ORIGINAL ARTICLE

LEARNING CURVE OF FULL ENDOSCOPIC LUMBAR SPINE SURGERY; A RETROSPECTIVE ANALYSIS AT FAROOQ NEUROSPINE INSTITUTE, PESHAWAR

Muhammad Farooq[1], Muhammad Idrees[2], Ikram Alam[3], Ali Shahjehan[4], Syeda Farwah[5], Haider Ali[5], Abdal Wasim Khan[5]

ABSTRACT

Introduction: Learning curve for minimally invasive endoscopic spine surgeries is the required time in which a surgeon becomes proficient in the skill of operating through the endoscope along with the quantity and number of cases needed to master specific Minimally Invasive endoscopic spinal procedures .The aim of this retrospective study was to investigate the learning curve of full endoscopic lumber spine surgery from the experience of an individual practicing endoscopic spine neurosurgeon.

Material & Methods: The records of patients who underwent full endoscopic spine surgery from March 2018 to March 2022 were evaluated at Afridi Medical Complex, Peshawar. To evaluate the learning curve, cases were categorized into four sequential groups based on the order of surgeries performed. Group 1 comprised the initial cases encompassing first year (2018-2019), and subsequent cases were grouped into Group 2, 3 and 4 representing year 2019-2020,2020-2021,2021-2022. The learning curve was assessed through the analysis of various outcome parameters, including operative time, intraoperative complications, postoperative complications, length of hospital stay, and patient-reported outcomes.

Results: A total of 543 patients met the inclusion criteria and were included in the analysis. The majority of patients were males (n =346, 64%) and 194(36) % were female. Mean operative time reached to plateau level at 160th surgery. Mean operative time decreased throughout each year from 90 minutes (Group 1) to 75 (Group 2), 60 (Group 3) and 45 (Group 4).

Conclusion: Progressive reduction in operative time and favorable patient-reported outcomes along with decreased complications are noted as surgical experience increased in operating endoscopic spine surgeries. These results underscore the importance of ongoing training and proficiency in full endoscopic techniques, ultimately enhancing patient care and outcomes in neurosurgical practice.

Key Words: endoscopic surgery, learning curve, lumbar spine

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Authors' Affiliation

[1]Consultant Neurosurgeon, Peshawar General Hospital
[2]Consultant Neurosurgeon, Khyber Teaching Hospital, Peshawar
[3]Consultant Neurosurgeon, Naseerullah Khan Babar Memorial Hospital
[4]Consultant Neurosurgeon, MMC Hospital Peshawar
[5]Physical Therapist, Afridi Medical Complex, Peshawar

Corresponding Author

Muhammad Farooq
Consultant Neurosurgeon,
Peshawar General Hospital
Email: farooqendospine33@gmail.com

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INTRODUCTION

Endoscopic lumber spine procedures characterized as minimally invasive techniques including transforaminal and interlaminar approach has gained worldwide popularity over the past few decades in the management of disc herniations at different levels owing as an alternative to conventional open surgeries which are associated with large incisions and greater muscle injury leading to secondary instabilities.[1,2] Lower surgical morbidity and mortality are associated with endoscopic procedures. However, the procedure requires specific skills and expertise owing to which majority of the spine surgeons are still unfamiliar and uses the conventional discectomy procedures.[3]

Learning curve for minimally invasive endoscopic spine surgeries is the required time in which a surgeon becomes proficient in the skill of operating through the endoscope along with the quantity and number of cases needed to master specific Minimally Invasive endoscopic spinal procedures in terms of anticipated blood loss, decrease operational time, minimal soft tissue dissection, associated adverse events/morbidity and mortality.[4] Different studies had described a steep learning curve for lumber spine endoscopic procedures as the surgical outcomes of these procedures are strongly associated with the skillfulness of the surgeon.[5,6] Decreased skillfulness and training in equipment's handling in endoscopic procedures have resulted in the more steeped curve and increased rate of complications which can be attributed to as main barriers hindering the incorporation of these minimally invasive procedures as primary treatment options for patients suffering from disc or lateral canal stenosis.[7]

Although the steep learning curve is reported in literature, but no such data is reported from Pakistan and therefore the aim of this study was to report the experience of a single practicing endoscopic spine neurosurgeon in the province and to report the learning curve of full endoscopic lumber spine surgeries.

