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Erkek Üreme Sağlığı

The effect of varicocelectomy on intracytoplasmic sperm injection pregnancy success in patients with severe oligospermia and varicocele

Şiddetli oligospermi ve varikoseli olan hastalarda varikoselektominin intrasitoplazmik sperm enjeksiyonu gebelik başarısına etkisi

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ABSTRACT

OBJECTIVES: There is still controversy about the necessity of varicocelectomy in infertile men with severe oligospermia if varicocelectomy is additionally available and Intracytoplasmic Sperm Injection (ICSI) is planned. This study will investigate the effect of varicocelectomy on ICSI success in varicocele patients with severe oligospermia.

MATERIAL and METHODS: The data of 60 patients with varicocelectomy before ICSI (Group 1) and 32 patients without varicocelectomy before ICSI (Group 2) were compared. Patient and partner age, hormone levels and sperm parameters from demographic data, hormone levels and sperm parameters from laboratory tests, and scrotal Doppler ultrasonography results radiologically were compared. After ICSI, clinical pregnancy rates, miscarriage rates and live birth rates were evaluated.

RESULTS: There was a significant increase in sperm count and motility in Group 1 patients after varicocelectomy surgery. When the preoperative and postoperative sperm parameters of the patients in Group 1 were compared with those in Group 2, it was found that there was no difference before the varicocelectomy , while only sperm count was statistically affected after the surgery. Clinical pregnancy was observed in 44 patients (73.3%) in Group 1 and 21 patients (65.6%) in Group 2 and there was no statistical difference between the groups (p: 0.321). Miscarriage was observed in 11 patients (25%) in Group 1 and 7 patients (33.3%) in Group 2 (p: 0.128). Live birth was observed in 33 patients (55%) in Group 1 and 14 patients (43.7%) in Group 2 and was statistically higher in Group 1 (p: 0.026).

CONCLUSION: In varicocelectomy patients with severe oligospermia, varicocelectomy before ICSI does not affect clinical pregnancy and miscarriage rates, but causes an increase in live birth rates.

Keywords: intracytoplasmic sperm injection, varicocelectomy, severe oligospermia, pregnancy rate

ÖZ

AMAÇ: Ciddi oligospermi olan infertil erkeklerde ek olarak varikoselektomi varsa ve İntrasitoplazmik Sperm Enjeksiyonu (ICSI) planlanıyorsa varikoselektomi gerekliliği konusunda tartışmalar mevcuttur. Bu çalışmada ciddi oligospermisi olan varikosel hastalarında varikoselektominin ICSI başarısı üzerine etkisi araştırılacaktır.

GEREÇ ve YÖNTEMLER: Çalışmada ICSI öncesi varikoselektomi olan (Grup 1) 60 ve ICSI öncesi varikoselektomi olmayan (Grup 2) 32 hastanın verileri karşılaştırılmıştır. Hastaların demografik verilerinden hasta ve parternini yaşı, laboratuvar tetkiklerinden hormon seviyeleri ve sperm parametreeleri, radyolojik olarak Skrotal Doppler Ultrasonogragi bulguları karşılaştırılmıştır. İntrasitoplazmik sperm enjeksiyonu sonrası ise klinik gebelik oranları, düşük oranları ve canlı doğum oranları değerlendirilmiştir.

BULGULAR: Grup 1'deki hastalarda varikoselektomi operasyonu sonrasında sperm sayısı ve hareketlilikte belirgin artış görülmüştür. Grup 1'deki hastaların operasyon öncesi ve sonrası sperm parametrelerinin Grup 2 ile karşılaştırılmasında ise operasyon öncesi hiçbir farklılık yokken operasyon sonrasında sadece sperm sayısında istatistiksel olarak etkilendiği saptanmıştır. Grup 1'de 44 hastada (%73,3) ve Grup 2'de 21 hastada (%65,6) klinik gebelik gözlenmiş ve gruplar arasında istatistiksel fark bulunmamıştır (p: 0,321). Grup 1'de 11 hastada (%25) ve Grup 2'de 7 hastada (%33,3) düşük gözlenmiştir (p: 0,128). Canlı doğum Grup 1'de 33 hastada (%55) ve Grup 2'de 14 hastada (%43,7) gözlenmiştir ve Grup 1'de istatistiksel olarak daha yüksektir (p: 0,026).

