

Intraoperative Morphology-based Laparoscopic Ovarian Drilling in Women with Polycystic Ovary Syndrome: Technique and Reproductive Outcomes

SNEHA ARAMANDLA¹, SURAKSHITH BATTINA², SARAT BATTINA³, NANDHANA VENKATESWARAN⁴, KHUSH SHAH⁵

ABSTRACT

Introduction: Polycystic Ovary Syndrome (PCOS) is a common cause of anovulatory infertility. Although Laparoscopic Ovarian Drilling (LOD) is an established second-line treatment, conventional techniques typically employ a fixed number of punctures irrespective of ovarian morphology and ovarian reserve. This study describes an intraoperative morphology based LOD technique tailored to ovarian characteristics and evaluates its reproductive outcomes and perioperative safety.

Aim: To evaluate the technique of LOD employed in the study, among women with PCOS and determine the reproductive outcomes after LOD.

Materials and Methods: This was a retrospective study conducted at Indigo Women's Center, Chennai, Tamil Nadu, India from September 2025 to February 2026. Data was obtained from past clinical records, extended from June 2022 to May 2024 (a total duration of two years). The number of ovarian punctures was individualised according to ovarian morphology and ovarian reserve parameters. Operative characteristics,

perioperative safety, and reproductive outcomes were analysed using descriptive statistics.

Results: A total of 152 women underwent LOD. The median number of punctures performed per ovary was 10 (IQR: 7-13), with a mean operative time of 20±10 minutes. No intraoperative or postoperative complications were recorded. During six months of follow-up, 60 women (39.5%) achieved pregnancy, of whom 56 (36.84%) had live births, three (1.97%) experienced miscarriage, and one (0.66%) had an ectopic pregnancy. Women who did not conceive within the first three months subsequently received Ovulation Induction (OI) with letrozole as part of routine clinical management.

Conclusion: LOD, employing an individualised technique, in this study of 152 women with PCOS, using a monopolar electrode was associated with favourable reproductive outcomes and an excellent perioperative safety profile in women with PCOS. The procedure was completed within a relatively short operative time, including diagnostic hysteroscopy and chromopertubation, supporting its feasibility as a safe surgical option for OI.

Keywords: Infertility, Live birth, Ovulation induction

INTRODUCTION

The PCOS is one of the most common endocrine pathologies and is a frequent cause of anovulatory infertility affecting 5-20% of reproductive age women [1], and the incidence is much higher in south Asian women. Patients with PCOS fall into a range of diagnostic criteria where some have ultrasonography detection of polycystic ovaries alone, without any other symptoms suggestive of hyperandrogenism. Restoration of ovulation and achievement of pregnancy remain the primary therapeutic goals in women with infertility associated with PCOS. Although oral OI agents are the first-line treatment, a significant proportion of women remains resistant to medical therapy and requires second-line interventions. Gonadotropin therapy is effective but is associated with increased treatment costs, intensive monitoring, Ovarian Hyperstimulation Syndrome (OHSS), and multiple pregnancies [2].

The standard approach for managing infertility in women with PCOS involves six to nine cycles of OI before considering In-Vitro Fertilisation (IVF) or intracytoplasmic sperm injection (ICSI) [3]. LOD is currently accepted as a successful second-line treatment in drug-resistant PCOS where either lasers or cauteries have been used [4]. Although LOD has been practiced for several decades, considerable variability exists in the surgical technique. Most published studies [5,6] have employed a standardised approach, commonly the "rule of four" or a fixed number of punctures per ovary, irrespective of ovarian size, ovarian reserve, or follicular burden [5,6]. The rule of four strategy consists of performing

four punctures bilaterally each, with a monopolar electrosurgical needle, for a depth of 3-4 mm, each for 4s at 40 W (rule of 4) delivering 640 J of energy per ovary [6,7].

