Original Article

Evaluation of Alteration in Testicular Perfusion after Laparoscopic Hernioplasty : A Prospective Study Conducted at one of the Tertiary Care Centres of Western India

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Background : Hernia repair is one of the most common general surgeries performed today. Despite its widespread use, the impact of laparoscopic Total Extraperitoneal (TEP) repair on Testicular Perfusion remains under-explored, especially in Indian literature. This study aims to evaluate changes in testicular blood flow following laparoscopic TEP hernia repair using Color Doppler Ultrasound (CDUS).

Materials and Methods : This prospective study was conducted at Sheth V S General Hospital, Ahmedabad in 25 male patients with clinically diagnosed Inguinal Hernia who underwent laparoscopic TEP repair. Testicular perfusion was assessed pre-operatively and post operatively at 24 hours, 1 week and 3 months using CDUS. Key parameters measured included Peak Systolic Velocity (PSV), End-Diastolic Velocity (EDV) and Resistive Index (RI). Statistical analysis was performed using Mean ± Standard Deviation, paired t-test, ANOVA and Pearson correlation.

Results : The study observed minor alterations in Testicular blood flow postoperatively. RI values showed a significant reduction in the testicular artery ($p<0.05$), while PSV and EDV demonstrated dynamic changes over time. The RI decreased slightly in the Testicular and capsular arteries with an increase in the Intratesticular Artery.

Conclusion : The findings suggest that TEP hernia repair does not lead to significant long-term alterations in Testicular Perfusion and health when measured at 3 months postoperatively. Research study with larger sample sizes and extended follow-up periods is recommended to fully understand the long-term impact of laparoscopic TEP repair on testes.

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***Key words* : Laparoscopic TEP Hernia Repair, Testicular Perfusion, Color Doppler Ultrasound, Resistive Index, Peak Systolic Velocity.**

A hernia is defined as the abnormal protrusion of an organ or tissue through a defect in its surrounding walls. Although hernias can occur in various parts of the body, they most frequently involve the abdominal wall, particularly the inguinal region[1].

Inguinal hernia repair is one of the most frequently performed general surgeries today. Despite its prevalence, the technical aspects of hernia repair have significantly evolved over time and continue to advance[2]. Testicular complications, which can impact sexual function, are among the rare but serious issues requiring careful attention during inguinal hernia surgeries, as inguinal hernias are anatomically close to the testicular blood vessels.

The literature shows significant variation in the incidence of ischemic orchitis and testicular atrophy following hernia repair. According to Fong and Reid, primary ischemic orchitis occurs in 0.7% to 1.0% of patients undergoing open hernia surgery, with 0.35% to 0.65% developing testicular atrophy[3,4].

All meshes used in hernia repair induce an initial and chronic inflammatory response after implantation. One potential outcome of this inflammation is ischemic orchitis and/or testicular atrophy in adult males[5].

High-resolution Color Doppler Ultrasound (CDUS) is an effective and non-invasive technique which reliably demonstrates testicular arterial anatomy and blood flow which helps in detecting blood flow alterations[6].

Since Ger *et al* introduced laparoscopic inguinal hernia surgery in 1990[7], it has undergone significant modifications and is widely used in general surgery. Though safe and effective, laparoscopic surgery still

Editor's Comment :

- Laparoscopic hernia repair (TEP) minimally impacts testicular blood flow, maintaining perfusion levels up to 3 months postoperatively. This suggests that when performed by skilled surgeons, TEP repair is safe for testicular health. Further research with larger cohorts and extended follow-up period is needed to explore long-term effects on fertility and testicular function.

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has its drawbacks. When performed meticulously, laparoscopic TEP repair results in complications and short-term recurrence rates comparable to open hernia repair, with less pain and faster recovery[8].

Few studies have evaluated the impact of Laparoscopic Inguinal Hernia Surgery on Testicular Perfusion, showing that blood flow typically normalizes to pre-operative levels after a few months[9-12]. There is limited Indian literature on this subject, highlighting the need for further research in this context.

