Outcomes and Predictors of Fistula Closure After Laser-Assisted Surgery for Anal Fistula: A Retrospective Cohort Study from Nepal

Surendra Shah[1], Prerana Shrestha[2]

Abstract

Introduction: Laser-assisted surgery is an emerging option as a sphincter-sparing procedure for anal fistula, with varied treatment outcomes in the literature. The aim of the study was to evaluate the treatment outcomes and complications of laser-assisted surgery for anal fistula and develop a predictive model for fistula closure.

Methods: This was a retrospective cohort study of 86 patients who underwent laser-assisted surgery for anal fistula from 14th April 2024 to 12th April 2025 at Sumeru Hospital, Dhapakhel, Lalitpur, Nepal. Demographic, fistula characteristics and clinical variables were recorded in Microsoft Excel and variables were compared between fistula closure and non-closure groups. Independent predictors were identified using logistic regression model. A predictive model was developed using predictors which were significant in univariate analysis. Performance of the model was evaluated using receiver operating characteristic (ROC) curve analysis and a web-based predictive tool was developed.

Results: Among 86 cases, urinary retention was seen in 2(2.3%), bleeding in 2(2.3%), and post-operative wound infection in 14(16.3%) cases. Fistula closure was achieved in 72 (83.7%) patients. On univariate analysis, patients with higher grade fistula (p < 0.001), longer fistula tract (p < 0.001), branched fistula tract (p < 0.001), inflammation at the time of surgery (p < 0.001), and post-operative wound infection (p < 0.001) were associated with failure to close fistula. However, multivariable logistic regression analysis identified branched fistula tract (p=0.033; OR= 0.049; 95% CI: 0.003-0.783) and post-operative wound infection (p = 0.017; OR = 0.044; 95% CI: 0.003-0.575) as independent predictors for failure to close fistula (R^2 = 0.772). Area under the ROC curve was 0.92 for the predictive model which showed excellent ability to predict fistula closure.

Conclusion: Laser-assisted surgery is associated with low complications with high closure rates. This predictive model is effective to predict fistula closure with high accuracy. However, this model needs external validation with large dataset.

Keywords: Anal fistula; Laser-assisted surgery; Treatment outcome.

Author affiliations:

[1] Department of Gastrointestinal and HPB Surgery,
Sumeru Hospital Pvt. Ltd., Dhapakhel, Lalitpur, Nepal.

[2] Chief Nurse, Operation Theater,
Sumeru Hospital Pvt. Ltd., Dhapakhel, Lalitpur, Nepal

Correspondence:

Dr. Surendra Shah,
Department of Gastrointestinal and HPB Surgery,
Sumeru Aspatal Pvt. Ltd., Dhapakhel, Lalitpur, Nepal.

Email: drsurendrashah@gmail.com

Introduction

Anal fistula, which is a chronic abnormal communication between the epithelialized surface of the anal canal and perianal skin, mostly develops in patients who have a history of perianal abscess.[1] Despite fistulotomy having good outcome, it carried a significant risk of fecal incontinence, especially in complex or high type of anal fistula.[2] Use of laser for anal fistula treatment was first introduced by Wilhelm in 2011.[3] Thereafter, laser surgery for anal fistula have emerged as a sphincter-sparing alternative. Diode laser delivered through radial (360°) emitting fiber and delivered to ablate the fistula tract with reported closure rate of 64% to 82% and associated with low complications.[2,4-6]

There are encouraging reports, but widely variable success rates have been reported. Despite that, there is a lack of studies analyzing independent predictors of fistula closure. Cao et al reported 'total fistula volume' as a predictor of fistula closure, but did not develop a predictive model to predict probability of fistula closure.[7]

This study aims to evaluate treatment outcomes and complication after laser-assisted surgery in Nepal and identify the independent predictor of the fistula closure to develop web-based predictor tool to quantify the probability of fistula closure.