SONUÇ: Ciddi oligospermisi olan varikoselektomi hastalarında ICSI öncesi varikoselektomi klinik gebelik ve düşük oranlarını etkilemezken canlı doğum oranlarında artışa neden olmaktadır.

Anahtar Kelimeler: intrasitoplazmik sperm enjeksiyonu, varikoselektomi, şiddetli oligospermi, gebelik oranı

INTRODUCTİON

Infertility is a multifactorial condition affecting a significant proportion of couples worldwide, with male factors contributing to approximately 40–50% of cases.[1,2] Among these factors, severe oligospermia, defined as a sperm concentration of less than 5 million sperm per milliliter, poses a considerable challenge to achieving natural conception.[3,4] Varicocele, an abnormal enlargement of the veins within

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the scrotum, is frequently associated with oligospermia and is believed to impair spermatogenesis through various mechanisms, including increased scrotal temperature and oxidative stress.[5] Varicocelectomy, a surgical procedure aimed at ligating the affected veins, has been proposed as a potential treatment to improve sperm parameters and, consequently, fertility outcomes.[6] Conversely, intracytoplasmic sperm injection (ICSI), have emerged as effective alternatives for couples facing infertility due to male factor issues.[7] This article aims to critically compare the efficacy of varicocelectomy and ICSI in enhancing pregnancy rates among infertile men diagnosed with severe oligospermia.

MATERIAL and METHODS

We performed a retrospective cohort study describing 92 patients who were diagnosed with varicocele and underwent ICSI between January 2016 and January 2024 using our hospital database. This study was approved by our institutional ethical review board (Decision No: 2025/03-24, Date: 10.04.2025). It was conducted in accordance with the Declaration of Helsinki regarding human subjects. In our study, we obtained detailed data on the age of the patient and his/her partner, duration of infertility, varicocele degree, testicular volume, hormone level (FSH, LH, Total testosterone), semen parameters and ICSI parameters.

Inclusion criteria were primary infertile patients with varicocele detected and a history of unprotected sexual intercourse for at least 1 year. Patients excluded from the study included infertile patients without at least 2 spermiogram evaluations, without hormonal evaluation, with unprotected sexual intercourse of less than 1 year and patients with no varicocele detected on FM, with a history of cryptorchidism, testicular trauma, orchitis, systemic or hormonal dysfunction and genetic abnormalities, azoospermia/cryptozoospermia and normospermia on spermiogram. Patients with severe oligospermia who underwent varicocelectomy and ICSI and patients with severe oligospermia who underwent ICSI without varicocelectomy were defined as Groups 1 and 2 and a total of 92 patients were included in the study.

The diagnosis of varicocele was made on physical examination. Scrotal Colour Doppler Ultrasonography (USG) was available to evaluate the testicular volume in each varicocele patient. Varicocele physical examination was graded between grade 1 and 3 while the patient was standing. Grade 1 varicocele was defined as palpable with valsalva, grade 2 was defined as palpable without valsalva, and grade 3 was defined as varicocele that was visible from the external view. Testicular volume was measured by scrotal Doppler USG. Hormone profile included serum testosterone, FSH and LH. The first ICSI cycle of each patient was included. Blood samples were collected before 10 am. Three hormone levels were recorded: testosterone (normal value: 15.2–24.2 nmol/L), LH (normal value: 6–23 mIU/mL) and FSH (normal value: 1.24–7.8 mIU/mL).

Semen was obtained by masturbation after 3 to 5 days of sexual abstinence. Samples were analysed within 1 h of collection to determine semen parameters including semen volume (in mL), sperm concentration (in 106/mL), total motility (%), progressive motility (%) and normal morphology (%). Severe oligospermia was defined as a sperm count <5 × 106/mL in two consecutive semen analyses. Total motile sperm count (TMSC) was calculated using the formula: semen volume × concentration × % total motility.