Furthermore, many studies [8,9] have focused primarily on reproductive outcomes, with relatively limited attention given to tailoring the extent of ovarian drilling according to patient-specific ovarian characteristics. Zakerinasab F et al., compared unilateral and bilateral LOD, while Baradwan S et al., compared transvaginal and LOD, with both studies focusing predominantly on reproductive and hormonal outcomes [8,9]. Concerns regarding excessive ovarian tissue destruction and thermal injury remain important because LOD may be associated with reductions in Anti-Müllerian Hormone (AMH) and other markers of ovarian reserve [10,11]. Based on this rationale, the present study determined the number of punctures according to intraoperative ovarian morphology and ovarian reserve parameters, aiming to achieve adequate drilling while avoiding unnecessary thermal exposure.

The present retrospective study was undertaken to describe a morphology-based LOD technique in women with PCOS, in which the number of ovarian punctures was determined according to the characteristics of each ovary based on ovarian morphology, ovarian volume, Antral Follicle Count (AFC), and serum AMH levels. The rationale for this approach was based on the considerable variation in ovarian size and follicular burden among women with PCOS. In addition, this study reported the operative characteristics, safety profile, and reproductive

outcomes following this individualised approach among 152 women treated at a tertiary infertility centre.

MATERIALS AND METHODS

The study was a retrospective study conducted at Indigo Women’s Center, Chennai, Tamil Nadu, India for a period of six months (September 2025 to February 2026). Data were obtained from past clinical records, extended from June 2022 to May 2024 (a total duration of two years) and supplemented by video footage of intraoperative findings. An institutional review board approval was not procured due to the study being retrospective in nature, with an exemption letter from the head of the institution. All patients were followed retrospectively using hospital outpatient records for a minimum of six months. The initial three months were allocated for spontaneous conception following LOD. Women who failed to conceive during this period received letrozole for OI for the subsequent three months. Pregnancy outcomes were obtained exclusively from hospital records.

Inclusion criteria: Women aged 20 to 37 years who were diagnosed with PCOS based on the Rotterdam criteria [12]. Eligible participants met at least two of the following conditions: oligomenorrhea or amenorrhea, biochemical or clinical signs of hyperandrogenism, and ultrasound evidence of polycystic morphology of the ovaries.

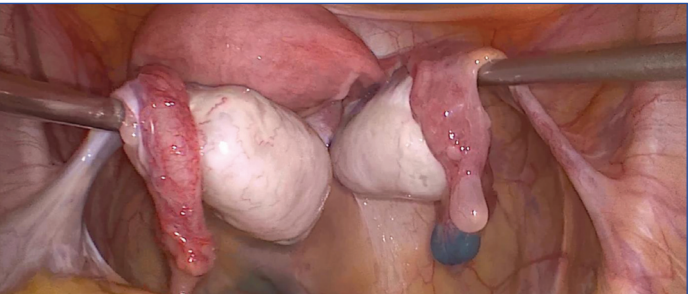
Exclusion criteria: Patients who were younger than 20 years of age, had endocrine disorders affecting reproductive function, or had other conditions causing hyperandrogenism or ovulatory dysfunction. Additionally, patients who had received hormone therapy within the preceding three months were excluded from the study.

Sample size: All consecutive women with PCOS who underwent LOD during the study period and fulfilled the eligibility criteria were included. Thus, the final sample size comprised 152 patients.

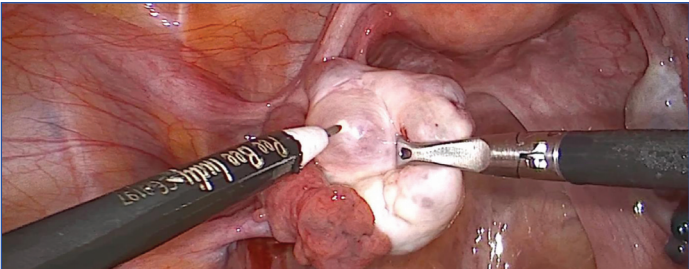
Study Procedure

Prior to surgery, blood samples to measure AMH values and Ultrasonography to detect AFC and ovarian volume were done. All patients underwent LOD, with the technique employed in this study, based on intraoperative ovarian morphology and were not derived from a previously validated grading system, performed by a single author.