Laparoscopic hernia repair is widely adopted for its minimally invasive approach and favorable recovery profile. However, there is limited data on its impact on Testicular Perfusion, which is crucial for preventing complications such as ischemic orchitis and testicular atrophy. This study aims to address this gap by measuring bilateral Testicular Perfusion using CDUS at multiple time points: pre-operatively and postoperatively at 24 hours, 1 week and 3 months. The primary objectives were to assess any alterations in testicular blood flow following laparoscopic TEP repair and to compare these measurements over time, thereby providing valuable insights into the procedure's impact on testicular health and guiding improvements in surgical techniques.

Materials and Methods

Study Design and Population :

This prospective controlled trial was conducted in the Department of General Surgery and Department of Radiodiagnosis, Sheth V S General Hospital, Ahmedabad. The study included 25 male patients, aged above 18 years, with clinically diagnosed inguinal hernia who underwent laparoscopic Total Extraperitoneal (TEP) repair from August, 2013 to July, 2015.

Inclusion and Exclusion Criteria :

Male patients above 18 years with a clinical diagnosis of inguinal hernia and suitability for laparoscopic TEP under general anesthesia were included. Exclusion criteria encompassed coagulation defects, undescended testis, recurrent hernia, co-existent varicocele, complicated hernias (irreducible, strangulated, obstructed), history of previous lower abdominal surgery or radiotherapy, and complete inguinal hernia.

Preoperative and Operative Preparation :

Informed consent was obtained from all participants. Pre-operative workup included filling out a detailed proforma, Routine Blood Tests, Chest X-ray, ECG for patients over 40 years and pre-anesthetic clearance. Testicular Perfusion was assessed using Color Doppler Ultrasound (CDUS) with Philips HD11™. For the laparoscopic TEP procedure, patients were given prophylactic antibiotics, kept nil per oral before surgery and underwent a laparoscopic repair with mesh placement under general anaesthesia.

Postoperative Care and Analysis :

Postoperative care included monitoring for complications, administering prophylactic antibiotics, and pain management with diclofenac sodium. Patients were discharged on the first postoperative day after CDUS evaluation and follow-up CDUS was conducted on the 7th day and at 3 months. Statistical analysis of results was performed using Mean ± Standard deviation, paired t-test, ANOVA and Pearson correlation with significance set at $p<0.05$, utilizing SPSS software (version 16.0).

Results

Table 1 presents the results of a linear regression analysis examining how various demographic and clinical factors influence blood flow in the testicular, capsular and intratesticular arteries. The analysis identified several significant findings: Patients under 25 years old exhibited a significant decrease in Testicular Artery blood flow ($\beta = 0.09$, $p = 0.031$), suggesting that younger patients may be more vulnerable to changes in blood flow post-surgery. In contrast, no significant changes were observed in patients aged 26-45 or over 45 years. Smokers showed a significant reduction in Testicular Artery blood flow ($\beta = 0.07$, $p = 0.047$) and a near-significant decrease in Intratesticular Artery blood flow ($\beta = 0.05$, $p = 0.058$). These findings emphasize the negative impact of smoking on vascular health in the context of hernia repair.

The analysis found no significant differences in blood flow changes between unilateral and bilateral hernia repairs, indicating that the type of surgical approach does not markedly affect vascular outcomes. Similarly, whether the repair was performed on the right or left side did not significantly affect blood flow in any of the measured arteries. There was a non-significant trend toward reduced blood flow in the testicular artery for patients with direct hernias ($\beta = 0.08$, $p = 0.077$), but overall, the nature of the hernia (direct *versus* indirect) did not significantly impact blood flow. Patients without mesh fixation showed a significant increase in Intratesticular Artery blood flow ($\beta = 0.04$, $p = 0.028$), suggesting that avoiding mesh fixation could have beneficial

Table 1 — Impact of Demographic and Clinical Factors on Testicular, Capsular, and Intratesticular Artery Blood Flow : Linear Regression Analysis

