Reproductive Outcomes in Infertile Men With Spinal Cord Injury (SCI): A Retrospective Case-Control Analysis

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OBJECTIVE To evaluate semen characteristics and reproductive outcomes after assisted ejaculation methods with fresh in vitro fertilization/intracytoplasmic sperm injection cycles in patients suffering from spinal cord injury (SCI), compared to controls, affected by idiopathic male infertility (non-SCI group).

METHODS SCI patients first underwent penile vibratory stimulation. Men "non-responders" to penile vibratory stimulation underwent electroejaculation. Third, testicular sperm aspiration was proposed.

RESULTS This retrospective monocenter case-control study included 193 couples: 53 couples in SCI group and 140 couples in non-SCI group. Overall, 210 fresh in vitro fertilization/intracytoplasmic sperm injection cycles were performed. Median semen volume of SCI was significantly lower, compared to non-SCI (1.5 mL vs 3.1 mL; $P < .01$). Median sperm concentration/mL and total sperm count was considerably higher in SCI. Mean sperm progressive motility was significantly lower in SCI (5.0% vs 35.0%; $P < .01$). Normal fertilization rate was significantly lower in SCI (46.0% vs 71.0%; $P < .01$). Total fertilization rate was 50.0% and 75%, respectively, in SCI and non-SCI groups. A trend toward higher pregnancy rates per cycle was found in non-SCI (31.4% vs 21.4%), or in the live birth rate, which was 27.1% and 20.0%, respectively. No significant differences were found in pregnancy, miscarriage, and live birth rates per cycle, between the 2 groups.

CONCLUSION The assisted ejaculation methods in SCI proved to be efficacious and safe to obtain viable sperm for assisted reproductive technologies. Overall, pregnancy and live birth rates were similar to non-SCI patients. Thus, SCI men have the same opportunity to father biological children, compared to men without SCI. UROLOGY 141: 82−88, 2020.

Spinal cord injury (SCI) has an incidence of 16 million/year in Western Europe and may affect males in reproductive age.[1] If it occurs when parental goals have not been met yet, fertility issues may appear. Most of the men involved experience erectile and ejaculatory failure, due to autonomic nervous system injury and neuromuscular dysfunction.[2] Therefore, <5% of SCI patients can procreate without medical interventions.[3,4] Actually, the rate of ejaculation during masturbation or coitus without medications aid or devices is still very low, rising 16% overall.[5]

However, sperm retrieval methods and assisted reproductive technologies (ARTs), including intrauterine insemination (IUI) and in vitro fertilization/intracytoplasmic sperm injection (IVF/ICSI), give men with SCI an opportunity for conception.

Approximately 80% of men suffering from ejaculatory dysfunction with intact ejaculatory reflex arc (above T10) can obtain antegrade ejaculation using penile vibratory stimulation (PVS). In case of PVS failure, any condition affecting the ejaculatory mechanism of the central and/or peripheral nervous system may be successfully treated by electroejaculation (EEJ). When both PVS and EEJ are ineffective, techniques for surgical sperm retrieval, such as testicular fine-needle aspiration (TEFNA), epididymal percutaneous sperm aspiration (PESA), and testicular sperm extraction (TESE), should be offered to the patient.

Nevertheless, most of men with SCI have poor sperm quality. Low sperm motility and viability but normal or higher sperm concentration, as well as leukocytospermia and high sperm fragmentation, are frequent in this population.[6,7]

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The primary objective of this study is to assess the seminal characteristics and the reproductive outcomes after assisted ejaculation methods with fresh IVF/ICSI cycles in a group of infertile patients suffering from SCI, in comparison to a control group.

MATERIAL AND METHODS

Study Population

From 2010 to 2019, in our ARTs center, all the couples with SCI-caused male infertility factor were retrospectively registered. The SCI group was compared to a control group, composed of couples with idiopathic male infertility (non-SCI group). All severe female infertility factors, including diminished ovarian reserve, poor response to ovarian stimulation, chromosome aberration, repeated failure of IVF cycles, or premature ovarian failure were excluded from the analysis in both groups. SCI patients were previously evaluated by a specialized team of neuro-urologists at the Spinal Unit & Neuro-Urology Department. In accordance with the World Health Organization (WHO) guidelines,[8] male infertility factor was here intended as sperm parameters under the 5th percentiles, defined as low sperm concentration, low sperm motility, and poor sperm morphology.