After pneumoperitoneum was created [Table/Fig-1], the ovary was held with a laparoscopic babcock forceps, and the procedure was performed on both surfaces of the ovary, done bilaterally with an insulated electrode needle. The needle was pointed perpendicularly to the ovarian surface with a cutting current of 30W-40 W used as an aid for the entry of the needle. The entire needle tip (8 mm) was inserted into the ovary, with 40 W of coagulating current for one second at each point [Table/Fig-2]. According to intraoperative ovarian morphology including ovarian size, cortical thickness, pearly white appearance, follicular density, around 5-15 punctures per ovary were drilled and this was determined based on morphology, for each ovary. The LOD technique and puncture range is shown in [Table/Fig-3].



[Table/Fig-1]: Pre-operative image of right and left ovaries - bulky ovaries, increased volume, increased stromal thickness, whitish and opaque giving a pearly sheen, suggestive of PCO morphology.



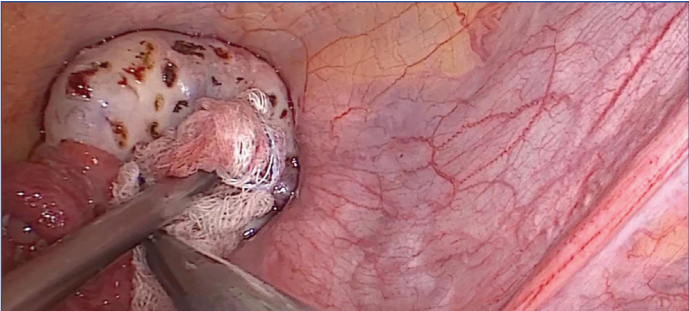
[Table/Fig-2]: Laparoscopic Ovarian Drilling (LOD) using monopolar cautery.

Intraoperative assessment	Approximate puncture range
Mild ovarian enlargement/relatively less prominent cortex and follicular density	5-6
Moderate enlargement/increased cortical and follicular prominence	7-9
Marked enlargement/thick cortex and dense follicular appearance	10-12
Very bulky ovary/marked stromal and follicular prominence	13-15

[Table/Fig-3]: LOD in PCOS and the technique.

Preoperative ovarian volume, AFC, and serum AMH were recorded as supportive parameters; however, no predetermined numerical cut-offs were used to determine the number of punctures. The final puncture range was based mainly on the intraoperative appearance of the ovary.

After the drilling was done, the ovarian surface was compressed with a gauze to achieve haemostasis and drain the excess fluid [Table/Fig-4], which measured 10-15 mL, after which a wash of normal saline was given. All ovaries were dried at the end. In addition, all patients underwent tubal chromopertubation and hysteroscopy in the course of the same surgery. Intraoperative findings were noted and a follow-up of the patients led to data of the number of pregnancies that occurred after the procedure. Data entry and statistical analysis were performed, with patient information kept confidential at all times throughout the study.



[Table/Fig-4]: Compression of ovary with a gauze to remove the excess fluid.

Miscarriage was defined as spontaneous pregnancy loss before 20 completed weeks of gestation [13]. Intrauterine Foetal Demise (IUFD) was defined as foetal death occurring at or after 20 weeks of gestation and before delivery [14]. Stillbirth was defined as the birth of a foetus with no signs of life at or after 28 completed weeks of gestation, in accordance with the World Health Organisation (WHO) definition [15].

STATISTICAL ANALYSIS

Data entry was carried out using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). Statistical analyses were conducted with GraphPad Prism version 10. Descriptive statistics were summarised in the form of frequencies and percentages. Continuous variables with a normal distribution are presented as mean±Standard Deviation (SD), whereas non-normally distributed continuous variables are expressed as median with Interquartile Range (IQR). Baseline demographic and clinical characteristics,

operative details, the distribution of the LOD technique according to ovarian morphology and ovarian reserve parameters, and reproductive outcomes were summarised using descriptive statistics. Pregnancy rate, live birth rate, miscarriage rate, ectopic pregnancy rate, and perioperative complications were calculated.

RESULTS

A total of 152 women with clomiphene-resistant PCOS underwent LOD based on intraoperative morphology. The mean age was 30.8 ± 3.6 years, and the mean BMI was 26.0 ± 3.1 kg/m². Demography and clinical characteristics are shown in [Table/Fig-5].