Methods

This was a retrospective cohort study conducted at Sumeru Hospital Pvt. Ltd. located in Dhapakhel, Lalitpur, Nepal. Patients with cryptoglandular anal fistula who underwent laser-assisted surgery at Sumeru Hospital from 14 April, 2024 to 12 April, 2025 were included in the study. Patient who were lost to follow-up or who did not have MR fistulogram done, immunocompromised, prior seton placement, ASA grade more than II and fistula associated with Crohn's disease were excluded from the study. All the patients were treated with one of the three laser-assisted surgery named, Distal laser proximal submucosal ligation of fistula tract (DLPS), ligation of intersphincteric fistula tract (LIFT) with fistula laser closure (FiLaC), and distal laser proximal fistulotomy (DLPF). Diode laser (wavelength of 1470nm) was used in all cases at the rate of 100 J/cm with withdrawal of fiber at the rate of 3s/cm of tract length using radial-emitting fiber (360° emission) in continuous mode. An ice-pack was applied for 5 minutes after delivery of diode laser. Surgeries were performed under either laryngeal mask airway or saddle block anesthesia. Patients were discharged on the same day (6 to 8 hours after surgery). The selection of one of the three laser-assisted surgeries were on the basis of surgeon's preferences. Patients were followed-up at 1 week, 4 weeks and 3 months after surgery. Patients who were not able to come to hospital at 3 months, follow-up were performed by phone call to know their fistula related condition. Analysis were conducted from a prospectively maintained electronic records in the excel sheet. Approval for the study was taken from Sumeru Aspatal Pvt. Ltd and study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Primary objective of the study was to analyze the treatment outcomes of the laser-assisted surgery for anal fistula in term of fistula closure rate, and post-operative complication (urinary retention, bleeding, wound infection, fecal/flatus incontinence). Secondary objective of the study was to analyze and find out the predictors of the fistula closure and develop a web-based predictive tool.

Variables collected and studied were: age, gender, grade of the fistula according to St. James's University Hospital Classification for Anal Fistula[8], length of fistula tract, branched fistula tract, inflammation at the time of surgery, previous intervention for anal fistula (recurrent type), presence of diabetes mellitus, type of laser-assisted surgery, fistula closure status at 3 months follow up, return to work in days, and post-operative complications (post-operative urinary retention, bleeding, wound infection, fecal/flatus incontinence).

Fistula closure was defined as complete healing of wound and absence of discharge from the wound. Persistent discharge from the wound even after 3 months of follow up was defined as failure to close the fistula tract. Patients who presented with pus discharge from wound were investigated with pus swab culture and sensitivity. Culture positive wound were defined as wound infection.

Statistical analysis was performed using Python (v3.12.4) and associated libraries like pandas, numpy, matplotlib, pyplot, seaborn, scipy.stats, statsmodels, sklearn. Descriptive analysis was done to summarize characteristics of the patients and post-operative outcomes. Distribution of data were analyzed using boxplot and Q-Q plot. Categorical variables were expressed as counts and percentages, and either Fisher's exact test or Chi-square test was performed to analyze differences between fistula closure and non-closure group. Continuous variables were presented as either means with standard deviation or median (interquartile range) according to normality of data distribution and either student t-test or Mann-Whitney U test were performed to analyze differences of mean or median between the fistula closure and non-closure group. The p-value < 0.05 were considered as a significant difference. Variables with p-value <0.05 in univariate analysis were evaluated using multivariable analysis and odds ratios (OR) with 95% confidence intervals (CI) were reported.

Model Development and Validation:
Considering small dataset, we selected logistic regression for predicting modeling to minimize overfitting compared to more complex machine learning methods. A logistic regression model was trained using the "scikit-learn library". The dataset was divided into 80:20 ratio for training and testing the model. The model performance was evaluated using predicted probabilities on the test dataset.

Performance of the model was evaluated using receiver operating characteristics (ROC) curve and area under the curve (AUC) analysis. Predictive model was developed using variables which were significant in the univariate analysis which also showed trend in the multivariable logistic regression model.

The logistic regression model was saved using python and joblib, and integrated into a prototype online application using GitHub and Streamlit. This web-based probability estimation prototype tool (application) for fistula closure will only serve as a proof of concept demonstration. This online application will need validation with larger and multicentric datasets before clinical use.

Results

A total of 86 patients were included in the study including 77 (89.5%) males and 9(10.5%) females. The median age of the patient was 35.5 years (interquartile range [IQR]: 16.7 years) ranges from 9 to 69 years. According to St. James's University Hospital Classification of anal fistula, Grade 1 was present in 17 (19.8%) patients, grade 2 in 4 (4.7%), grade 3 in 35 (40.7%), grade 4 in 24 (27.9%) and grade 5 in 6 (7.0%) patients. The median length of fistula tract was 38 mm (IQR: 30.5 mm) ranges from 19 to 90 mm.

