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LARYNGOLOGY

Office-based blue laser therapy for vocal fold polyps and Reinke's edema: a case study and review of the literature

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Abstract

Purpose To report the efficacy of blue laser in the treatment of vocal fold polyps and Reinke's edema in an office setting.

Methods The medical records and video-recordings of patients who underwent office-based blue laser therapy in a tertiary referral center for vocal fold polyps and/or Reinke's edema were reviewed. The primary outcome measures were the Voice Handicap Index-10 (VHI-10) score and disease regression. Acoustic and aerodynamic parameters were also analyzed.

Results Thirty-five patients (21 with vocal fold polyps and 14 with Reinke's edema) were included and a total of 47 lesions were treated. Out of the 35 patients, 7 patients were lost for follow-up. The mean VHI-10 score dropped significantly after surgery by 17.41 ± 8.67 points ($p < 0.001$). The endoscopic examinations of 38 lesions were reviewed (17 vocal fold polyps and 21 Reinke's edema) before and up to 6 months after laser therapy. In the subgroup with vocal fold polyps ($N = 17$), there was complete disease regression in 13 and partial in 4. In the subgroup with Reinke's edema ($N = 21$), there was complete disease regression in 7 and partial disease regression in 14. For patients with vocal fold polyp, there was a significant decrease in shimmer and a significant increase in maximum phonation time postoperatively. For patients with Reinke's edema, there was a significant decrease in shimmer and noise-to-harmonic ratio following treatment.

Conclusion Office-based blue laser therapy is an effective treatment for vocal fold polyps and Reinke's edema leading to complete or partial disease regression. All patients had improvement in voice quality.

Keywords Office-based · Blue laser · Vocal fold polyps · Reinke's edema · Laryngology

Introduction

Phonation is a complex and multi-dimensional phenomenon that involves various systems in the body. A disturbance in any of these systems, compounded by external stressors, can lead to a change in voice quality. Various classification systems for voice disorders have been suggested in the literature, and different terms have been used interchangeably to denote subgroups of patients with similar clinical presentations. A simple classification is one that stratifies dysphonic patients into three tiers: structural, neurologic, and functional. Among the structural voice disorders are vocal fold polyps and Reinke's edema. Vocal fold polyps and Reinke's edema are exudative lesions of the superficial layer of the lamina propria with distinguished histologic features. Reinke's edema is characterized by excess deposition of hyaluronic acid and the presence of edematous lakes, whereas vocal fold polyps are characterized by fibrovascular changes and neovascularization. Both lesions may exhibit similar histologic findings such as basement membrane thickening and epithelial hyperplasia [1, 2].

Patients with vocal fold polyps or Reinke's edema usually present with a change in vocal pitch, loudness, or timber. Additional complaints include vocal fatigue, contracted vocal range, and loss of the high notes. Although the treatment of vocal fold polyps and Reinke's edema is multidimensional, the mainstay therapy is surgery. Microlaryngeal

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surgery is usually performed in the operating room under direct laryngoscopy. Despite the advances in surgical techniques, there are still feared complications many of which are related to direct laryngoscopy [3, 4]. The last two decades witnessed a reform in laryngology practice toward office-based laryngeal surgery, thus sparing the patients the risk of general anesthesia and the morbidity of surgical exposure. Among the various laryngeal procedures performed in-office is laser therapy. There is a ubiquity of reports in the literature supporting the use of lasers for the treatment of benign and pre-malignant lesions of the vocal folds, with the main focus being on the pulse dye laser (PDL) (wavelength of 582 nm) and the potassium titanyl laser (KTP) (wavelength of 532 nm) [5, 6]. In a systematic review and meta-analysis on the efficacy of in-office laser therapy for Reinke's edema, Hamdan et al. reported a significant decrease in the size of the lesion and a significant improvement in the VHI-10 score following treatment. The subjective improvement in voice quality was associated with a significant decrease in jitter and an increase in fundamental frequency. In another systematic review on office-based laser therapy for vocal fold polyps which included 10 papers and 242 patients, the authors also noted a significant improvement in the VHI-10 score associated with partial or complete disease regression following a single laser session. These findings were accompanied by a significant decrease in shimmer and a significant increase in the maximum phonation time [7].