Variable	Value
Age (years), mean $\pm$ SD	30.8 $\pm$ 3.6
BMI (kg/m ²), mean $\pm$ SD	26.0 $\pm$ 3.1
AMH (ng/mL), median (IQR)	6.7 (5.5-7.1)
AFC, median (IQR)	25 (23-28)
Right ovarian volume (mL), median (IQR)	27.7 (22.8-37.4)
Left ovarian volume (mL), median (IQR)	32.4 (22.0-37.4)
Number of punctures, median (IQR)	10 (7-13)

[Table/Fig-5]: Baseline demography and clinical characteristics.

The fertility outcomes following LOD after which patients conceived naturally are enlisted below [Table/Fig-6]. No tests were done to confirm ovulation restoration in the form of serial ultrasonography or serum progesterone. Transvaginal sonography as well as serum β -human chorionic gonadotrophin were used to confirm pregnancy. All patients were - up for a duration of six months. Out of 152, 18 (11.8%) women became spontaneously pregnant within three months of LOD. Among those who did not conceive spontaneously, OI drugs like Letrozole were administered for a period of three months, resulting in 42 of 152 (27.63%) additional pregnancies. There was no loss of follow-up as it was a retrospective study. During the six-month follow-up, 60 of 152 women (39.5%) achieved pregnancy following LOD employed in this study. Live birth was the most common outcome, occurring in 56 women (36.84%), whereas miscarriage and ectopic pregnancy were observed in 3 (1.97%) and 1 (0.65%) woman, respectively. No pregnancy was recorded in 92 women (60.5%). None of the participants experienced more than one pregnancy during the study period.

Reproductive Outcomes after LOD	No. (%)
Total pregnancies	60 (39.5)
Live births	56 (36.84)
Miscarriage	3 (1.97)
Ectopic pregnancy	1 (0.65)
No pregnancy	92 (60.5)
More than one pregnancy	0

[Table/Fig-6]: LOD in 152 women of PCOS and their reproductive outcome.

The distribution of the intraoperative morphology based LOD technique is presented in [Table/Fig-7].

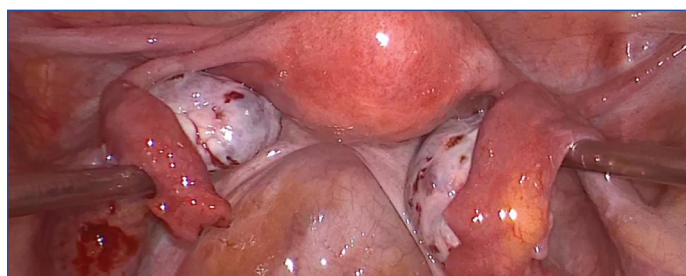
The LOD technique varied according to ovarian morphology which was noted intraoperatively based on size, sheen, cortical thickness and ovarian reserve parameters. The number of punctures was individualised primarily according to intraoperative ovarian morphology, considering ovarian size, cortical thickness, follicular density, followed by ovarian reserve parameters [Table/Fig-8]. A total of 28 women (18.4%) with mildly enlarged ovaries underwent 5-6 punctures per ovary [Table/Fig-9], while 46 (30.3%) with moderately enlarged ovaries underwent 7-9 punctures. Markedly enlarged ovaries required 10-12 punctures in 40 women (26.3%) [Table/Fig-10], and severely enlarged or

Variable	Value
Operative time (minutes)	20 $\pm$ 10
Number of punctures per ovary, median (IQR)	10 (7-13)
Intraoperative complications	0
Postoperative complications	0

[Table/Fig-7]: Laparoscopic Ovarian Drilling (LOD) in 152 women of PCOS and their operative outcomes.

Number of punctures per ovary	Intraoperative ovarian morphology*	n (%)
5-6	Mild enlargement	28 (18.4)
7-9	Moderate enlargement	46 (30.3)
10-12	Marked enlargement	40 (26.3)
13-15	Severe enlargement/bulky ovaries	38 (25.0)
Total	—	152 (100.0)

[Table/Fig-8]: Distribution of ovarian punctures according to intraoperative ovarian morphology in 152 women of PCOS.