There were branched fistula tracts in 19 (22.1%) patients, inflammation at the time of surgery in 32 (37.2%), recurrent fistula in 21 (24.4%) and diabetes in 10 (11.6%) patients. Among the 86 patients, DLPS were performed in 35 (40.7%) patients, DLPF in 19 (22.1%) and LIFT with FiLaC in 32 (37.3%) patients. Post-operative urinary retention was developed in 2(2.3%) patients which were relieved with in-and-out catheterization, bleeding from the wound margin was present in 2(2.3%) patients which were managed with compression dressing and tranexamic acid for 5 days. Wound infection developed in 14(16.3%) patients. There was no fecal or flatus incontinence in our study. The median duration to return to work was 14 days (IQR: 10 days) ranging from 3 to 30 days.

Among 86 patients who underwent laser-assisted surgery, fistula closure was achieved in 72 (83.7%) patients and 14 (16.3%) patients failed to achieve fistula closure. Patients with higher grade fistula, longer fistula tract, branched fistula tract, presence of inflammation at the time of surgery, and development of post-operative wound infection were significantly associated with failure to close fistula in univariate analysis (**Table 1**). Post-hoc analysis of grade of fistula after Chi-square test using adjusted standardized residuals showed that grade 1 (Z = -1.66), grade 2 (Z = -0.81) and grade 3 (Z = -2.39) were associated with higher fistula closure than expected, and grade 4(Z=2.58) and grade 5(Z = 4.07) fistula were associated with lesser closure of fistula than expected (z > 1.96 is significant).

Higher length of fistula (67.5 mm vs 34 mm; p < 0.001), fistula with collection or branched tract (grade 2, 4) and

Table 1. Comparison of baseline and clinical characteristics between fistula closure group and non-closure of fistula group

Variable	Fistula closure (n = 72)	Non-Closure of fistula (n = 14)	Total (n = 86)	p-value
Age in years (IQR)	35 (18)	37 (16)	-	0.101
Gender				
Male	63 (87.5)	14 (100)	77 (89.5)	0.344
Female	9 (12.5)	0 (0)	9 10.5)	
Grade of fistula				
Grade 1	17 (23.6)	0 (0)	17 (19.8)	< 0.001
Grade 2	4 (5.6)	0 (0)	4 (4.7)	
Grade 3	35 (48.6)	0 (0)	35 (40.7)	
Grade 4	15 (20.8)	9 (64.3)	24 (27.9)	
Grade 5	1 (1.4)	5 (35.7)	6 (7.0)	
Length in mm (IQR)	34 (24.2)	67 (22.8)	-	< 0.001
Branched fistula tract				
Yes	7 (9.7)	12 (85.7)	19 (22.1)	< 0.001
No	65 (90.3)	2 (14.3)	67 (77.9)	
Inflammation				
Yes	19 (26.4)	13 (92.9)	32 (37.2)	< 0.001
No	53 (73.6)	1 (7.1)	54 (62.8)	
Recurrent fistula				
Yes	20 (27.8)	1 (7.1)	21 (24.4)	0.171
No	52 (72.2)	13 (92.9)	65 (75.5)	
Diabetes				
Yes	7 (9.7)	3 (21.4)	10	0.355
No	65 (90.3)	11 (78.6)	76	
Type of surgery				
DLPS	27 (37.5)	8 (57.1)	35 (40.7)	0.385
DLPF	17 (23.6)	2 (14.3)	19 (22.1)	
LIFT+FiLaC	28 (38.9)	4 (28.6)	32 (37.2)	
Urinary retention				
Yes	1 (1.4)	1 (7.1)	2 (2.3)	0.220
No	71 (98.6)	13 (92.9)	84 (97.7)	
Bleeding				
Yes	1 (1.4)	1 (7.1)	2 (2.3)	0.220
No	71 (98.6)	13 (92.9)	84 (97.7)	
Wound infection				
Yes	4 (5.6%)	10 (71.4)	14 (16.3)	< 0.001
No	68 94.4%)	4 (28.6)	72 (83.7)	
Return to work (days)	14 (10)	17 (10)	-	0.067

Continuous data are presented in median (IQR), categorical data in number (%) where percentage are calculated within each outcome group (column-wise). p-value were calculated using Mann-Whitney -U test for continuous data and Fisher's exact test for categorical data. DLPS = Distal laser proximal submucosal ligation of fistula tract; LIFT = Ligation of fistula tract; FiLaC = Fistula laser closure; DLPF = Distal ligation proximal fistulotomy; IQR = Interquartile range, length = length of the fistula tract.