Demographic data, including male and partner's age, were collected from our records. Specifically, a comprehensive history based upon age of the patient at the time of injury, cause of injury, level of lesion, and duration of infertility (intended as the time elapsed between injury and attempt to conceive) was obtained. Hereafter, an endocrinology profile was created by subjecting males to follicle-stimulating hormone, luteinizing hormone, estradiol, thyroid-stimulating hormone, and prolactin. A detailed physical examination, particularly observing the size and consistency of the testicles, epididymis, and vasa, was performed.

Patients first underwent PVS, as the first-line method used to obtain ejaculation, except for medullary lesions at or below T10. Men with SCI who were "non-responders" to PVS underwent EEJ. If applying the above methods, a persistent anejaculation still occurred, testicular sperm aspiration was last proposed to retrieve autologous spermatozoa.

Penile Vibratory Stimulation

Stimulation of the afferent penile dorsal nerve was achieved through the application of a vibrating disk against the frenular area or on the glans for periods of 3 minutes or until antegrade ejaculation occurred (Supplementary Fig. 1). In case of ejaculation failure, stimulation was stopped for 1-2 minutes and then resumed. The stimulation was repeated for up to 10 minutes. It required appropriate settings of frequency and amplitude, usually 100 Hz and 2.5 mm, respectively.

Electroejaculation

EEJ was carried out by an electrical probe, which was rectally inserted and placed in contact with the rectal wall in the area of the prostate gland and seminal vesicles (Supplementary Fig. 2). Electric current was then delivered in a pattern of 5 seconds of stimulation followed by rest periods of approximately 20 seconds, during which ejaculation could occur. EEJ induced an intermittent, nonprojectile semen emission, more often ejaculated in the bladder (54%) than as antegrade emission. It was important to milk the urethra to retrieve as much semen as possible. At the beginning and at the end of this procedure, rectoscopy was performed to confirm that there were no pre-existing lesions and no EEJ-caused new injuries to the rectum.

Testicular Fine-Needle Aspiration

Each testis was manually immobilized locating the epididymis and vas deferens posteriorly, safe from injury. The needle was inserted into the testis at a depth of about 2 cm. Testes were aspirated twice at the upper, middle, and lower site, using a larger disposable 18-gauge butterfly needle with a 20-mL Luer-Lock syringe attached to it (Supplementary Fig. 3). Multiple precise rapid in and out movements were performed until the yellowish fluid aspirated ceased to flow or if bloody fluid appeared. The tubing was then occluded with artery forceps, maintaining negative pressure. Subsequently, by slowly removing the needle from the testis and scrotal skin, some intact seminiferous tubules were extracted, protruding from the site of puncture. This tissue was prudently cut with sharp scissors and placed in the Petri dishes, using 2 pairs of fine tweezers. Following each puncture, the contents were washed in a 15-mL centrifuge tube containing 1 mL of flushing medium, using a 20-mL syringe filled with Hams medium.

Laboratory Management

In both groups, diagnostic semen analysis was performed before fresh IVF/ICSI. In the non-SCI group, semen was collected thanks to masturbation. After PVS or EEJ, ejaculates were firstly liquefied in an incubator at 37°C for 30 minutes, then examined and categorized. Semen characteristics were collected, as follows: volume, pH, concentration (sperm/mL), total sperm count (total number of sperms in the entire specimen), progressive motility (PR), nonprogressive motility, immotility, and morphology. Seminal samples were treated under sterile conditions, using the density gradient centrifugation method with 95% and 50% gradient layers (PureSperm100, Nidacon). Each sample was distributed into 1-mL aliquots, which were relocated into 15-mL conical tubes (Nunc) containing 1 mL of the 50% fraction and 1 mL of the 95% fraction. Oligospermic specimens were managed using smaller volumes of the gradient layers. The semen samples, layered on top of the double density gradient, were centrifuged at 300 g for 20 minutes. Supernatants were prudently removed using a sterile Pasteur pipette for each tube. The pellets of the same sample were subsequently placed into a new conical tube, re-suspended in 2.5 mL of sperm medium (Flushing, Origio, CooperSurgical Fertility & Genomic Solutions, Denmark) and centrifuged at 250 g for 10 minutes. The tube was placed at a 45 degree angle and incubated for 1 hour at 37°C. After incubation, the upper 1 mL layer of medium was recovered and used for IVF/ICSI treatment. One drop of medium was used to assess microscopically sperm concentration/mL and total motility. Following TEFNA, each sample was processed by centrifugation at 1800 rpm for 7 minutes. The pellet was observed under inverted microscopy at 200× for a first evaluation of the presence and motility of spermatozoa. If retrieved, spermatozoa were used fresh for ICSI cycle. If the embryologist observed more than 1-2 sperms/field (corresponding to an estimated concentration of 0.001×10^6 spermatozoa/mL), sperm retrieval was considered successful for use.