MATERIAL AND METHODS

A retrospective observational analysis was conducted using data collected from Farooq neurospine institute at Afridi Medical Complex, Peshawar, spanning a period of 4 years from March 2018 to March 2022. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki and Ethical approval was granted from the Institutional Review Board of Afridi Medical complex. Patient confidentiality and privacy were strictly maintained throughout the study. Patient records, surgical notes, and imaging reports of all lumbar endoscopic surgeries performed by the single neurosurgeon during the study period were reviewed. Inclusion criteria encompassed patients who underwent full endoscopic lumbar spine surgery by the same neurosurgeon. Cases with incomplete or inadequate documentation or operated by other surgical techniques were excluded from the analysis. Data was collected about the mean age, duration of pain and level of endoscopic surgery along with surgical outcomes. Surgical details including the level of lumbar spine operated on, specific procedure performed, operative time, blood loss, complications encountered, and intraoperative findings were recorded for each case.

Surgical steps of Inter laminar approach:

In the interlaminar approach, the surgical procedure began with the administration of general anesthesia, which included induction using medications such as propofol, Acuron, and Nelbufin, with the dosage adjusted according to the patient's body weight. Once the patient was under anesthesia, they were carefully positioned in a prone orientation, and a bolster was strategically placed beneath the chest and abdomen to ensure the pelvis was adequately free and accessible for the surgical intervention. The surgical team maintained aseptic conditions by diligently scrubbing the lumbar area and applying sterile draping.

To guide the surgical steps, an anteroposterior (AP) image was obtained to precisely identify the entry point for the procedure. A 7mm incision was then made at this designated entry point, and the lumbar fascia was incised using a 15mm knife. A dilator was introduced medially to the facet joint, and a working sheath was placed over the dilator. Once the sheath was in position, the dilator was removed, and an endoscope was introduced for precise visualization of the surgical field. The remainder of the surgical procedure was conducted under endoscopic guidance, ensuring a clear view with the assistance of constant irrigation.

During the procedure, the surgical team coagulated the surrounding muscle using RF cautery or a probe, and the ligamentum flavum was meticulously cleared. An annular cutter was

employed to create a hole in the ligamentum flavum, placed as medially as possible. The ligamentum flavum was then carefully cut from the medial to the lateral side, extending up to the lateral border of the nerve root. The lateral border of the nerve root was identified, and the nerve root was gently retracted medially, with the beveled tip positioned on the lateral side of the nerve root. The beveled tip was rotated 180 degrees to protect the nerve root.

Further in the procedure, vessels on the disc were coagulated, and discectomy was performed to address the condition. The surgical team conducted a final assessment by ensuring the free movement of the nerve root to confirm successful decompression, ensuring both the safety and efficacy of the procedure.

Surgical steps of Trans foraminal approach:

In the transforaminal approach, the patient was placed in a prone position to facilitate access to the affected area. A bolster was positioned to ensure the abdomen and pelvis were free and well-supported. An anteroposterior (AP) image was obtained to delineate the spinous process line, followed by the drawing of a discal line to mark the target site. Subsequently, a disc inclination line was sketched on the lateral image, measuring the distance from the anterior aspect of the disc to the patient's back surface.

The measurement obtained from the disc inclination line served as the entry point from the medial line, established by the spinous process line, for the transforaminal discectomy. To ensure patient comfort and minimize discomfort, a 10% lidocaine solution was administered at the entry point, effectively anesthetizing the skin and underlying muscle.

An 18-gauge cannula was then introduced at the entry point, directed towards the transforaminal area to target the superior articular process. Once the superior articular process was identified, the needle was slightly withdrawn and repositioned into the disc space. Subsequently, a discography was performed to confirm the accuracy of the entry point. Following this confirmation, the stylet was removed from the cannula, and a guide wire was inserted in its place, accompanied by the removal of the cannula.

A dilator was then placed over the guide wire and introduced into the foramen, its positioning verified through lateral and anteroposterior imaging. The dilator was then removed, and a working sheath was inserted in its stead. The endoscope was introduced through the working sheath, and the remainder of the surgery proceeded under endoscopic visualization with constant irrigation.

