate a mild impact on the quality of life, values between 60 and 80 indicate a moderate impact, and values above 80 are associated with a severe impact.

Sociodemographic, biometric, and clinical data were also collected pre- and postoperatively, including age, sex, body mass index (BMI), and tonsillar hypertrophy grade (according to the Friedman classification). The nutritional status was classified using the National Center for Health Statistics (NCHS) growth charts adopted by the Directorate-General of Health (DGS) in Clinical Guideline No. 05/DSMIA of 2006.[23] Overweight was defined as a BMI between the 85th and 95th percentiles and obesity as a BMI at or above the 95th percentile for age and sex.

Statistical analysis was conducted using Python-based statistical tools on the Julius AI analytical platform. Continuous variables with a normal distribution were presented as mean ± standard deviation (SD), and variables with a nonnormal distribution as median and interquartile range (IQR). Categorical variables were expressed as absolute and relative frequencies. The normality of the distributions was assessed using the Shapiro–Wilk test.

Paired continuous variables were compared between the pre- and postoperative periods using the paired Student *t*-test when the differences were normally distributed; otherwise, the Wilcoxon signed-rank test was used. Continuous variables were compared between independent groups using Welch's t-test for independent samples. When the comparison included more than two groups, one-way analysis of variance (ANOVA) was used. The associations between continuous variables were assessed using Spearman's correlation coefficient.

A univariable analysis was first performed to explore the factors potentially associated with the magnitude of clinical improvement, defined as ΔOSA-18 (preoperative OSA-18 score − postoperative OSA-18 score). Subsequently, two multiple linear regression models were constructed. In the first model, ΔOSA-18 was used as the dependent variable, with the preoperative OSA-18 score, age, sex, obesity, and preoperative tonsillar hypertrophy grade as independent variables, to identify the factors associated with the magnitude of clinical improvement. In the second model, the postoperative OSA-18 score was used as the dependent variable, adjusting for the preoperative OSA-18 score and remaining clinical variables, to identify the factors associated with the clinical status after surgery. The residual normality was evaluated using the Shapiro–Wilk test, and heteroscedasticity using the Breusch–Pagan test. Where appropriate, robust standard errors (HC3) were used to ensure valid statistical inference. In all analyses, a *P*-value < .05 was considered statistically significant.

Results

Sample characteristics

A total of 44 children were included, none of whom were lost to follow-up. The sample included 26 boys (59.1%) and 18 girls (40.9%), with a median age of 5.5 years (IQR 4.0–8.0). Regarding the nutritional status, 22 children (50.0%) had normal weight, 4 children (9.1%) were overweight, and 18 children (40.9%) had obesity (Table 1). Preoperatively, most children had grade III tonsillar hypertrophy (n = 26; 59.1%), followed by grade IV (n = 12; 27.3%) and grade II (n = 6; 13.6%).

Comparison of OSA-18 scores before and after surgery

Preoperatively, the impact on the quality of life assessed by the OSA-18 was mild in 15 children (34.1%), moderate in 12 children (27.3%), and severe in 17 children (38.6%). After surgery, the severity distribution improved markedly: 43 children (97.7%) were classified as having a mild impact and 1 (2.3%) as having a moderate impact, with no cases of severe impact.

The mean total OSA-18 score decreased from 71.02 ± 19.52 preoperatively to 35.16 ± 11.54

postoperatively, corresponding to a mean reduction of 35.86 points (95% CI, 30.36–41.37), equivalent to a relative improvement of approximately 50% (Table 2). This difference, evaluated using a paired Student *t*-test, was statistically significant ($P < .001$), with a very large effect size (Cohen's d = 1.98). Analysis of the change in OSA-18 severity category, assessed using the Wilcoxon signed-rank test, confirmed a significant reduction in the disease impact after surgery ($P < .001$).

Analysis by OSA-18 domains

The scores decreased significantly in all OSA-18 domains after surgery, as assessed by paired Student *t*-test (Table 2). The largest improvements occurred in the Sleep Disturbance and Caregiver Concerns domains, with relative reductions of 66.7% and 61.5%, respectively. The Physical Suffering domain showed an intermediate improvement (47.7%), while the Emotional Distress and Daytime Problems domains showed more moderate reductions.