For ovarian stimulation, it was first performed with gonadotropin-releasing hormone (GnRH) agonist followed by human menopausal gonadotropin (hMG) or recombinant human follicle-stimulating hormone (r-hFSH). Human chorionic gonadotropin (hCG) was administered when 2 or more ovarian follicles had reached an average diameter of 18 mm. Thirty-four to 36 hours after hCG administration, transvaginal ultrasound-guided oocyte retrieval was performed and ICSI was performed. Clinical pregnancy was confirmed by gestational sac with an embryo showing cardiac activity on ultrasound at 5 to 6 weeks. When a non-viable clinical pregnancy was observed on ultrasound follow-up, it was considered a miscarriage.

RESULTS

The ages of the patients and their partners did not differ between the groups. The mean gestation interval was 16.4±11.3 months in Group 1 patients and 23.8±12.3 months in Group 2 patients, and it was found that pregnancy was achieved earlier in Group 1 patients (p: 0.008). In the varicocele evaluation between the groups, high grade varicocele was observed more in Group 1 (p<0.001). There was no difference in FSH, LH and total testosterone levels between the two groups. There was no difference between the groups in terms of testicular volumes. Demographic, clinical and laboratory data of both groups are shown in Table 1.

When the sperm parameters of the patients in Group 1 were analysed, no difference was observed in sperm volume and sperm morphology in preop and postop values. Sperm count and total sperm count in mL were 3.7±1.3 million and 7.1±3.8 million preop, 8.1±3.7 and 15.9±8.3

Table 1. Comparison of demographic, clinical and laboratory values between groups

Variable	*Group 1 (n:60)*	*Group 2 (n:32)*	*p*
Female age, years	28.8 ±6.2	30.7 ±7.6	0.347
Male age, years	34.1 ±8.8	36.8 ±10.9	0.496
Time to pregnancy, months	16.4 ± 11.3	23.8± 12.3	0.008
Grade of Varicocele (n, %)			
1	2	12	0.001
2	15	8	
3	43	10	
FSH (mIU/mL)	4.81±2.1	4.47±2.6	0.877
LH (mIU/mL)	3.96 ±1.86	4.12±1.7	0.691
Testosterone (nmol/L)	21.4 ± 9.7	20.4 ± 8.4	0.752
Left testicle volume, mL	17.8 ± 5.6	19.6 ± 7.2	0.345
Right testicle volume, mL	18.3 ± 6.2	20.1 ± 8.6	0.169

Table 2. Comparison of preoperative and postoperative sperm parameters of patients in Group 1 with those of patients in Group 2

	Group 1		*p Value*	*Group 2*	*p Value vs Group 1*	
	Preop	*Postop*	*p Value (paired Student's t test)*		*Preop*	*Postop*
Sperm Volume (ml)	2.3 ± 1.1	2.7 ± 1.4	0.433	2.6 ± 1.7	0.496	0.30
Sperm count/ml(x10^6)	3.7 ±1.3	8.1 ± 3.7	<0.001	2.9 ± 1.7	0.109	<0.001
Total Sperm Count (x10^6)	7.1 ± 3.8	15.9 ± 8.3	<0.001	8.8 ±6.1	0.157	<0.001
% Progressive motility	33.8 ± 9.7	44.5 ± 11.6	0.008	39.5 ± 12.4	0.273	0.371
Total motile sperm count (×10^6)	4.7 ± 3.5	6.4 ± 4.3	0.04	5.1 ± 3.2	0.125	0.183
% Strict morphology	4.1 ±2.4	4.3 ±2.1	0.765	4.4 ± 2.3	0.765	0.869

million postoperatively, respectively, and increased significantly after the operation (p<0.001). Percentage of forward motility was 33.8±9.7 and 44.5±11.6 preoperatively and postoperatively, respectively (p: 0.008). Total motile sperm count was 4.7±3.5 and 6.4±4.3 preoperatively and postoperatively, respectively, showing a significant increase (p: 0.04). No difference was observed in the preoperative sperm values of the patients in Group 1 and the sperm values of the patients in Group 2. When the postoperative sperm values of the patients in Group 1 were compared with the sperm values of the patients in Group 2, the number of sperm per mL and total sperm count were higher in Group 1, while no difference was observed in other sperm parameters. Data on sperm parameters of the patients in both groups are shown in Table 2.