There is a limited number of studies in the literature on office-based blue laser therapy for benign lesions of the vocal folds [8–14]. The blue laser is a new photoangiolytic laser with a wavelength of 445 nm. In 2018, Hess et al. described its use for the treatment of various vocal fold pathologies with promising results. Its main added value is the blend of cutting and angiolysis, which provides the surgeon with more versatility in the treatment of mucosal and submucosal lesions of the vocal folds [15].

The purpose of this study is to cast more information on the efficacy of blue laser in the treatment of vocal fold polyps and Reinke's edema in an office setting. The authors report a large case series of 38 lesions that have not been previously published, together with a comprehensive review of the literature.

Patients and methods

Patients and setting

The medical records and video-recordings of patients who underwent office-based blue laser therapy in a tertiary referral center between October 2022 and September 2023 for vocal fold polyps and/or Reinke's edema were reviewed. None of the patients included in this review have been included in any previous investigation or study. Demographic data included age, gender, history of phono-trauma (overuse, abuse, misuse), history of smoking, history of reflux disease, and site of the lesion. Procedure-related factors included the duration of the procedure, and the amount of Joules delivered. The IRB approval was obtained from the American University of Beirut Medical Center (IRB BIO ID: 2022-0280).

Disease and voice quality outcomes

The primary outcome measures in this study were the Voice Handicap Index-10 (VHI-10) score and disease regression based on the laryngeal examination performed before and after therapy. Disease regression was graded as complete, partial, or no change. Partial disease regression in patients with vocal fold Reinke's edema was defined as a change in the type of Reinke's edema based on the Yonekawa classification, with type 1 denoting the presence of edema limited to the upper surface of the vocal folds with preservation of the glottic patency, type 2 denoting extension of the edema from the upper to the lower surface of the vocal folds, and type 3 denoting extensive edema of the vocal fold with the glottic opening being limited posteriorly [16]. In patients with vocal fold polyps, partial disease regression was defined as a decrease in the size of the polyp.

Secondary outcome measures included acoustic and aerodynamic measures. Patients underwent acoustic analysis of their voice using the VISI Pitch II Kay Elemetric program, Model 3300 (Kay Elemetrics Corporation, Lincoln Park, NJ). The average fundamental frequency (F0), jitter percent, shimmer percent, noise to harmonic ratio (NHR), and voice turbulence index (VTI) were measured by asking the patient to sustain the vowel/a/for a few seconds at a comfortable pitch and loudness. The middle segment of the recording, which consisted of 2–3 s, was used for analysis. The habitual pitch (HP) was measured by asking the patient to count to 10 at a comfortable pitch and loudness. The maximum phonation time (MPT) was calculated by asking the patients to take a deep breath and sustain the vowel "a" for as long as they can on 2 attempts.

Results

Demographic data

A total of 35 patients, 21 with vocal fold polyps and 14 with vocal fold Reinke's edema were included in this study.

Twelve out of the 14 patients with Reinke's edema had bilateral disease. A total of 47 lesions were treated with the blue laser. The mean age of the study group was 48.43 ± 13.38 years. Eighteen of the participants were females and 17 were males. Almost two-thirds were smokers, 25.7% had reflux disease, and 45.7% reported a history of phonotrauma. All patients had a single treatment session, the mean duration of which ranged between 3.5 and 20.45 min with a mean of 9.58 ± 4.92 min. The procedure was well tolerated by all patients and the average amount of Joules delivered was 79.49 ± 53 J (Table 1).

Table 1 Demographic data of the study population

Demographic data (N = 35)	Value
Gender (Male:Female ratio)	1:1
Age in years (mean ± SD)	48.43 ± 13.38
Smoking [n (%)]	23 (65.7)
Reflux [n (%)]	9 (25.7)
History of phonotrauma [n (%)]	16 (45.7)
Type of pathology [n (%)]	
Polyps	21 (60)
Reinke's edema	14 (40)
Laterality [n (%)]	
Unilateral	23 (65.7)
Bilateral	12 (34.3)
Duration of procedure in minutes (mean ± SD)	9.58 ± 4.92
Amount of Joules delivered (mean ± SD)	79.49 ± 53

SD Standard deviation

Voice quality outcomes evolution

Out of the 35 patients, 7 patients were lost for follow-up. All patients had a decrease in their VHI-10 score after treatment. The mean VHI-10 score of the remaining 28 patients dropped significantly after surgery by 17.41 ± 8.67 points ($p < 0.001$). In the polyp group (n = 17), the mean VHI-10 score decreased significantly from 21.24 ± 7.56 to 3.88 ± 4.13 ($p < 0.001$). In the Reinke's edema group, the mean VHI-10 score decreased significantly from 20.00 ± 10.04 to 2.5 ± 3.81 ($p < 0.001$).