A radiofrequency (RF) probe was employed to identify the anatomical landmarks within the surgical site. Once these structures were correctly located, the disc was carefully removed, providing unobstructed access to the transversing nerve root, thus achieving complete decompression. Following the successful decompression, the endoscope was removed, concluding the procedure.

Learning Curve Assessment

To evaluate the learning curve, cases were categorized into four sequential groups based on the order of surgeries performed. Group 1 comprised the initial cases encompassing first year (2018-2019), and subsequent cases were grouped into Group 2,3 and 4 representing year 2019-2020,2020-2021,2021-2022. The learning curve was assessed through the analysis of various outcome parameters, including operative time, intraoperative complications, postoperative complications, length of hospital stay, and patient-reported outcomes. Postoperative MRI was indicated only for those patients with postoperative pain or nerve injury.

Data Analysis:

Descriptive statistics were used to summarize patient demographics, surgical characteristics, and outcome variables. Continuous variables were presented as means ± standard deviations (SD). Categorical variables were expressed as frequencies and percentages. To assess the learning curve, trends in outcome variables across different surgical groups were analyzed using appropriate statistical tests. ANOVA was used for the association of those categorical variables having more than two categories with the normally distributed continuous variable while for not normally distributed data, Kruskal-wallis test was applied. The learning curves for the transforaminal and interlaminar procedures of full-endoscopic discectomy were assessed by Spearman's coefficient of rank correlation (rho). A positive significance level was assumed at a probability of less than 0.05.

Data analysis was performed using SPSS version 26.A p-value of less than 0.05 was considered statistically significant.

RESULTS

Patient Demographics

A total of 543 patients met the inclusion criteria and were included in the analysis. The mean age of the patients was 43 years (SD = [13.8) with a range of 37-58 years. The majority of patients were males (n =347 , 64%%) and 196[36]% were female. Mean follow up time was 8 months. Mean duration of pain was 4 months ± 17.3.

Majority of the cases were operated at L5-S1 level 300 (55%) through interlaminar approach followed by at L4,L5 149 (27%).While majority of cases through trans foraminal approach were at L4,L5 55(10%).Frequency and percentages of approaches at each level is mentioned in table 2.

Surgical Characteristics

The surgical characteristics of the included patients are summarized in Table 3. The most common indication for lumbar endoscopic surgery was disc herniation 392(72%) followed by spinal stenosis 152(28)%. Mean operative time for full endoscopic discectomy was 67.5 minutes.

Mean operative time for L4, L5 transforaminal approach was 46 minutes while mean operative time for L5, S1 through interlaminar approach was 42 minutes. The number of patients who could ambulate without any postoperative leg pain as soon as they regained consciousness from general anesthesia were 462(85%).

Operative blood loss was very negligible throughout the cases. Dural tears were observed in 2 patients while no patient had postoperative bleeding.2 patients had nerve root injury reported. Persistent symptoms after surgery at follow ups were reported by 5 patients. Recurrence of symptoms was observed in 4 patients while 2 patients were again re operated.

Learning Curve Assessment

The learning curve was evaluated by dividing the cases into four sequential groups based on the order of surgeries performed. Group 1 included the first (2018-2019), and subsequent cases were grouped into Group 2,3 and 4 representing the year 2019-2020,2020-2021,2021-2022. The mean operative time decreased progressively across the surgical groups along with intra and post-operative complications, as depicted in table 5.

In group 1 first three cases were converted to open surgery while incomplete decompression was reported in 2 patients. Length of hospital stay was same for all group of patients. In group 2 there were two nerve root injuries observed, one was due to multiple surgeries done before and a tightly adherent nerve root and cauda equine and patient demonstrated foot drop post operatively. Significant improvement in terms of operating time (Figure 1), complications (Figure 2) and patient reported symptoms was observed as the surgeon gained experience throughout these years.

Mean operative time reached to plateau level at 120th surgery while for interlaminar approach the plateau was achieved after 30 cases.

An analysis of variance (ANOVA) was conducted to assess the differences in operative time across the surgical groups. A statistically significant decrease in mean operative time was observed as surgical experience increased (p 0.002).