Forest Plot of Predictors for Fistula Closure
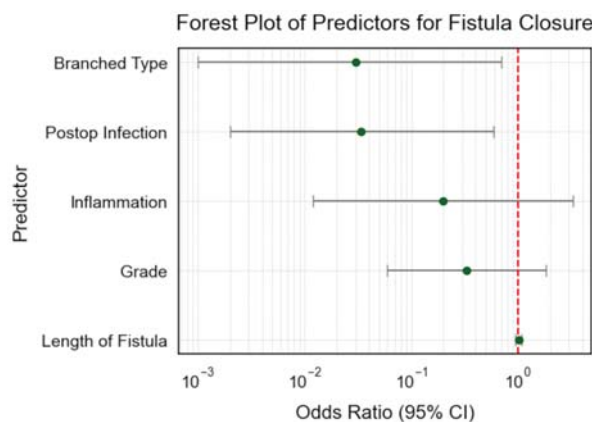
Figure 1. Forest plot of predictors for fistula closure.
Odds ratio (OR) with 95% CI were evaluated using multivariable logistic regression. A red dashed line is at OR = 1 representing no effect.

ROC Curve for Fistula Closure Prediction

Figure 2. Receiver operating characteristic (ROC) curve demonstrating the performance of the logistic regression model to predict fistula closure.

grade 5 (p<0.001), branched fistula tract (p<0.001), inflammation at the time of surgery (p<0.001), patient with diabetes (p =0.008) were significantly associated with failure to close fistula.

The multivariable logistic regression analysis of the variables which were significant in univariate analysis showed that branched fistula tract (p=0.033; OR= 0.049; 95% CI: 0.003-0.783) and post-operative wound infection (p =0.017; OR = 0.044; 95% CI: 0.003-0.575) were significantly associated with failure to close fistula. Although grade of fistula (p=0.341; OR = 0.367; 95% CI: 0.047-2.886), length of the fistula tract (p-0.915; OR=1.004; 95% CI: 0.935-1.078), and inflammation at the time of surgery (p=0.189; OR =0.124; 95% CI: 0.006-2.791) showed trends, they were not statistically significant (**Figure 1**).

A fistula closure predictive model was developed using these variables: grade of the fistula, length of the fistula tract, branched fistula tract, inflammation at the time of surgery, and post-operative wound infection. These variables, which had trends, were used in predictive model using logistic regression method irrespective of statistical significance in multivariate analysis to avoid excluding variables with meaningful associations and potential contribution to overall model stability in larger datasets, while acknowledging the risk of overfitting in small sample size. The dataset was randomly divided into training set (80%) and testing set (20%) to evaluate performance of the model. The performance of the model demonstrated excellent discriminatory ability with area under the ROC curve (AUC) of 0.92 on ROC curve analysis of the test (**Figure 2**). A web-based application was developed using Streamlit: *https://fistula-predictor.streamlit.app*. This is a prototype online application to demonstrate a proof of concept, which will allow surgeons to estimate the probability of fistula closure after laser assisted surgery (DLPS, DLPF, LIFT with FiLaC) and help in counseling the patients and plan treatment. This online application is
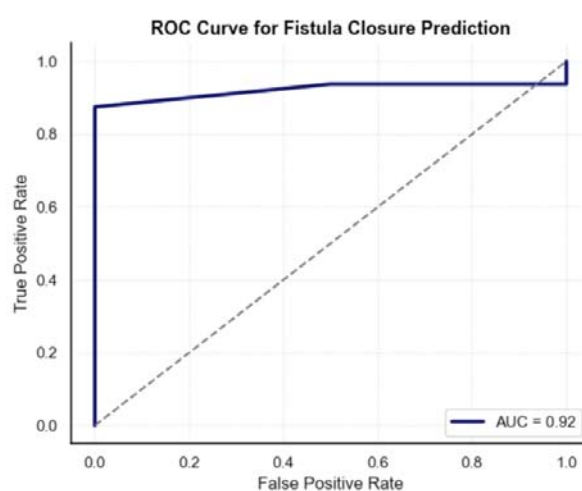
not intended for direct clinical use before validation with larger and multicentric datasets.