Disease evolution

A total of 28 patients, 17 with vocal fold polyps and 11 with Reinke's edema, had their video recordings available after surgery. Of the 11 patients with Reinke's edema, 10 had bilateral disease. The endoscopic examinations of 38 lesions were reviewed (17 vocal fold polyps and 21 vocal fold Reinke's edema) before and after laser therapy. The follow up period extended between 3 weeks and 6 months. In the subgroup with vocal fold polyps (N = 17), 13 had complete regression of the lesion (76.5%) (Fig. 1). In the remaining 4, there was partial disease regression. In the subgroup with vocal fold Reinke's edema (N = 21), there was complete disease regression in 7 and partial disease regression in 14. Of these 21 lesions, 8 had type 3 (38%), 11 type 2 (52.4%), and 2 had type 1 (9.6%). Following laser therapy, all patients with type 1 lesion had complete regression. Of those with type 2 and type 3 lesions, 4 (36%) and 2 (25%) had complete disease regression, respectively (Fig. 2). The remaining cases had partial disease regression.

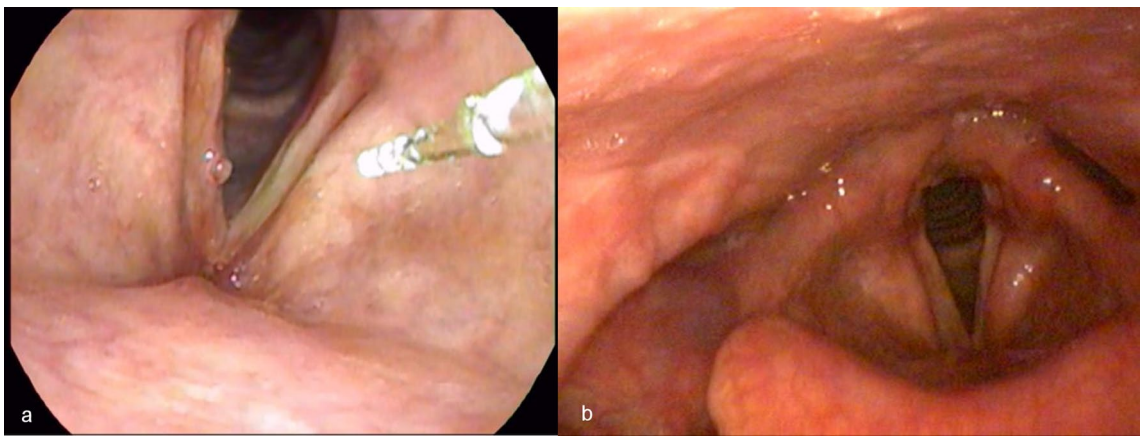

Fig. 1 An endoscopic view of the larynx showing right vocal fold polyp pre-operatively (**a**) and 3 weeks post-operatively (**b**). Note the complete regression of the lesion following a single session of in-office blue laser therapy. Laser setting used: Power 10 watts, pulse duration 10 ms, and pulse pause of 300 ms