Factor	Category	Testicular Artery (β)	Capsular Artery (β)	Intratesticular Artery (β)	p-value (Testicular Artery)	p-value (Capsular Artery)	p-value (Intratesticular Artery)
Age Group	< 25 Years	0.09	0.05	0.03	0.031	0.06	0.201
	26-45 Years	0.03	0.02	0.02	0.487	0.532	0.277
	> 45 Years	0.04	0.01	0	0.511	0.724	0.916
Smoking Status	Smoker	0.07	0.03	0.05	0.047	0.091	0.058
	Non-Smoker	0.02	0.01	0.01	0.668	0.812	0.53
Repair Type	Unilateral	0.03	0.02	0.02	0.621	0.572	0.285
	Bilateral	0.08	0.03	0.02	0.092	0.161	0.313
Side of Repair	Right	0.05	0.02	0.01	0.204	0.073	0.429
	Left	0.03	0.01	0.02	0.342	0.254	0.343
Nature of Hernia	Direct	0.08	0.02	0.01	0.077	0.294	0.328
	Indirect	0.03	0.01	0.01	0.458	0.609	0.491
Mesh Fixation	Fixed	0.04	0.02	0.02	0.213	0.487	0.354
	Not Fixed	0.09	0.01	0.04	0.045	0.739	0.028

effects on blood flow in this artery. No significant effects were noted in patients with mesh fixation. These findings highlight the importance of considering patient-specific factors, such as age and smoking status, in the management and monitoring of hernia repairs, as they can significantly affect vascular health outcomes.

In the study, bilateral testicular perfusion was measured through the Resistive Index (RI) of different testicular arteries, including the Testicular Artery, Capsular Artery and Intratesticular Artery, both pre-operatively and three months post-operatively. Pre-operative measurements showed mean RI values of 0.77 (± 0.05) for the Testicular Artery, 0.64 (± 0.06) for the capsular artery, and 0.58 (± 0.07) for the Intratesticular Artery. Postoperative measurements indicated a slight decrease in the testicular artery RI to 0.72 (± 0.04), a minimal reduction in the capsular artery RI to 0.63 (± 0.05), and a minor increase in the intratesticular artery RI to 0.60 (± 0.06). Comparative analysis revealed significant changes in RI values postoperatively, with a reduction of 0.05 in the Testicular Artery RI and 0.01 in the Capsular Artery RI, while the Intratesticular Artery RI increased by 0.02. These changes were statistically significant, with p-values less than 0.05 (Tables 2&3).

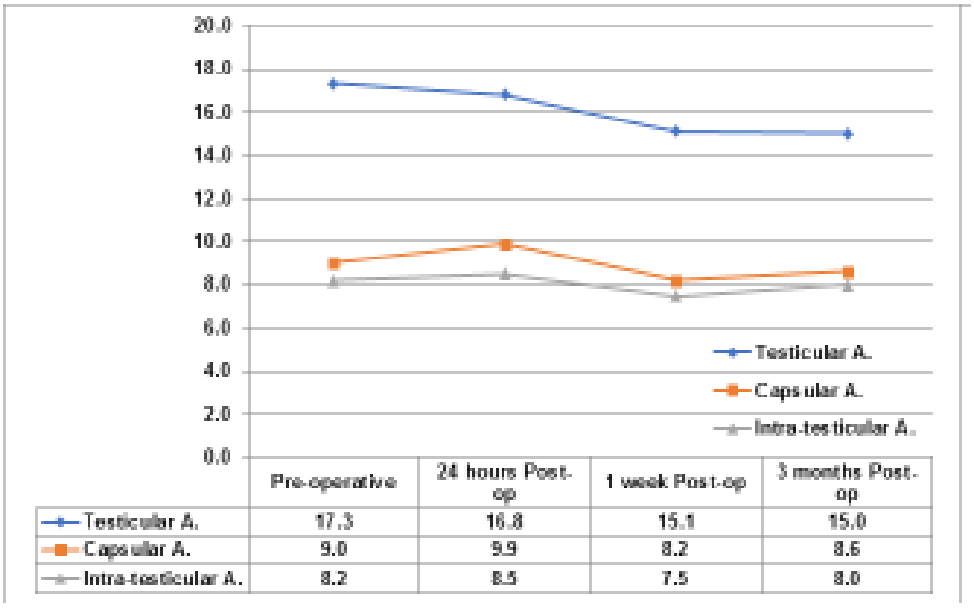
Table 2 — Measurement of Bilateral Testicular Perfusion

Time Point	Testicular Artery RI (± SD)	Capsular Artery RI (± SD)	Intratesticular Artery RI (± SD)
Preoperative	0.77 (± 0.05)	0.64 (± 0.06)	0.58 (± 0.07)
Late Postoperative (3 months)	0.72 (± 0.04)	0.63 (± 0.05)	0.60 (± 0.06)