In terms of ICSI outcomes, clinical pregnancy was observed in 44 patients (73.3%) in Group 1 and 21 patients (65.6%) in Group 2 and there was no statistical difference between the groups (p: 0.321). Miscarriage was observed in 11 patients (25%) in Group 1 and 7 patients (33.3%) in Group 2 (p: 0.128). Live birth was observed in 33 patients (55%) in Group 1 and 14 patients (43.7%) in Group 2 and was statistically higher in Group 1 (p: 0.026). Data on ICSI outcomes of both groups are shown in Table 3.

Table 3. Comparison of ICSI results between groups

	Group 1	*Group 2*	*p Value*
Clinical pregnancy (n, %)	44 (73.3)	21 (65.6)	0.321
Miscarriage (n, %)	11(25)	7 (33.3)	0.128
Live birth (n, %)	33 (55)	14 (43.7)	0.026

DISCUSSION

Infertility is a complex condition that affects approximately 15% of couples of reproductive age, with male infertility being a significant contributor.[8] Severe oligospermia is characterized by a markedly low sperm count, which can severely hinder natural conception.[9] The presence of a varicocele is a common finding in men with oligospermia, and its management remains a topic of considerable debate within the field of reproductive

medicine.[10–13] The decision for varicocelectomy for ICSI in men with severe oligospermia is usually based on clinical factors, patient preferences and the underlying aetiology of infertility.[14] While varicocelectomy may offer the potential for spontaneous conception, ICSI provides a more immediate solution, especially when time is of the essence or varicocele repair may not result in significant improvements in sperm parameters.[15] In a systematic analysis comparing the two approaches, it was found that varicocelectomy can improve sperm parameters and potentially increase spontaneous conception rates, but in cases of severe oligospermia, ICSI may provide faster results to achieve pregnancy.[16] The choice between these interventions should be made in co-operation, taking into account the couple's reproductive goals, the severity of male factor infertility and the likelihood of success with each approach.[16] Diegidio et al.[17] reported that varicocelectomy operation improved semen parameters by 60–80% and increased pregnancy rates by 35–44%. In a prospective study by Enatsu et al.[18] evaluating 102 patients with severe oligozoospermia, 41.1% of men showed improvement in sperm density and motility. In addition, spontaneous pregnancy was achieved in 17.6%. Ishikawa et al.[19] significantly improved sperm density and motility in 69.4% and 54.5% of patients with severe oligozoospermia after varicocelectomy and achieved spontaneous pregnancy in 35.1% of patients within one year.

Intracytoplasmic sperm injection has revolutionised the management of male infertility.[20] It allows direct injection of a single sperm into an oocyte, making it a viable option for men with severe oligospermia and even azoospermia.[20] The success of ICSI is influenced by many factors, including female age, ovarian reserve and the specific male factor contributing to infertility.[21] ICSI-related pregnancy rates in cases of severe oligospermia are generally favourable, and studies show varying success rates depending on the specific technique used and the characteristics of the couple.[22,23] In particular, the use of ICSI has been shown to be particularly effective when sperm motility or morphology is compromised.[24] Esteves et al.[10] evaluated ICSI results in treated and untreated varicocele patients and showed that sperm parameters such as sperm count and total sperm motility increased significantly after varicocele operastion, but progressive motility did not increase significantly. In terms of ICSI success, clinical pregnancy, miscarriage and live birth rates were 60%, 22% and 37%, respectively, in patients with varicocelectomy, while these rates were 45%, 30% and 31%, respectively, in patients without varicocelectomy. Clinical pregnancy and live birth rates increased significantly after varicocelectomy operation. In the study by Pasqualotto et al.[11], clinical pregnancy, miscarriage and live birth rates after varicocelectomy were 73%, 21% and 31%, respectively, while these rates were 64%, 23% and 31% in patients without varicocelectomy. Pasqualotto et al.[11] reported that although more clinical pregnancies were obtained with varicocelectomy operation, the live birth rate did not affect. Shiraishi et al.[12] reported that varicocelectomy operation had a significant effect on clinical pregnancy and live births related to ICSI results, increasing clinical pregnancy success from 28% to 61% and live birth rates from 24% to 52%. Similar to Shiraishi, Haydardedeoğlu et al.[13] found clinical pregnancy and live birth rates of 52% vs 74% and 41% vs 64% in patients without and with varicocele, respectively, and emphasised the importance of varicocelectomy. In our study, clinical pregnancy, miscarriage and live birth rates were 65%, 33%, 43% and 73%, 25%, 55% in the patient groups without and with varicocelectomy, respectively, and we concluded that varicocelectomy operation increased the live birth rate from these values.