Reproductive Outcomes

After the transvaginal oocyte retrieval, all MII oocytes retrieved were submitted to a fresh ICSI cycle. In order to investigate the presence of 2 distinct pronuclei, all the zygotes were assessed 16-18 hours by ICSI. Consequently, embryos on days 2, 3, and 5 of development were examined under an inverted microscope. Total and normal oocyte fertilization rate (FR) was calculated by the total number of fertilized oocytes and "two pronuclear" fertilized oocytes by the number of injected oocytes, respectively. Cleavage rate (CR) was calculated based on the number of embryos obtained by the number of normally fertilized oocytes. On day 3 or 5 after ICSI, embryos were transferred into the uterine cavity. After 14 days, the HCG test was performed. Clinical pregnancy rate per cycle (PR/C) was defined by HCG levels above 50 mU/L and documented by transvaginal ultrasound visualization of an intrauterine gestational sac with heartbeat at 5-6 of gestational weeks. Even though they were not considered, biochemical pregnancies were registered. Pregnancy loss before 20 weeks of gestation was considered as miscarriage. The live birth rate was defined as the percentage of all cycles that lead to a living birth.

Ethical Considerations and Statistical Analysis

All patients gave written informed consent for the procedures, and for the anonymous use of data related to their medical history in observational studies. All procedures were performed following the ethical standards of the institutional and national research committee and according to the 1975 Helsinki Declaration. Statistical analysis was performed using Statistical Package for Statistical Sciences (SPSS, Version 22.0, IBM, Chicago, IL). Continuous variables were presented as median and interquartile range (IQR), and categorical variables were presented as rate and percentage and were tested with the chi-square test; a P value <.01 was considered statistically significant.

RESULTS

This retrospective monocenter case-control study included 193 couples: 53 couples from the SCI group and 140 couples from the non-SCI group. The median paternal age was 38.0 (IQR: 36.0-44.0) in the SCI group and 34.5 (IQR: 32.0-37.0) years in the non-SCI group, whereas the median female age was 34.0 (IQR: 32.0-36.0) and 36.0 (IQR: 34.0-39.09) years, respectively. In both groups, male hormonal parameters were in the normal range. As depicted in Figure 1, 210 fresh IVF/ICSI cycles were performed. All patients with SCI did not have antegrade ejaculation during masturbation or coitus without the aid of medications or devices. In the SCI group, procedures to obtain sperm for ARTs were performed: ejaculation was achieved by EEJ in 52 cycles (74%), by PVS in 15 cycles (21%), and 3 patients (5%) performed TEFNA. No perioperative and postoperative complications or side effects were recorded in the above procedures. In the SCI group, the median duration of infertility was 14.1 ± 10.2 years (range 1.0-59.0). The causes of injury included: traumatic accidents (90%), medullary anchorage of spina bifida (4%), abdominal aortic aneurysm rupture (2%), acute compressive myelopathy due to vertebral hemangioma (4%). According to the American Spinal Injury Association scale,[9] the level of injury was cervical in 7 patients, T1-T10 in 31 men, T11 or caudal in 15 men. The presence of clinical varicocele≤ grade 2 was recorded in 6 SCI patients (11.3%) and in 16 non-SCI patients (11.4%).