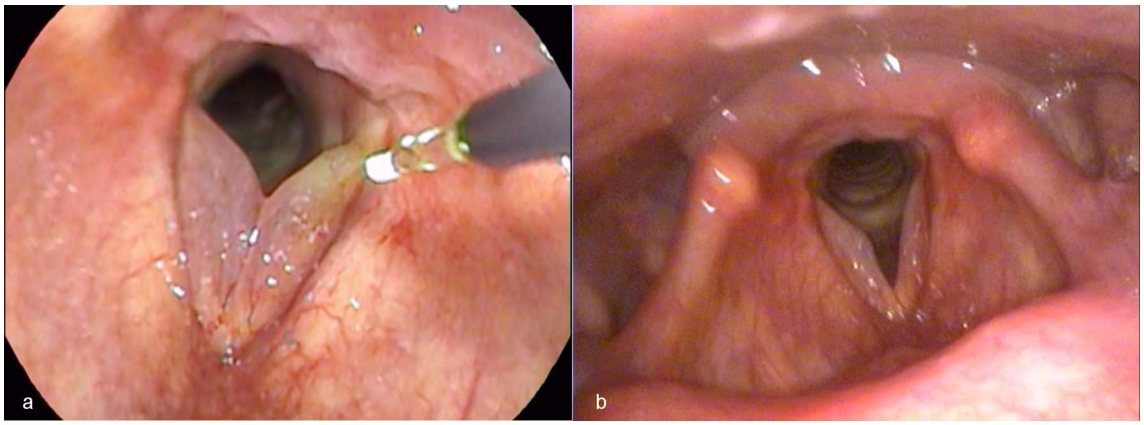

Fig. 2 An endoscopic view of the larynx showing bilateral vocal folds Reinke's edema type 3 during surgery (**a**) and 6 weeks later (**b**). Note the complete regression of the lesion on the left side and partial regression on the right side. Laser setting used: Power 10 watts, pulse duration 40 ms, and pulse pause of 300 ms

Acoustic analysis and aerodynamic measures before and after blue laser therapy

For patients with vocal fold polyps, there was a significant decrease in shimmer from 3.39 ± 1.57 to 2.6 ± 0.81 (p = 0.028). There was a non-significant decrease in the jitter percent from 1.17 ± 0.59 to 0.94 ± 0.43 (p = 0.177). With respect to the aerodynamic parameter, there was a significant increase in the MPT from 9.48 ± 4.18 s pre-operatively to 14.93 ± 6.06 s post-operatively (p = 0.012) Table 2.

For patients with Reinke's edema, there was a significant decrease in shimmer and NHR following surgery. The shimmer percent value decreased from 9.59 ± 5.81 pre-operatively to 5.31 ± 4.38 post-operatively (p = 0.035),

Table 2 Mean scores of acoustic and aerodynamic parameters before and after blue laser treatment

	Polyps			Reinke's edema		
	Before	After	*p* value	Before	After	*p* value
Jitter (%)	1.17 ± 0.59	0.94 ± 0.43	0.177	2.6 ± 1.62	1.49 ± 0.64	0.064
Shimmer (%)	3.39 ± 1.57	2.6 ± 0.81	0.028*	9.59 ± 5.81	5.31 ± 4.38	0.035*
NHR	0.12 ± 0.019	0.134 ± 0.059	0.401	0.197 ± 0.11	0.145 ± 0.066	0.020*
VTI	0.041 ± 0.016	0.062 ± 0.052	0.152	0.065 ± 0.037	0.059 ± 0.025	0.544
MPT (s)	9.48 ± 4.18	14.93 ± 6.06	0.012*	6.59 ± 3.24	9.75 ± 5.88	0.121

NHR noise-to-harmonic ratio, *VTI* voice turbulence index, *MPT* maximum phonation time

*Statistically significant ($p < 0.05$)

Table 3 Mean scores of fundamental frequency (F_0) Hz and habitual pitch before and after blue laser therapy

	Polyps				Reinke's edema			
	Males		Females		Males		Females	
	Fundamental frequency (Hz)	Habitual pitch (Hz)	Fundamental frequency (Hz)	Habitual pitch (Hz)	Fundamental frequency(Hz)	Habitual pitch (Hz)	Fundamental Frequency (Hz)	Habitual pitch (Hz)
Before	133.79 ± 36.96	130.51 ± 34.17	169.85 ± 37.6	177.39 ± 30.49	81.77 ± 0.24	94.9 ± 7.78	160.76 ± 49.77	149.52 ± 37.41
After	115.77 ± 16.18	117.03 ± 16.88	186.59 ± 18.67	177.82 ± 37.75	97.85 ± 14.63	108.87 ± 24.57	170.47 ± 38.04	159.78 ± 38.77
p value	0.198	0.194	0.134	0.960	0.369	0.448	0.524	0.380

while the NHR decreased from 0.197 ± 0.11 to 0.145 ± 0.066 (p = 0.020). There was a non-significant decrease in the jitter percent from 2.6 ± 1.62 to 1.49 ± 0.64 (p = 0.064) and in the VTI from 0.065 ± 0.037 to 0.059 ± 0.025 (p = 0.544). With respect to the aerodynamic parameter, there was a non-significant increase in the MPT from 6.59 ± 3.24 s to 9.75 ± 5.88 s (p = 0.121) Table 2.