Patient-Reported Outcomes

Patient-reported outcomes were evaluated using the visual analogue scale and Oswestry low back pain questionnaire. Mean pain score on VAS pre-operatively was 8 while post operatively was improved to 2 indicating significant level of improvement in pain scores. Pre-operative mean Oswestry low back pain questionnaire score mean was 32 indicating moderate disability while post operatively mean score reported was 3.

DISCUSSION

The present study investigated the learning curve associated with full endoscopic lumbar spine surgery, an evolving and minimally invasive approach to address various lumbar spine pathologies.[8,9] We assessed this learning curve by categorizing patients into four sequential groups based on the order of surgeries performed over the course of four years (2018-2022).

Endoscopic spinal surgery has significant surgical benefits over conventional spinal surgery, including less postoperative discomfort and quicker recovery times because of less complications, according to previous literature.[10,11] Indications for endoscopic spinal surgery now include more complex situations, such as substantially migrated disc herniation, in addition to conventional simple disc

herniations.[12] However, there remain barriers for spine surgeons to use endoscopic spine surgery as the primary treatment for lumbar canal stenosis because of the steep learning curve and high complication rates.[13]

Mean operative time reported in our study was 67.5 minutes throughout the study duration which was more than 100 minutes starting from the initial surgeries and then becoming to the plateau in the subsequent years as the expertise and confidence of the surgeon increased. This mean time in our study is less than as observed by a study done by Chul-Woo Lee, Kang-Jun Yoon in 2019 which reported the mean time of 84.51±31 minutes and a plateau at 100th surgery.[14] In our study mean operative time reached to plateau level at 120th surgery while for interlaminar approach the plateau was achieved after 30 cases. The findings are in accordance to a study carried out Moscow, Russia in 2020 in which the plateau was achieved for operating time In interlaminar approach after 20 cases to 45 minutes.[15] This result is consistent with what Wang et al reported as the mean time for IL operation after 20 cases, which was 43 12 min.[16]

The neurosurgeon emphasized the critical importance of a surgeon being well-equipped with specialized endoscopic instruments to ensure the smooth execution of surgeries. Initially, the surgeon embarked on performing percutaneous full endoscopic lumbar laminectomies and foraminotomies using basic endoscopic tools typically employed for endoscopic discectomies. The turning point occurred when specialized endoscopic instruments specifically designed for decompression procedures were introduced. This breakthrough effectively resolved the impasse, reinvigorating the surgical process, and notably reducing the overall operative times emphasizing the importance of up to date instruments.[17,18] These specialized endoscopic tools included drills equipped with large-sized burrs, boasting high speed and robust torque capabilities.[7,19] However, it's worth noting that while the current array of endoscopic instruments has significantly improved the surgical experience, there are still areas where enhancements are needed.

One of the most important finding was the progressive decrease in mean operative time as the surgical experience increased. This trend highlights the proficiency and efficiency gained by the surgical team over time. The mean operative time decreased significantly from 90 minutes (±13.5) in the initial group (2018-2019) to 45 minutes (±2.6) in the most recent group (2021-2022). This substantial reduction in operative time suggests that surgeons became more proficient at performing full endoscopic lumbar spine surgery as they gained experience. Our statistical analysis, using analysis of variance (ANOVA), corroborated these observations, demonstrating a statistically significant decrease in mean operative time ($p < 0.002$) as surgical experience increased. This reduction in operative time is of clinical significance, as it can lead to shorter anesthesia exposure for patients and potentially reduced healthcare costs.[20,21]

Failure rate, complication rate, and clinical outcome are additional clinically significant factors that are used to evaluate surgeon skill as they progress along the learning curve. In minimally invasive spine surgery, the majority of complications and failed surgeries typically happen during the learning phase.[20] The clinical outcome is worse and the complication rate is higher at the novice level than at the expert level, according to numerous research on minimally invasive spine surgery.[22,23] These findings are also in accordance with our study as relatively increased number of complications and nerve injuries were reported in the novice and initial years stage, subsiding and reducing to a negligible level at the end of fourth year.

The limitations of the study are the single-center retrospective analysis, which may introduce selection bias and limit the generalizability of the findings. The study's retrospective nature limits the ability to control for confounding variables that may impact surgical outcomes. Future research should consider multi-center prospective studies to enhance the external validity of the findings and reduce potential biases. Long-term follow-up studies are essential to evaluate the durability of surgical outcomes and the potential for recurrence or complications over time.