[Table/Fig-9]: Bilateral LOD in a patient requiring 5-10 drills.



[Table/Fig-10]: Comparison of left ovary after LOD in a patient requiring 10-12 drills vs right ovary PCO morphology.

bulky ovaries underwent 13-15 punctures in 38 women (25.0%) [Table/Fig-11].



[Table/Fig-11]: Bilateral LOD in a patient requiring more than 15 drills.

DISCUSSION

The present study evaluated the LOD technique which was employed in 152 women with PCOS, in which the number of ovarian punctures was determined according to intraoperative ovarian morphology, with ovarian reserve parameters used as adjuncts. The principal findings were that pregnancy was achieved in 39.5% of women during the six-month follow-up and no intraoperative or postoperative complications were observed. The number of punctures varied from 5 to 15 per ovary according to ovarian size, cortical characteristics and follicular

density, rather than applying a fixed number of punctures to all ovaries.

The therapeutic effect of LOD is thought to result from thermal destruction of the androgen-producing ovarian stroma and a reduction in the number of small follicles. This decreases intraovarian androgen concentrations and restores normal hypothalamic-pituitary-ovarian axis function, thereby facilitating spontaneous mono-ovulation in women with PCOS. This method leads to spontaneous ovulation after surgery [8]. When considering LOD, factors such as the comparative cost of the procedure, the availability of surgical expertise, and the potential intraoperative and postoperative risks should be taken into account [16].

Conventional LOD techniques have commonly employed a predetermined number of punctures and a relatively uniform thermal dose, irrespective of variations in ovarian morphology. In contrast, in the present study, the number of punctures was determined primarily according to the intraoperative appearance of each ovary, including ovarian size, cortical prominence or thickness, stromal appearance and follicular density. Preoperative ovarian volume, AFC and serum AMH were used as adjunctive parameters. Thus, while the electrosurgical settings were kept constant, the extent of drilling varied between ovaries. This approach was intended to provide adequate stromal treatment while avoiding unnecessary ovarian thermal injury [Table/Fig-12].

Conventional LOD	Morphology-based LOD (Present Study)
Fixed "Rule of Four"	5-15 punctures
Same energy to all ovaries	Tailored to ovarian morphology
No consideration of cortical thickness	Cortical thickness considered
No consideration of ovarian size	Ovarian size considered
Uniform approach	Individualised approach
Mainly based on surgeon convention	Guided by intraoperative morphology with ovarian reserve as adjunct

[Table/Fig-12]: Conventional vs morphology based LOD.

Recent literature has largely concentrated on reproductive and hormonal outcome following ovarian drilling or comparisons between different drilling approaches, with relatively limited attention to determining the extent of drilling according to individual ovarian characteristics. Zakerinasab F et al., compared unilateral and bilateral LOD, whereas Baradwan S et al., compared transvaginal ovarian drilling with LOD, with both studies primarily evaluating reproductive and hormonal outcomes rather than a morphology-guided method for deciding the number of ovarian punctures [8,9].

In the current study, with 152 women, mean age was 30.8 ± 3.6 years, and the mean BMI was 26.0 ± 3.1 kg/m². The median serum AMH was 6.7 ng/mL (IQR 5.5-7.1). This was similar in comparison to a study by Masroor M et al., in which 84 women with PCOS underwent LOD. The mean age of the patients was 29.10 ± 4.01 years. The mean BMI of the patients was 26.33 ± 4.14 kg/m². Most (41%) of the women had normal BMI. The mean AMH value was 8.81 ± 6.16 prior to LOD [11].

One of the problems of individuals with PCOS is an increase in BMI, which contributes to poorer fertility results by creating insulin resistance [8]. LOD also has been reported to have beneficial effects on insulin resistance and androgen production from ovaries. The improvements achieved with LOD have been observed to remain for a long time in 54% of the PCOS population [17].

In the current study, 152 PCOS cases who underwent LOD with a monopolar electrode, both pregnancy rates along with live-birth rates were notably high. The fertility rates amongst patients (39.5%) were congruent with those of previous literature. Ansari S et al., reported pregnancy in eight of 30 women following LOD, corresponding to an overall pregnancy rate of 26.7% in the study

cohort [2]. Among the 24 women who ovulated following LOD, the reported pregnancy rate was 33.33%. In a pooled study by Bordewijk EM et al., involving 3326 women, evidence suggest that if the chance of live birth following medical OI alone is 42%, the chance following LOD would be between 28% and 40% [6].