Table 3 — Comparative Analysis of RI Changes

Artery	Preoperative RI	Late Postoperative RI	Change	p-value
Testicular Artery	0.77 (± 0.05)	0.72 (± 0.04)	-0.05	> 0.05
Capsular Artery	0.64 (± 0.06)	0.63 (± 0.05)	-0.01	> 0.05
Intratesticular Artery	0.58 (± 0.07)	0.60 (± 0.06)	0.02	> 0.05

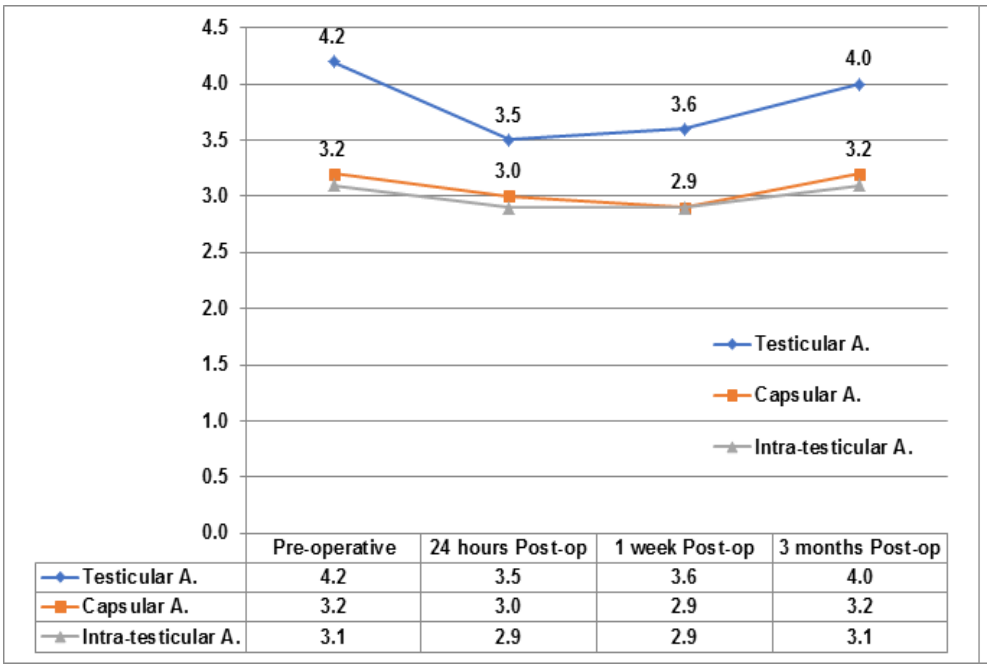
Peak Systolic Velocity (PSV) : Pre-operative measurements indicated PSV values of 17.3 ± 5.2 cm/s for the testicular artery, 9.0 ± 3.2 cm/s for the capsular artery, and 8.2 ± 3.3 cm/s for the intratesticular artery. At 24 hours postoperatively, there was a slight decrease in PSV in the Testicular Artery to 16.8 ± 6.7 cm/s, while the capsular and Intratesticular Arteries showed minor increases to 9.9 ± 2.5 cm/s and 8.5 ± 3.9 cm/s, respectively. One week postoperative measurements revealed a further reduction in PSV for the Testicular Artery to 15.1 ± 4.0 cm/s and for the Intratesticular [a]rtery to 7.5 ± 2.1 cm/s, while the capsular artery PSV decreased to 8.2 ± 2.7 cm/s. At 3 months postoperative, the testicular artery PSV remained stable at 15.0 ± 4.3 cm/s, the capsular artery showed a slight increase to 8.6 ± 1.6 cm/s, and the intratesticular artery PSV increased to 8.0 ± 2.2 cm/s. These findings reflect the dynamic changes in blood flow characteristics following surgical intervention (Fig 1).