Our study has both strengths and limitations. The strengths of our study are that all semen analyses were performed in the same laboratory and at least two semen analyses were evaluated. We also present pregnancy data in men with severe oligospermia. Limitations of our study include its retrospective design and small sample size.

CONCLUSION

Both varicocelectomy and ICSI play critical roles in the management of infertility in men with severe oligospermia. While varicocelectomy may improve sperm parameters and offer a chance for spontaneous conception, ICSI provides a more direct and often more successful route to achieving pregnancy. Future research should focus on identifying the most appropriate candidates for each intervention and optimizing treatment protocols to enhance outcomes for couples facing male factor infertility.

Declarations

Ethics approval: The study was approved by The University of Health Sciences, İzmir Training and Research Hospital Ethical Committee (Decision No: 2025/03-24, Date: 10.04.2025).

Consent to participate: For this type of retrospective study, formal consent is not required.

Inform of publication: The results of the study were not published in full or in part in the form of an abstract.

Research involving human participants and/or animals: This article does not contain any studies with animals performed by any of the authors. All procedures performed in studies involving human participants were by the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Conflict of interest: The authors declare no competing interests.

Ethics Committee Approval
The study was approved by The University of Health Sciences İzmir Training and Research Hospital Ethics Committee. (date and number of approval: 10.04.2025/2025/03-24).

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Conflict of Interest
No conflict of interest was declared by the authors.