The mean fundamental frequencies and habitual pitch of the study group before and after surgery, stratified by gender and pathology type are displayed in Table 3.

Discussion

Office-based laser therapy for vocal fold polyps and Reinke's edema is a well-established treatment modality that is gaining popularity in otolaryngology practice. The most commonly used lasers are the photoangiolytic lasers characterized by their high affinity for oxyhemoglobin and superior hemostatic properties in comparison to the cutting lasers. Most of the studies in the literature are on PDL and KTP laser, with only a few studies on blue laser reporting comprehensive voice quality outcome after surgery [8–14]. In 2021**,** Hamdan et al. described un-sedated office-based blue laser therapy in 11 patients, 6 of whom had vocal fold polyps or Reinke's edema. The authors noted partial or complete disease regression in all the cases following a single session of therapy. The response to treatment was associated with a significant improvement in voice quality using the visual analog scale (VAS) and a significant decrease in the mean VHI-10 score [8]. In 2021**,** Miller et al. reported their experience in office-based blue laser surgery in a cohort of 29 patients, 9 of whom had benign lesions of the vocal folds that included polyps. All patients had improvement in their voice quality after therapy. There was also a significant decrease in the mean VHI-10 score [9]. In 2022, Ghanem and Hamdan reported complete or partial disease regression of vocal fold Reinke's edema in 10 patients who underwent office-based blue laser therapy. The disease regression on laryngeal endoscopy was accompanied by a significant improvement in perceptual voice evaluation and in the mean VHI-10 score of the study group [10]. Although the increase in the mean fundamental frequency following surgery was non-significant, the authors noted that blue laser therapy can be used for voice feminization in patients with a history of androphonia secondary to vocal fold Reinke's edema. In another investigation by the same authors, blue laser therapy improved dyspnea and the risk of obstructive sleep apnea in a cohort of 10 patients with type 3 Reinke's edema. The results alluded to the successful use of office-based laser in the treatment of airway obstructive symptoms often ascribed to lower airway diseases [11]. In 2023, Hamdan et al. investigated the impact of office-based blue laser therapy on voice in 18 patients with vocal fold polyps and noted complete regression in 11 patients and partial in 4. The disease regression was associated with improvement in voice quality and a significant decrease in the mean VHI-10 score. There was also a significant increase in the maximum phonation time and a non-significant decrease in acoustic perturbation parameters [12]. In 2023, in a prospective study on transoral flexible blue laser therapy for the treatment of various laryngeal pathologies, Gonzalez-Herranz et al. reported a success rate of 90%. The study group consisted of 23 patients who were treated in-office alone, 7 of whom had vocal fold polyps and 3 patients had vocal fold Reinke's edema. The success rate referred to as "resolution of the lesion" was achieved in 90% of the cases following a single session [13]. In 2023, Filauro et al. reported their experience with blue laser therapy of vocal fold polyps and Reinke's edema in-office vs. operating room and found no difference in patients' reported voice outcome. The decrease in the VHI-10 score post-operatively was significant and comparable in those who underwent office-based surgery vs. suspension micro-laryngoscopy [14] Tables 4, 5.

The results of this study are in accord with the literature and further support the use of the blue laser in the management of vocal fold polyps and Reinke's edema in an office setting. There was complete or partial regression of vocal fold polyps in 76.5% and 23.5% of the cases, respectively. The disease regression was substantiated by a significant decrease in the mean VHI-10 score, a significant decrease in shimmer percent, and a significant increase in MPT. Similarly, all patients with vocal fold Reinke's edema had a decrease in the size of the lesion, partial or complete, associated with a significant decrease in the VHI-10 score and a significant decrease in shimmer percent and NHR.

The high success rate of office-based blue laser therapy in patients with vocal fold polyps and Reinke's edema can be ascribed to the hybrid property of the blue laser, cutting and angiolytic, which is best achieved by controlling the distance between the tip of the glass fiber and the target tissue, and by adjusting the speed of movement of the laser. The dual characteristic of the blue laser is surmounted by its superior absorption rate in the red and black spectrum in comparison to the KTP laser. In an animal study, Lin et al. reported more vocal fold fibrosis following the use of the KTP laser vs. the blue laser [17].