	Pre-operative	24 hours Post-op	1 week Post-op	3 months Post-op
Testicular A.	17.3	16.8	15.1	15.0
Capsular A.	9.0	9.9	8.2	8.6
Intra-testicular A.	8.2	8.5	7.5	8.0

Fig 1 — Line graph depicting alteration in Peak Systolic Velocity of testicular vessels in postoperative period

End-Diastolic Velocity (EDV) : Pre-operative EDV values were 4.2 ± 1.7 cm/s for the Testicular artery, 3.2 ± 1.5 cm/s for the capsular artery, and 3.1 ± 1.1 cm/s for the Intratesticular artery. At 24 hours postoperatively, EDV decreased to 3.5 ± 1.3 cm/s, 3.0 ± 1.0 cm/s, and 2.9 ± 1.3 cm/s for the respective arteries. By 1 week postoperatively, the values were relatively stable at 3.6 ± 1.1 cm/s, 2.9 ± 1.0 cm/s, and 2.9 ± 0.9 cm/s. At 3 months postoperative, EDV values showed a slight recovery to 4.0 ± 1.0 cm/s for the testicular artery, 3.2 ± 0.8 cm/s for the capsular artery, and 3.1 ± 0.7 cm/s for the intratesticular artery (Fig 2).



	Pre-operative	24 hours Post-op	1 week Post-op	3 months Post-op
Testicular A.	4.2	3.5	3.6	4.0
Capsular A.	3.2	3.0	2.9	3.2
Intra-testicular A.	3.1	2.9	2.9	3.1

Fig 2 — Line graph depicting alteration in End Diastolic Velocity of testicular vessels in postoperative period

Resistive Index (RI) : Pre-operative RI values were 0.75 ± 0.08 for the testicular artery, 0.65 ± 0.09 for the capsular artery, and 0.60 ± 0.08 for the

Intratesticular Artery. At 24 hours postoperatively, RI values increased to 0.78 ± 0.07, 0.69 ± 0.10 and 0.64 ± 0.09, respectively. One week postoperatively, the values slightly decreased to 0.76 ± 0.07, 0.64 ± 0.08, and 0.61 ± 0.08. By 3 months postoperative, RI values further decreased to 0.72 ± 0.06 for the testicular artery, 0.63 ± 0.06 for the capsular artery, and remained steady at 0.61 ± 0.05 for the Intratesticular Artery (Fig 3).

Discussion

Laparoscopic inguinal hernia repair, is leading to the development of two primary techniques: TAPP (Transabdominal Preperitoneal) and TEP (Totally Extraperitoneal Preperitoneal)[11]. TEP is often preferred due to its minimally invasive nature and preservation of the peritoneum. Studies have shown that TEP results in less postoperative pain, quicker recovery, and better cosmetic outcomes compared to open repair[13].

Despite the proven efficacy of laparoscopic hernia repair, limited data exists on its impact on the spermatic cord and testicular blood flow, especially concerning the potential effects of polypropylene mesh. Our study, which appears to be one of the first to examine these parameters, involved 25 male patients who underwent evaluation, surgery and a three-month follow-up.

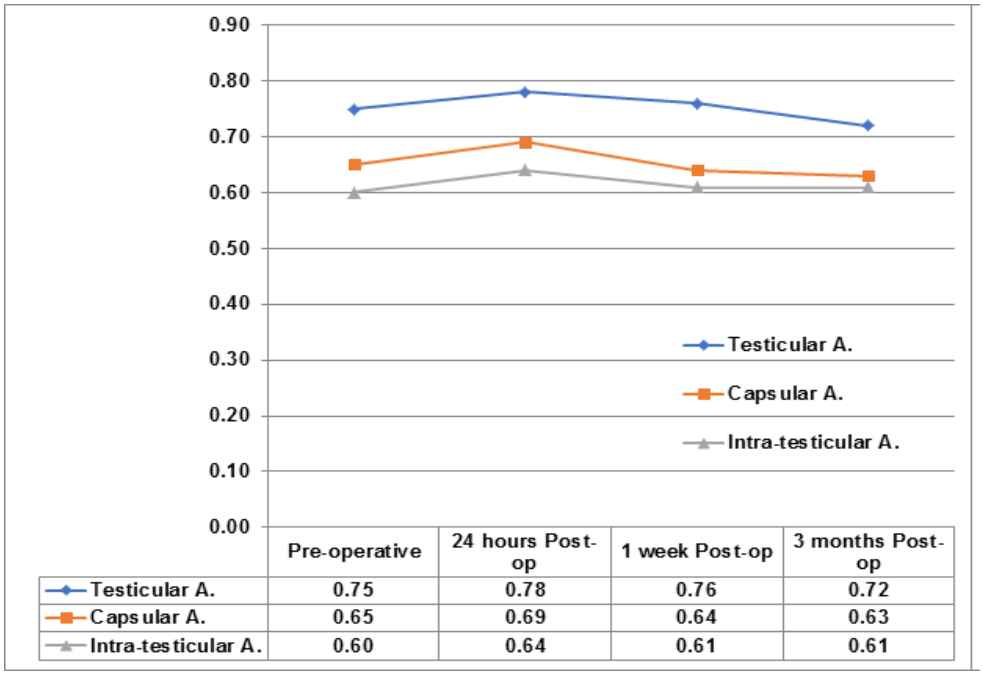
The study population had a mean age of 42.1 years, with cases distributed between bilateral, left, and right-sided inguinal hernias. The analysis focused on alterations in testicular blood flow pre- and post-surgery, comparing unilateral to bilateral repairs and evaluating various perioperative parameters.