Change in tonsillar hypertrophy grade

After surgery, there was a marked reduction in the tonsillar hypertrophy grade. Postoperatively, 37 children (84.1%) had grade I and 7 children (15.9%) had grade II tonsillar hypertrophy; no cases of grade III or IV were observed (Table 3). The median tonsillar grade decreased from 3.0 preoperatively to 1.0 postoperatively; this reduction was statistically

Table 1
Sample characteristics

Parameter	Value
Total number of patients (n)	44
Age (years), median (IQR)	5.5 (4.0–8.0)
Sex, n (%)	
Female	18 (40,9%)
Male	26 (59,1%)
BMI percentile, n (%)	
<3rd percentile	2 (4,5%)
3rd–85th percentile	20 (45,5%)
85th–95th percentile	4 (9,1%)
≥95th percentile	18 (40,9%)
Preoperative tonsillar hypertrophy grade, n (%)	
I	0 (0,0%)
II	6 (13,6%)
III	26 (59,1)
IV	12 (27,3)

Table 2
Comparison of OSA-18 scores before and after surgery

Domain	Pre (mean ± SD)	Post (mean ± SD)	p-value	Absolute improvement (points)	Relative improvement (%)
Sleep Disturbance	20.07 ± 3.76	6.68 ± 2.24	<0,001	13.39	66.7
Physical Suffering	14.43 ± 5.63	7.55 ± 2.91	<0,001	6.88	47.7
Emotional Distress	8.95 ± 5.61	6.98 ± 4.34	0,003	1.97	22.0
Daytime Problems	10.45 ± 4.24	7.36 ± 3.02	<0,001	3.09	29.6
Caregiver Concerns	17.11 ± 6.91	6.59 ± 4.24	<0,001	10.52	61.5
Total OSA-18	71,02 ± 19,52	35,16 ± 11,54	<0,001	35.86	50.5%

significant by the Wilcoxon signed-rank test (*P* < .001). All patients had a decrease in tonsillar grade.

Univariable analysis

A univariable analysis was performed to explore the factors potentially associated with the magnitude of clinical improvement, defined as ΔOSA-18 (preoperative OSA-18 score − postoperative OSA-18 score; Table 4). No statistically significant difference in clinical improvement was observed between children with and without obesity (mean difference, −7.6 points; 95% CI, −18.76 to 3.42; *P* = .170). Similarly, sex, age, and the preoperative tonsillar hypertrophy grade were not significantly associated with the magnitude of clinical improvement. However, a positive association was observed between the preoperative OSA-18 score and magnitude of improvement, indicating that higher preoperative scores were associated with a greater reduction in score after surgery (β = .756; 95% CI, 0.588–0.924; *P* < .001).

Multivariable analysis of the magnitude of clinical improvement

Multiple linear regression was conducted using ΔOSA-18 as the dependent variable and preoperative OSA-18 score, age, sex, obesity, and preoperative tonsillar hypertrophy grade as independent variables (Table 4). The model had an R^2 of .722, explaining approximately 72% of the variability in clinical improvement. After adjustment for the remaining parameters, obesity was associated with a milder magnitude of clinical improvement, corresponding to a mean reduction of approximately 8.3 points in ΔOSA-18 (β = −8.29; 95% CI, −14.88 to −1.70; *P* = .015). The preoperative OSA-18 score remained significantly associated with the magnitude of improvement, with a mean increase of .78 points in improvement for each additional point in the baseline score (β = 0.782; 95% CI, 0.603–0.960; *P* < .001). The remaining variables included in the model showed no statistically significant association with clinical improvement.

Table 3
Tonsillar hypertrophy grade in the pre- and postoperative periods

Tonsillar grade	Preoperative n (%)	Postoperative n (%)
Grade I	0 (0.0%)	37 (84.1%)
Grade II	6 (13.6%)	7 (15.9%)
Grade III	26 (59.1%)	0 (0.0%)
Grade IV	12 (27.3%)	0 (0.0%)

Table 4
Predictors of the magnitude of clinical improvement (ΔOSA-18)

Variable	Univariable analysis		Multivariable analysis	
	95% CI	P-value	95% CI	P-value
Preoperative OSA-18	0.588 a 0.924	<0.001	0,603 – 0,960	<0,001
Obesity	-18.756 a 3.423	0.17	−14,877 – −1,695	0,015
Age	-3.77 a 0.096	0.062	-0.94, 1.66	0.579
Sex	-13.251 a 9.405	0.734	-8.94, 4.51	0.509
Tonsillar hypertrophy grade (II vs. III)	-10.56 a 23.124	0.456	-8.88, 10.69	0.853
Tonsillar hypertrophy grade (II vs. IV)	-11.927 a 25.26	0.473	-13.81, 7.84	0.579