CONCLUSION

The results of our study concluded that progressive reduction in operative time and favorable patient-reported outcomes along with decreased complications are noted as surgical experience increased in operating endoscopic spine surgeries. These results underscore the

importance of ongoing training and proficiency in full endoscopic techniques, ultimately enhancing patient care and outcomes in neurosurgical practice.

REFERENCES

1. Son S, Ahn Y, Lee SG, Kim WK. Learning curve of percutaneous endoscopic interlaminar lumbar discectomy versus open lumbar microdiscectomy at the L5–S1 level. PLoS One. 2020;15(7):0236296.
2. Ujjan BU, Nawaz S, Khalil S, ur Rehman M, Maqsood A, De Simone M. Endoscopic Microdiscectomy Versus Conventional Discectomy for Lumber Disc Diseases; A Randomized Controlled Trial at Tertiary Care Hospital. Pakistan Journal of Medical & Health Sciences. 2022;16(09):661-.
3. Morgenstern R, Morgenstern C, Yeung AT. The learning curve in foraminal endoscopic discectomy: experience needed to achieve a 90% success rate. International Journal of Spine Surgery. 2007;1(3):100-7.
4. Epstein NE. Learning curves for minimally invasive spine surgeries: Are they worth it? Surgical neurology international. 2017;8:61.
5. Hsu H-T, Chang S-J, Yang SS, Chai CL. Learning curve of full-endoscopic lumbar discectomy. European Spine Journal. 2013;22(4):727-33.
6. Hahn B-S, Park J-Y. Incorporating New Technologies to Overcome the Limitations of Endoscopic Spine Surgery: Navigation, Robotics, and Visualization. World Neurosurgery. 2021;145:712-21.
7. Lee CW, Yoon KJ, Kim SW. Percutaneous Endoscopic Decompression in Lumbar Canal and Lateral Recess Stenosis - The Surgical Learning Curve. Neurospine. 2019;16(1):63-71.
8. Wu PH, Kim H-S, Jang I-TJN. A narrative review of development of full-endoscopic lumbar spine surgery. 2020;17(Suppl 1):S20.
9. Chen C-M, Sun L-W, Tseng C, Chen Y-C, Wang G-CJPO. Surgical outcomes of full endoscopic spinal surgery for lumbar disc herniation over a 10-year period: A retrospective study. 2020;15(11):e0241494.
10. Phan K, Xu J, Schultz K, Alvi MA, Lu VM, Kerezoudis P, et al. Full-endoscopic versus micro-endoscopic and open discectomy: a systematic review and meta-analysis of outcomes and complications. 2017;154:1-12.
11. Komp M, Hahn P, Oezdemir S, Giannakopoulos A, Heikenfeld R, Kasch R, et al. Bilateral spinal decompression of lumbar central stenosis with the full-endoscopic interlaminar versus microsurgical laminotomy technique: a prospective, randomized, controlled study. 2015;18(1):61.
12. Choi K-C, Lee DC, Shim H-K, Shin S-H, Park C-KJWN. A strategy of percutaneous endoscopic lumbar discectomy for migrated disc herniation. 2017;99:259-66.
13. Ahn YJEromd. Transforaminal percutaneous endoscopic lumbar discectomy: technical tips to prevent complications. 2012;9(4):361-6.
14. Lee C-W, Yoon K-J, Kim S-WJN. Percutaneous Endoscopic Decompression in Lumbar Canal and Lateral Recess Stenosis? The Surgical Learning Curve. 2019;16(1):63-71.
15. Zelenkov P, Nazarov VV, Kisaryev S, Pimenova L, Zakirov BA, Goldberg M, et al. Learning Curve and Early Results of Interlaminar and Transforaminal Full-Endoscopic Resection of Lumbar Disc Herniations. 2020;12(3).
16. Wang H, Huang B, Li C, Zhang Z, Wang J, Zheng W, et al. Learning curve for percutaneous endoscopic lumbar discectomy depending on the surgeon's training level of minimally invasive spine surgery. 2013;115(10):1987-91.
17. Ahn YJAoTM. Current techniques of endoscopic decompression in spine surgery. 2019;7(Suppl 5).
18. Kim H-S, Wu PH, Jang I-TJN. Development of endoscopic spine surgery for healthy life: to provide spine care for better, for worse, for richer, for poorer, in sickness and in health. 2020;17(Suppl 1):S3.
19. Chung AS, McKnight B, Wang JCJWN. Scientific view on endoscopic spine surgery: can spinal endoscopy become a mainstream surgical tool? 2021;145:708-11.
20. Sclafani JA, Kim CWJCO, Research® R. Complications associated with the initial learning curve of minimally invasive spine surgery: a systematic review. 2014;472:1711-7.
21. Dagash H, Chowdhury M, Pierro AJJops. When can I be proficient in laparoscopic surgery? A systematic review of the evidence. 2003;38(5):720-4.
22. Choi K-C, Lee J-H, Kim J-S, Sabal LA, Lee S, Kim H, et al. Unsuccessful percutaneous endoscopic lumbar discectomy: a single-center experience of 10 228 cases. 2015;76(4):372-81.