Discussion

This was a retrospective cohort study to analyze the outcome and predictors of fistula closure after laser-assisted surgery in 86 patients with anal fistula. The results show fistula closure rate of 83.7%. There was no fecal or flatus incontinence in our study, reflecting the safety of a sphincter-sparing approach which includes: DLPS, DLPF, and LIFT with FiLaC compared with fistulotomy.[2] Although fistula closure rate varies in the literature,[3-6] Öztürk et al reported higher fistula closure rate (82%).[5] Similarly Kamal Gupta et al reported 83.4% fistula closure rate after FiLaC in his study.[9] However, these studies were performed with small number of cases, study design was retrospective and FiLaC with suture closure of the internal opening was performed in all cases. In our study, we performed either LIFT or submucosal ligation of fistula tract or proximal fistulotomy along with fistula laser closure. There is another comparative study by Kamal Gupta et al in 2020 which showed 84% fistula closure rate among 42 cases of FiLaC, 93.5% fistula closure among 46 cases of DLPS, and 96% fistula closure among 26 cases of DLPF.[10] However, his study included most of the cases with intersphincteric, trans-sphincteric or subcutaneous anal fistula. He did not mention about the presence of abscess (collection), inflammation at the time of surgery, branched fistula tract, length of fistula, and post-operative wound infection in his study. Our study reported negative association of presence of inflammation, which is common in cases with collection in the tract, higher length of fistula, branched type fistula tract, higher grade of fistula and post-operative wound infection. Lower fistula closure rate in our study (83.7%) compare to study by Kamal Gupta et al (2020) could be explained due to presence of more complex cases of anal fistula in our study. The important finding of his study was

that addition of SLOFT or proximal fistulotomy along with FiLaC was associated with better outcome compared to FiLaC only, which was supported by Kumar et al.[11] Ahmad et al also reported improved fistula closure rate with addition of LIFT with laser ablation of fistula tract (91.11%).[12] These findings highlight the adaptability of DLPS, DLPF, and LIFT with FiLaC and results effective treatment for anal fistula.

In our study, univariate analysis showed higher grade (grade 4 and 5), length of fistula, branched tracts, inflammation at the time of surgery and postoperative wound infection as a significant negatively associated predictor for fistula closure. However, multivariate logistic regression showed branched type fistula tract and post-operative wound infection only as a significant negatively associated predictor for fistula closure.

Other studies had also reported longer fistula tract, higher grade of fistula, branched fistula tract, inflammation as a negatively associated with fistula closure.[13,14] General surgical principles suggest that wound infection leads to delay in wound healing and delayed fistula closure due to ongoing inflammation and breakdown of tissues which may results in failure to close fistula. El-Anany et al reported up to 50% incidence of discharge from wound which was not proven by pus culture and sensitivity.[15] Elsayed et al reported 5% post-operative wound infection after laser surgery and common in complex fistula.[16] Our study reported 16.3% post-operative wound infection which is significantly common in patient with longer fistula length, fistula with collection or branched tract (grade 2, 4) and grade 5, branched fistula tract, inflammation at the time of surgery, and patients with diabetes. As post-operative wound infection was an independent predictor for failure to close fistula, our attempt should be to optimize correctable factors like collection (pus discharge) from external opening by prescribing antibiotics according to pus culture & sensitivity or draining a significant collection using either seton or incision and drainage before proceeding laser treatment. We should treat post-operative wound infection aggressively to achieve fistula closure in majority of cases. Branched fistula tract should be addressed either with laser or with surgical lay-open to achieve fistula closure in majority of cases.

Though there are few studies that reported predictor of fistula closure, there is lack of predictive tool to predict probability of fistula closure after laser treatment. One of the main contributions of our study is the development of a predictive model of fistula closure using logistic regression model which was deployed in GitHub and published using Streamlit with the intension to demonstrate this concept (*https://fistula-predictor.streamlit.app*). Although, the model performed exceptionally well (AUC = 0.92) on test data, validation with larger and multicentric data will be required before widespread clinical use. Our model would have been potential to serve as a valuable tool in decision making, particularly in resource-constrained settings which will help surgeons for counseling to the patient before surgery.

There are few limitations of this study. First, this is a retrospective and single-center study which limits external validation and introduces selection bias due to lack of blinding and presence of heterogeneity in selection of surgeries. Second, small sample size which limit the detection of smaller but potentially meaningful associations. Third, lack of imaging (MRI) confirmation of healing, outcomes were based solely on clinical assessment. There were only few cases of complex fistula (suprasphincteric tract) which limits this study to generalize this finding to suprasphincteric tract. Lastly, the predictive model to predict fistula closure need to be validated externally with larger and multicenter datasets before recommending for widespread clinical use.