(1) Demographics and Preoperative Parameters: The majority of patients were middle-aged or older. No significant correlation was found between age or pre-existing conditions (eg, diabetes, hypertension) and changes in testicular blood flow post-surgery. These findings contrast with some studies where older age or comorbidities were linked to altered blood flow[9,10].

(2) Intraoperative Parameters : Most repairs were unilateral, with no significant difference in blood flow alterations based on hernia type, side, or mesh use. The duration of surgery was longer for bilateral repairs, but this did not significantly impact blood flow, except for a slight decrease in Resistive Index (RI) in the intratesticular artery in some cases[9], This finding contrasts with Ersin, *et al*[14] who observed significant changes in PSV and EDV postoperatively, but did not follow patients for as long as our study.

(3) Postoperative Parameters : The majority of patients were discharged within one to two days. Complications like pneumoscrotum resolved quickly and did not significantly affect blood flow. This aligns with the findings of Koksal, *et al*[9] who reported no significant changes in RI postoperatively, while Celik, *et al*[15] noted a decrease in RI in the testicular artery during the late postoperative period, which was not observed in our study.

The study observed changes in blood flow parameters (PSV, EDV, RI) in the testicular, capsular, and intratesticular arteries. Notably, there was a transient increase in PSV in the testicular artery postoperatively, but no significant long-term changes in RI were observed, indicating no substantial impact on testicular blood supply. This is consistent with Koksal, *et al*[9] and contrasts with Stula, *et al*[10], who



	Pre-operative	24 hours Post-op	1 week Post-op	3 months Post-op
Testicular A.	0.75	0.78	0.76	0.72
Capsular A.	0.65	0.69	0.64	0.63
Intra-testicular A.	0.60	0.64	0.61	0.61

Fig 3 — Line graph depicting alteration in Resistive Index of testicular vessels in postoperative period

reported significant changes in RI and PSV postoperatively.

Our findings suggest that TEP hernia repair, particularly when performed by experienced surgeons, does not significantly compromise testicular blood flow. This conclusion aligns with some literature, though variations exist[14-17]. The study highlights the need for further research, especially involving larger sample sizes and exploring other factors influencing fertility. Additionally, there's a notable gap in data specifically assessing the Indian population in this context.

Conclusion

Based on the aims and results of our study, we can conclude that no significant difference in testicular blood supply exists between the affected side with a reducible incomplete inguinal hernia and the normal side preoperatively. Additionally, laparoscopic Total Extraperitoneal (TEP) repair of a reducible incomplete inguinal hernia does not significantly alter testicular blood supply up to three months postoperatively.

Limitations :

Our study's primary limitation is its small sample size, which included only 25 patients, limiting the generalizability of the results. Additionally, the follow-up period of three months may not be sufficient to capture all potential long-term effects on testicular blood supply and function.

Recommendations :

Future studies should aim to include a larger sample size to enhance the generalizability of the results. Extended follow-up periods beyond three months are recommended to better understand any long-term effects on testicular function. It would also be beneficial to compare the effects of different types of mesh and surgical techniques on testicular blood supply. Additionally, exploring the impact of laparoscopic TEP repair on fertility parameters, such as sperm count and anti-spermatic antibodies, could provide a more comprehensive assessment of the procedure's effects.

Conflicts of Interest : None

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