Despite tailoring the extent of drilling, reproductive outcomes remained comparable to those reported with conventional techniques, with no perioperative complications observed. In the present study, 39.5% of women achieved clinical pregnancy within the six-month follow-up period. The remaining 60.5% did not achieve pregnancy during the study follow-up. As per the institutional protocol, women were initially observed for spontaneous conception for three months following LOD, followed by OI with letrozole for a further three months if pregnancy was not achieved.

Patients with PCOS have a higher risk of developing OHSS [18] due to their heightened sensitivity to gonadotropins and typically high AFC. Compared with medical OI, LOD may restore spontaneous mono-ovulation without the need for intensive monitoring, while reducing the risk of multiple pregnancy and OHSS. For a similar success rate, LOD might be indicated as a second-line therapy instead of gonadotrophins to avoid gonadotropin-related adverse events [19]. Patients who remained infertile beyond the study follow-up were managed according to routine clinical practice with either Superovulation/Intrauterine insemination/ICSI or IVF. However, subsequent fertility treatments, including referral for assisted reproductive techniques such as IVF, were not systematically captured in this retrospective study and therefore could not be analysed.

A main drawback of LOD is the risk of adhesions occurring after cauterisation between the ovary and bowel as a sequel to slight bleeding on the surface of the ovary. Although in many cases, these are mild adhesions following LOD, that do not affect the rate of pregnancy rates. Adhesion prevention strategies like liberal peritoneal lavage, and application of adhesion barriers like intercede [20] is not effective in preventing de novo adhesions or in improving pregnancy rates [5]. In the technique employed in this study, the ovaries were compressed with a gauze after LOD which further reduce the chances of adhesions, followed by a saline wash to reduce the temperature, thereby reducing chances of injury.

Another potential risk is premature ovarian failure especially if the ovarian blood supply is damaged inadvertently or if large number of punctures is made, leading to excessive destruction of ovarian follicular pool or production of anti-ovarian antibodies [21]. So far, only one isolated case of ovarian atrophy following high-energy drilling (eight coagulation points at 400W for 5s) has been reported [20]. With application of the appropriate technique, the ovarian reserve can be maintained.

Limitation(s)

The present study represents a single-centre experience, which may limit the generalisability of the findings. Another limitation of this study was the lack of long-term follow-up beyond six months. Consequently, the reproductive outcomes of women who did not conceive during the study period, including subsequent OI, gonadotropin therapy, IVF, or spontaneous conception after the study period, were not available.

Future prospective multicentre studies with larger sample sizes are required to validate these results and assess the reproducibility of the technique.

CONCLUSION(S)

LOD, tailored according to ovarian morphology and ovarian reserve parameters, was feasible and demonstrated favourable reproductive outcomes with an acceptable safety profile in women with PCOS. Although this individualised approach appears

promising, the retrospective design and lack of a comparator group limit definitive conclusions regarding its comparative effectiveness. Larger prospective comparative studies with longer follow-up are warranted to validate these findings and establish the optimal surgical strategy.

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PARTICULARS OF CONTRIBUTORS:

1. Fellow, Department of Obstetrics and Gynaecology, Indigo Women's Center, Chennai, Tamil Nadu, India.
2. Consultant, Department of Obstetrics and Gynaecology, Indigo Women's Center, Chennai, Tamil Nadu, India.
3. Consultant, Department of Obstetrics and Gynaecology, Indigo Women's Center, Chennai, Tamil Nadu, India.
4. Fellow, Department of Obstetrics and Gynaecology, Indigo Women's Center, Chennai, Tamil Nadu, India.
5. Student, Department of Obstetrics and Gynaecology, Indigo Women's Center, Chennai, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Sneha Aramandla,
No. 6, 6th Main Road, Kasthuriba Nagar, Adyar, Chennai-600020,
Tamil Nadu, India.
E-mail: snehaa1@gmail.com

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