Multivariable analysis of the postoperative OSA-18 score

Multiple linear regression was also conducted using the postoperative OSA-18 score as the dependent variable, with adjustment for the preoperative OSA-18 score, age, sex, obesity, and preoperative tonsillar hypertrophy grade (Table 5). The model had an R^2 of .376 (adjusted R^2 = .255). The preoperative OSA-18 score was significantly associated with the postoperative score (β = 0.253; 95% CI, 0.076–.430; *P* = 0.014), indicating that children with greater preoperative symptom severity also tended to have higher scores after surgery. Obesity was also associated with higher postoperative OSA-18 scores, corresponding to a mean difference of approximately 8 points (β = 7.997; 95% CI, 1.609–14.386; *P* = .028). The remaining variables included in the model showed no statistically significant association with the postoperative score.

Discussion

The present study aimed to evaluate the efficacy of radiofrequency tonsillar reduction combined with adenoidectomy in improving the quality of life in children with suspected OSA, using the validated Portuguese version of the OSA-18, and to identify the predictors of clinical response. The results demonstrate a significant and clinically relevant improvement in the quality of life after the intervention, both in the overall score and in all domains evaluated. Beyond its statistical significance, the reduction in the OSA-18 score corresponds to tangible clinical benefits, including decreased snoring and nocturnal breathing pauses, improved sleep quality, less irritability and daytime sleepiness, and a reduced impact of the disease on family well-being and caregiver concerns. These results support the usefulness of this surgical approach in carefully selected children.

The magnitude of improvement observed is comparable to, and in some cases greater than, that reported in studies evaluating total adenotonsillectomy. In a retrospective study of 196 children undergoing adenotonsillectomy, Al-Iede et al.[24] documented a mean reduction of 15.14 points in the OSA-18 score. Similarly, in a series of 34 children, Mitchell et al.[25] reported a decrease in the mean total score from 76.7 to 32.0. In our study, the mean reduction was 35.86 points. This outcome indicates that radiofrequency tonsillar reduction combined with adenoidectomy can produce quality-of-life benefits comparable to those achieved with total tonsillectomy.

A domain analysis showed that the greatest improvements occurred in the Sleep Disturbance and Caregiver Concerns domains. This pattern is consistent with the pathophysiology of pediatric OSA, in which nocturnal respiratory symptoms are the predominant clinical manifestation and main reason for referral, reinforcing the importance of surgical treatment in resolving them. The marked improvement in the Caregiver Concerns domain may, in turn, reflect the relief of parental anxiety as the most visible obstructive symptoms, such as snoring and breathing pauses, resolve. In contrast, the Emotional Distress and Daytime Problems domains showed more

Table 5
Multiple linear regression for predictors of the postoperative OSA-18 score

Variable	β	95% CI	P-value
Preoperative OSA-18	0.253	0.076 – .430	0.014
Obesity	7.997	1.609 – 14.386	0.028
Sex	2.212	−4.515 to 8.938	0.559
Age	−0.358	−1.657 to 0.940	0.588
Tonsillar hypertrophy grade (II vs. III)	−0.901	−10.686 to 8.884	0.884
Tonsillar hypertrophy grade (II vs. IV)	2.989	−7.835 to 13.813	0.712