23. Dhall SS, Wang MY, Mummaneni PVJJoNS. Clinical and radiographic comparison of mini–open transforaminal lumbar interbody fusion with open transforaminal lumbar interbody fusion in 42 patients with long-term follow-up. 2008;9(6):560-5.

Table 1: Patient Demographics

Variables	***Frequency/Percentages***
Gender	*Male: 347 (64%)*
	Female: 196 (36%)
Age	*Mean: 43 ± 13.8*
	Range: 37-58 years
Mean Follow up	*8 months*
Mean duration of pain	*4 months ± 17.3.*

Table 2: Levels of operated cases

Levels and approach	***Frequency/Percentages***
L5-S1 interlaminar approach	300 (55%)
L4,L5 interlaminar approach	149 (27%)
L3,L4 Interlaminar approach	27 (5%)
L4,L5 transfromainal approach	55(10%)
L3,L4 transfromainal approach	3(1%)
L2,L3 transfromainal approach	5(1%)
L1,L2 transfromainal approach	4(1%)

Table 3: Surgical Characteristics

Surgical Characteristics	**Frequency/Percentages**
Indication of endoscopic surgery	Disc herniation: 391(72%)
	Stenosis: 152(28)%.
Mean operative time	67.5 minutes
Mean operative time for l4,l5 transforaminal approach	46 minutes
Mean operative time for L5,S1 through interlaminar approach	42 minutes
Ambulating patients without any postoperative leg pain as soon as they regained consciousness	462(85%)

Table 4: Complications

Complications	***Frequency***
Dural tear	*2*
Nerve root injury	*2*
Persistent symptoms after surgery at follow ups	*5*
Recurrence of symptoms and re herniation	*4*
Re operated patients	*2*

Table 5: Learning Curve Analysis

Surgical Group, Number of patients	Operative Time (minutes)	Intraoperative Complications (%)	Postoperative Complications (%)
Group 1 (n= 10) (2018-2019)	90 minutes ± *13.5*	5%	7%
Group 2 (n=91) (2019-2020)	75 minutes ± *11.8*	4%	4%
Group 3 (n=152) (2020-2021)	60 minutes ± *6.3*	2%	2%
Group 4 (n=290) (2021-2022)	45 minutes ± *2.6*	0%	1%