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REFERENCES

1. Greenberg SH, Lipshultz LI, Wein AJ. Experience with 425 subfertile male patients. J Urol. 1978;119(4):507–10. [CrossRef]
2. Irvine DS. Epidemiology and aetiology of male infertility. Hum Reprod. 1998;13 Suppl 1:33-44. [CrossRef]
3. Kamal KM, Jarvi K, Zini A. Microsurgical varicocelectomy in the era of assisted reproductive technology: influence of initial semen quality on pregnancy rates. Fertil Steril. 2001;75(5):1013–6. [CrossRef]
4. Matkov TG, Zenni M, Sandlow J, Levine LA. Preoperative semen analysis as a predictor of seminal improvement following varicocelectomy. Fertil Steril. 2001;75(1):63–8. [CrossRef]
5. Almekaty K, Zahran MH, Zoeir A, Minhas S, Salem K. The role of artery-preserving varicocelectomy in subfertile men with severe oligozoospermia: a randomized controlled study. Andrology. 2019;7(2):193–8. [CrossRef]
6. Baazeem A, Boman JM, Libman J, Jarvi K, Zini A. Microsurgical varicocelectomy for infertile men with oligospermia: differential effect of bilateral and unilateral varicocele on pregnancy outcomes. BJU Int. 2009;104(4):524–8. [CrossRef]
7. Kamo H, Komiya A, Ota K, Hiraoka K, Honma K, Kawai K. Successful pregnancy and delivery following microdissection testicular sperm extraction and intracytoplasmic sperm injection for non-obstructive azoospermia after microsurgical varicocelectomy: a case report and review of the literature. J Obstet Gynaecol Res. 2024;50(9):1732–6. [CrossRef]
8. Palani A, Cannarella R, Saleh R, Salvio G, Harraz AM, Crafa A, et al. Impact of varicocele repair on assisted reproductive technique outcomes in ınfertile men: a systematic review and meta-analysis. World J Mens Health. 2025;43(2):344–58. [CrossRef]
9. Vu Tan L, Phuc Cam Hoang N, Ba Tien Dung M, Vinh Phu P, Martinez M, Minh Duc N. Spontaneous pregnancies post-microsurgical varicocelectomy in infertile men with severe oligozoospermia: a preliminary vietnamese report. Clin Ter. 2023;174(2):126–31.
10. Esteves SC, Oliveira FV, Bertolla RP. Clinical outcome of intracytoplasmic sperm injection in infertile men with treated and untreated clinical varicocele. J Urol. 2010;184(4):1442–6. [CrossRef]
11. Pasqualotto FF, Braga DP, Figueira RC, Setti AS, Iaconelli A Jr, Borges E Jr. Varicocelectomy does not impact pregnancy outcomes following intracytoplasmic sperm injection procedures. J Androl. 2012;33(2):239-43. [CrossRef]
12. Shiraishi K, Matsuyama H, Takihara H. Pathophysiology of varicocele in male infertility in the era of assisted reproductive technology. Int J Urol. 2012;19(6):538–50. [CrossRef]
13. Haydardedeoglu B, Turunc T, Kilicdag EB, Gul U, Bagis T. The effect of prior varicocelectomy in patients with nonobstructive azoospermia on intracytoplasmic sperm injection outcomes: a retrospective pilot study. Urology. 2010;75(1):83–6. [CrossRef]
14. Masterson TA, Greer AB, Ramasamy R. Time to improvement in semen parameters after microsurgical varicocelectomy in men with severe oligospermia. Can Urol Assoc J. 2019;13(3):E66–9. [CrossRef]
15. Samplaski MK, Lo KC, Grober ED, Zini A, Jarvi KA. Varicocelectomy to "upgrade" semen quality to allow couples to use less invasive forms of assisted reproductive technology. Fertil Steril. 2017;108(4):609–12. [CrossRef]
16. Esteves SC, Roque M, Agarwal A. Outcome of assisted reproductive technology in men with treated and untreated varicocele: systematic review and meta-analysis. Asian J Androl. 2016;18(2):254–8. [CrossRef]
17. Diegidio P, Jhaveri JK, Ghannam S, Pinkhasov R, Shabsigh R, Fisch H. Review of current varicocelectomy techniques and their outcomes. BJU Int. 2011;108(7):1157–72. [CrossRef]
18. Enatsu N, Yamaguchi K, Chiba K, Miyake H, Fujisawa M. Clinical outcome of microsurgical varicocelectomy in infertile men with severe oligozoospermia. Urology. 2014;83(5):1071–4. [CrossRef]
19. Ishikawa T, Kondo Y, Yamaguchi K, Sakamoto Y, Fujisawa M. Effect of varicocelectomy on patients with unobstructive azoospermia and severe oligospermia. BJU Int. 2008;101(2):216–8. [CrossRef]
20. Pham TD, Dang VQ, Ho VNA, Tran CT, Nguyen DTP, Vuong LN, et al. Intracytoplasmic sperm injection versus conventional in vitro fertilization in infertile couples with normal total sperm count and motility: does sperm morphology matter? Hum Reprod. 2025;40(1):23–29. [CrossRef]
21. Dang VQ, Vuong LN, Luu TM, Pham TD, Ho TM, Ha AN, et al. Intracytoplasmic sperm injection versus conventional in-vitro fertilisation in couples with infertility in whom the male partner has normal total sperm count and motility: an open-label, randomised controlled trial. Lancet. 2021;397:1554–63. [CrossRef]
22. Zhou WJ, Huang C, Jiang SH, Ji XR, Gong F, Fan LQ, Zhu WB. Influence of sperm morphology on pregnancy outcome and offspring in in vitro fertilization and intracytoplasmic sperm injection: a matched case-control study. Asian J Androl. 2021 Jul-Aug;23(4):421-8. [CrossRef]
23. Villani MT, Morini D, Spaggiari G, Falbo AI, Melli B, La Sala GB, et al. Are sperm parameters able to predict the success of assisted reproductive technology? A retrospective analysis of over 22, 000 assisted reproductive technology cycles. Andrology. 2022;10(2):310–21. [CrossRef]
24. Sciorio R, Fleming SD. Intracytoplasmic sperm injection vs. in-vitro fertilization in couples in whom the male partners had a semen analysis within normal reference ranges: An open debate. Andrology. 2024;12(1):20–9. [CrossRef]