Conclusion

This study demonstrates laser-assisted surgery for anal fistula as effective and safe with low complication rate and rapid return to work. The postoperative wound infection and branched tracts were the adverse predictors of closure. The predictive model developed using multivariable logistic regression is excellent to evaluate probability of fistula closure (AUC = 0.92) and this model is web-based to enable real-time decision-making for other surgeons. Our findings support the use of laser-assisted surgery as a safe and effective alternative to traditional surgery, especially in sphincter preservation and the minimization of postoperative morbidity.

References

1. Bhusari S, Nikam K, Wakte P. Anal fistula: a comprehensive review. Pharma Innovation Journal. 2019;8(1):201-8.
2. Abdel Wahed M, Hamed MK, Qassem MG. Short term Outcomes of Fistula Laser Closure (FILAC) as a Sphincter Sparing Technique Versus Fistulotomy with Immediate Sphincter Reconstruction (FISR) in High Trans-Sphincteric Fistula–in-ano; a Prospective Cohort Study. Ain Shams Journal of Surgery. 2023 Jan 1;16(1):49-56.
3. Wilhelm A. A new technique for sphincter-preserving anal fistula repair using a novel radial emitting laser probe. Techniques in coloproctology. 2011 Dec;15(4):445-9.
4. Giamundo P, De Angelis M. Treatment of anal fistula with FiLaC®: results of a 10-year experience with 175 patients. Techniques in coloproctology. 2021 Aug;25(8):941-8.
5. Öztürk E, Gülcü B. Laser ablation of fistula tract: a sphincter-preserving method for treating fistula-in-ano. Diseases of the colon & rectum. 2014 Mar 1;57(3):360-4.
6. Wolicki A, Jäger P, Deska T, Senkal M. Sphincter-

saving therapy for fistula-in-ano: long-term follow-up after FiLaC®. Techniques in coloproctology. 2021 Feb;25(2):177-84.

7. Cao D, Wang X, Zhang Y, Qian K, Yang N, Zhu M, Li Y, Wu G, Cui Z. Total fistula volume predicts surgical outcomes in complex perianal fistulizing Crohn's disease following fistula-tract laser closure: a single-center retrospective study. Techniques in Coloproctology. 2025 Dec;29(1):70.

8. Morris J, Spencer JA, Ambrose NS. MR imaging classification of perianal fistulas and its implications for patient management. Radiographics. 2000 Mar;20(3):623-35.

9. Gupta K, Mital K, Gupta R, Singh T. Fistula laser closure–Sphincter saving, minimal invasive technique for fistula-in-ano. Int J Sci Res. 2019 Oct;8:1-4.

10. Gupta K, Mital K, Gupta R, Bakshi T. Distal laser proximal fistulotomy–A new sphincter saving technique a comparative study with other sphincter saving procedures. Int J Recent Sci Res. 2020 Jan;11(03):37892-4.

11. Raja Ram NK, Chan, K, Fareeda S, Sagap I. A prospective evaluation of the outcome of submucosal ligation of fistula tract. Colorectal Disease. 2020; 22(12):2199-2203.

12. Ahmad A, Kumar A, Sonkar A, Kumar P, Varma S. A Prospective Study of Combined Sphincter Preserving Procedure (LIFT+VAAFT+FiLAC) in Complex Anal Fistula. Indian Journal of Surgery. 2022;84: 1211-1216.

13. Lauretta A, Falco N, Stocco E, Bellomo R, Infantino A. Anal fistula laser closure: the length of fistula is the Achilles' heel. Techniques in coloproctology. 2018 Dec;22(12):933-9.

14. Teymouri A, Keshvari A, Ashjaei A, Ahmadi Tafti SM, Salahshour F, Khorasanizadeh F, Naseri A. Predictors of outcome in cryptoglandular anal fistula according to magnetic resonance imaging: A systematic review. Health Science Reports. 2023 Jun;6(6):e1354.

15. El-Anany ME, Mohammed TZ, Mohammed AM. Evaluation of Fistula Laser Closure (FiLaC) in Management of High Trans-sphincteric Fistula-in-ano. Al-Azhar International Medical Journal. 2023;4(2):7.

16. Elsayed I, Ibrahim M, Kareem AK, Ahmed AD. Comparative Study between Surgical Outcomes of Fistula Tract LASER Closure (FiLaC) Versus Fistulotomy with Primary Sphincter Reconstruction in Management of High Trans-Sphincteric Perianal Fistula. The Medical Journal of Cairo University. 2022 Dec;90(12):1937-47.