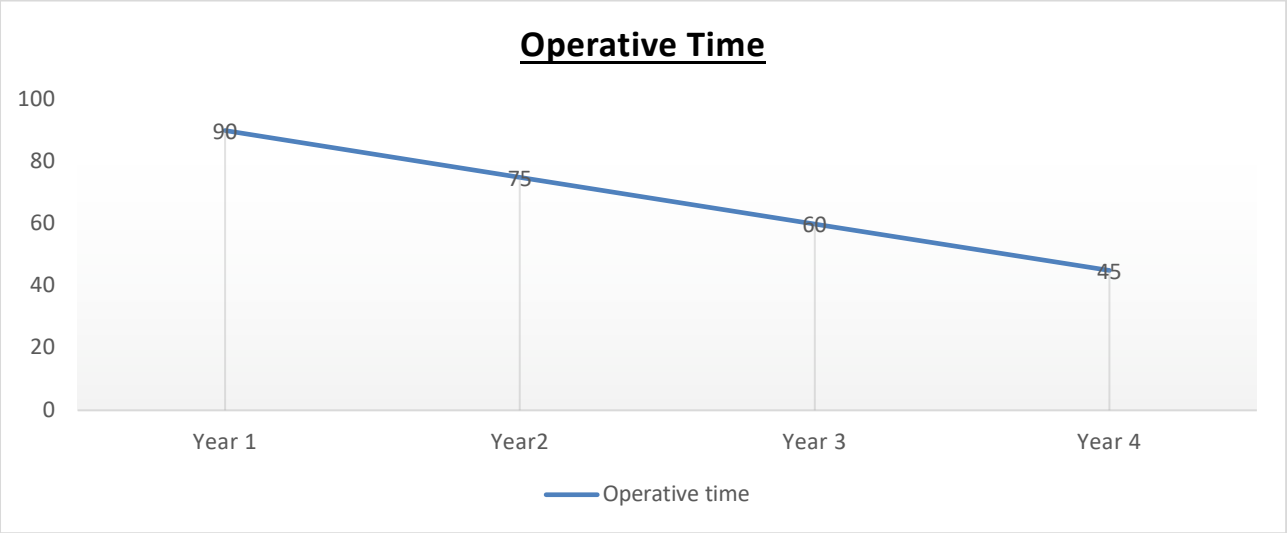

Figure 1: Operative time throughout the years

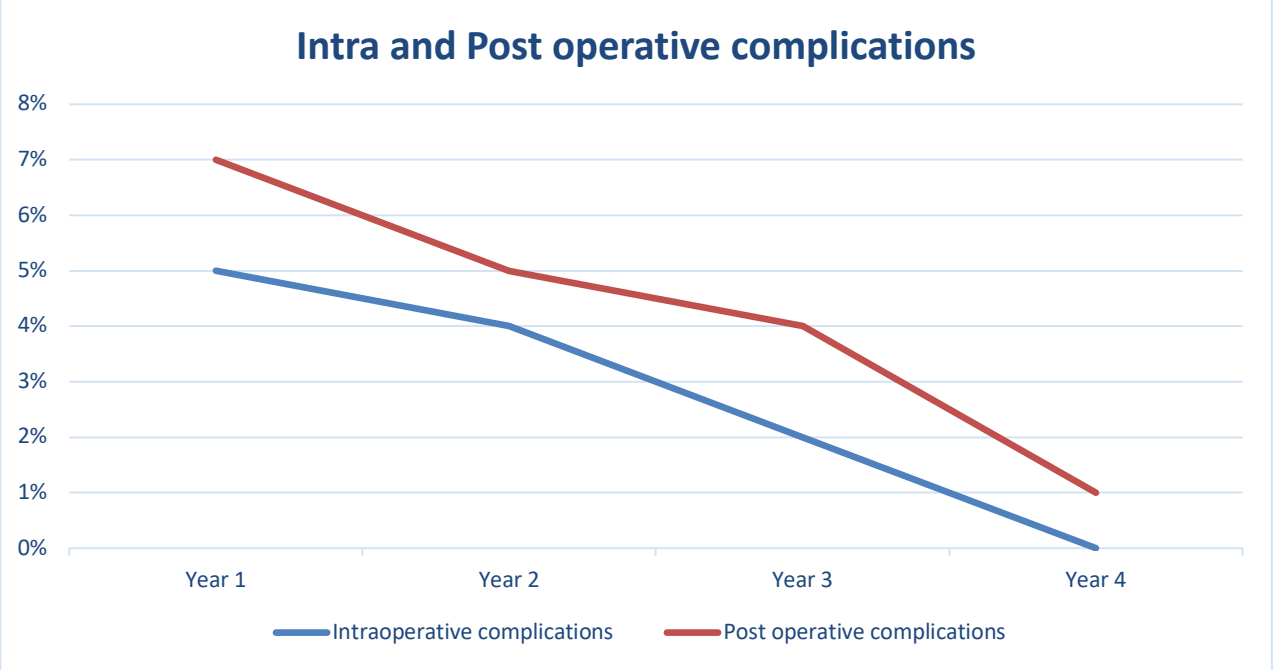

Figure 2:Intra and Post-operative complications throughout the years