Table 4 Office-based blue laser for benign lesions of the vocal fold: patient-related factors

References	Number of patients	Type of pathology	Follow-up period	Disease regression	Outcome measures
Hamdan and Ghanem [8]	6	Polyps (n = 4), RE (n = 2)	53.13 ± 41.10 days	50% complete 50% partial	Significant decrease in VHI-10 from 15.13 ± 8.77 to 3.50 ± 3.46 ($p = 0.015$)
Miller et al. [9]	9	Benign lesions (n = 9)	2 to 6 weeks	–	Significant decrease in VHI-10 from 21 to 2 ($p = 0.045$)
Ghanem and Hamdan [10]	8	RE (n = 8)	3 to 6 weeks	50% complete 50% partial	Significant decrease in VHI-10 from 14.86 ± 5.84 to 6.71 ± 7.32 ($p < 0.01$) and in the means of G, R, B ($p < 0.05$)
Hamdan et al. [11]	18	Polyps (n = 18)	4.67 ± 2.26 weeks	73% complete 27% partial	Significant decrease in VHI-10 from 17.6 ± 9.97 to 4.27 ± 5.76, $p < 0.001$, and in the means of G, R, B ($p < 0.001$). Marked decrease in jitter and shimmer, and a significant increase in MPT
Hamdan et al. [12]	10	RE (n = 10)	–	45% complete 55% partial	Significant decrease in VHI-10 from 22.7 ± 7.0 to 4.4 ± 5.6 ($p < 0.001$)
González-Herranz et al. [13]	7	Polyps (n = 7)	4 to 24 months	95.75% complete 4.25% partial	–
Filauro et al. [14]	52	Polyps (n = 37), RE (n = 15)	2 to 4 months	70% complete for RE 81% complete for polyps	Significant decrease in VHI-10 from 13.64 ± 10.28 to 2.57 ± 4.24; $p = 0.001$ (for RE) and from 11.84 ± 7.82 to 2.29 ± 3.07; $p < 0.001$ (for polyps)

RE Reinke's edema, *VHI* Voice Handicap Index, *G* Grade, *R* Roughness, *B* Breathiness

This study is an addition to the current literature supporting the use of blue laser in-office for the treatment of vocal fold polyps and Reinke's edema. The low number of participants is the primary limitation of the study. The retrospective design and the lack of long-term follow-up are other limitations. The retrospective design does not allow control of confounding factors such as vocal hygiene and phonatory behavior.

Conclusion

The results of this investigation supported that office-based blue laser therapy is effective in the treatment of vocal fold polyps and Reinke's edema. All patients had partial or complete disease regression associated with self-perceived improvement in voice quality. This latter was substantiated by an improvement in the perturbation parameters. Future

Table 5 Office-based blue laser therapy for benign lesions of the vocal fold: procedure-related factors

References	Approach	Type of pathology	Glass fiber size (mm)	Duration	Amount of joules
Hamdan and Ghanem [8]	Transnasal	Polyps (n = 4), RE (n = 2)	400	–	–
Miller et al. [9]	Transnasal	Benign lesions (n = 9)	300 or 400	–	–
Ghanem and Hamdan [10]	Transnasal	RE (n = 8)	400	–	–
Hamdan et al. [11]	Transnasal	Polyps (n = 18)	400	–	Between 28.3 Joules and 122.8 Joules
Hamdan et al. [12]	Transnasal	RE (n = 10)	400	Between 7 and 17.57 min with a mean of 10.11 min	Between 112 and 367 J with a mean of 240.4 J
González-Herranz et al. [13]	Transoral	Polyps (n = 7)	300, 400, or 600	–	–
Filauro et al. [14]	Transnasal/ Percutaneous	Polyps (n = 37), RE (n = 15)	400	3.65 ± 1.48 min for RE and 5.38 ± 2.88 min for polyps	–

RE Reinke's edema

studies with a larger number of participants and longer follow up are needed to better evaluate the long-term efficacy of these procedures.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [JH]. The first draft of the manuscript was written by [A-LH], [JL] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available upon request from the corresponding author.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical approval This retrospective chart review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration. The Institutional Review Board of the American University of Beirut approved this study. (IRB BIO ID: 2022-0280).

Informed consent Due to the retrospective nature of the study, informed consent was not obtained.

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