modest improvements, suggesting that these dimensions may be influenced by factors beyond airway obstruction, such as behavioral or environmental factors, or may require longer recovery periods. Regarding the surgical technique, radiofrequency tonsillar reduction was chosen because of its widely documented advantages over total tonsillectomy in children with obstructive sleep-disordered breathing. A meta-analysis by Wang et al.,[27] including 10 studies and 1,029 participants demonstrated that a partial tonsillectomy is associated with a lower hemorrhage rate, shorter operative time, and faster resolution of pain than total tonsillectomy, with no significant differences in the resolution of obstructive symptoms or long-term quality of life. In our study, tonsillar hypertrophy grade was effectively reduced in all patients, with 84.1% reaching grade I postoperatively. Nevertheless, the potential disadvantage of tonsillar reduction—symptom recurrence due to tonsillar regrowth—should be considered. In a study with 5 years of follow-up, Zhang et al.[28] observed tonsillar regrowth in 6.1% of children undergoing partial tonsillectomy, predominantly in children aged <5 years and in association with upper respiratory infections and a history of allergy. These data underscore the importance of appropriate follow-up, particularly in younger children or those with risk factors. One of the most relevant findings of our study was the identification of obesity as a factor independently associated with less clinical improvement after surgery. These results indicate that, although children with obesity benefit from surgical intervention, they may have greater persistence of symptoms after treatment. This finding is consistent with the literature, which recognizes obesity as one of the main determinants of the failure of any type of therapy in pediatric OSA, reflecting its multifactorial contribution to upper-airway obstruction. Indeed, adenotonsillar hypertrophy is not always the only mechanism involved. Factors, such as peripharyngeal fat deposition, reduced upper-airway caliber, greater pharyngeal collapsibility, and obesity-related ventilatory changes may contribute to residual symptoms after surgical correction of the lymphoid component. A recent systematic review by Cohen et al.[29] concluded that 82% of the included studies demonstrated a significant association between obesity and OSA recurrence after adenotonsillectomy. Kearney et al.[30] reported that adolescents with obesity were 7 times more likely than adolescents without obesity to have persistent moderate-to-severe OSA after adenotonsillectomy.

The high predominance of obesity in our sample warrants comment. According to the most recent WHO European Childhood Obesity Surveillance Initiative (COSI) Portugal 2022 data,[31] the incidence of overweight among Portuguese children aged 6 to 8 years was 31.9%, including 13.5% with obesity. The substantially higher proportion in our study may be explained by the fact that obesity is a recognized risk factor for pediatric OSA.[5] The bidirectional relationship between obesity and OSA—in which obesity worsens upper-airway obstruction and sleep fragmentation promotes metabolic changes that favor weight gain—may contribute to the overrepresentation of children with obesity in our cohort.[5,32] The preoperative OSA-18 score emerged as the main predictor of the magnitude of clinical improvement. Al-Iede et al.[24] also reported that preoperative OSA-18 scores in the severe-impact range were significant positive predictors of the score difference. Although part of this effect may stem from statistical regression to the mean, it also reflects a clinical reality: children with a greater symptom burden have more room for improvement once the obstruction is resolved. This study has a few limitations. The absence of PSG is an important limitation because it prevented the objective confirmation of OSA severity and postoperative respiratory response. The relatively mild sample size limits the statistical power to detect milder associations, which may explain the lack of statistical significance for variables such as sex, age, and tonsillar hypertrophy grade in the univariable analysis. The short-term follow-up does not allow the assessment of durability or possible tonsillar regrowth. In addition, the absence of a control group precludes attributing the improvement exclusively to the surgical intervention, because factors such as natural airway growth and the placebo effect may have contributed to the observed results. Despite these restrictions, this study adds to the available evidence by demonstrating that radiofrequency tonsillar reduction combined with adenoidectomy results in a significant improvement in quality of life in children with OSA symptoms, as evaluated by the Portuguese version of the OSA-18. The results reinforce the importance of obesity as a modifier of surgical outcomes in this population and suggest the need for a multidisciplinary approach that incorporates weight management into the treatment strategy for children with obesity and OSA.

Conclusion

Adenoidectomy combined with radiofrequency tonsillar reduction was associated with a significant improvement in the quality of life of children with symptoms indicative of OSA, with an approximately 50% reduction in the total OSA-18 score and consistent benefits across all evaluated domains. Obesity was independently associated with less clinical improvement and higher postoperative scores, reinforcing the need to incorporate weight management into the therapeutic method for these children. These results support radiofrequency tonsillar reduction as an effective alternative to total tonsillectomy for pediatric OSA, with potentially lower postoperative morbidity. Prospective studies with larger samples, longer follow-up, and polysomnographic evaluation will be required to confirm the durability of these benefits.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

Data Confidentiality

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the 2013 Helsinki Declaration of the World Medical Association.

Privacy policy, informed consent and Ethics Committee Authorization

The authors declare that they have written consent for the use of photographs of patients in this article.

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There are no datasets available, publicly related to this work.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT (OpenAI) and Perplexity AI to assist with scientific writing, language editing, and the consultation of relevant scientific literature. After using these tools/services, the authors reviewed and edited the content as necessary and take full responsibility for the content of the publication.

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