As shown in Table 1, median semen volume of SCI patients was significantly lower, compared to non-SCI patients (1.5 mL vs 3.1 mL; $P < .01$). Median sperm concentration and total sperm count seemed to be considerably higher in the SCI group. However, median sperm progressive motility was significantly lower in the SCI group compared to the one in the non-SCI group (5.0 % vs 35.0 %; $P < .01$). No significant differences were found in terms of sperm morphology among groups (4.0 % vs 3.0 %; $P = .33$). After sperm preparation techniques, median sperm concentration remained significantly higher in the SCI

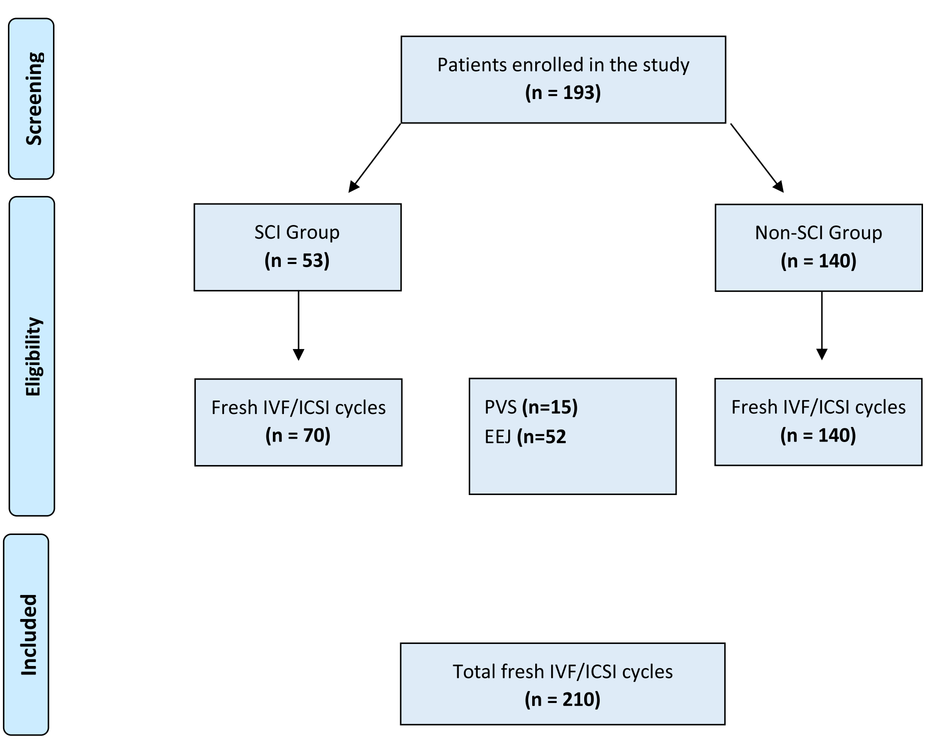

Figure 1. Flowchart of the identified patients. ART, assisted reproductive technologies; EEJ, electroejaculation; ICSI, intracytoplasmic sperm injection; IVF, in vitro fertilization; PVS, penile vibratory stimulation; SCI, spinal cord injury; TEFNA, testicular fine-needle aspiration. (Color version available online.)

Table 1. Comparison of seminal parameters between groups, before and after sperm preparation techniques

Parameter	SCI Group (70 Cycles)	Non-SCI Group (140 Cycles)	*P* Value
Volume (mL)	1.5 (1.0-3.0)	3.15 (2.2-4.2)	<.01*
pH	7.6 (7.4-7.8)	7.8 (7.6-7.8)	.10
Concentration (sperm/mL)	52.0 (8.0-110.0)	4.0 (1.0-7.8)	<.01*
Total sperm count	87.0 (13.2-207.0)	8.26 (3.36-23.25)	<.01*
Progressive motility (PR), (%)	5.0 (0.0-10.0)	35.0 (25.0-50.0)	<.01*
Nonprogressive motility (NP), (%)	5.0 (0.0-10.0)	10.0 (0.0-10.0)	.47
Immotility (IM), (%)	90.0 (75.0-99.0)	52.5 (40.0-70.0)	<.01*
Morphology (%)	4.0 (2.0-5.0)	3.0 (2.0-4.0)	.33
Concentration (sperm/mL) AC	2.5 (0.2-10.0)	0.7 (0.2-2.0)	<.01*
Total sperm motility AC (%)	5.0 (1.0-20.0)	80.0 (50.0-90.0)	<.01*

AC, after capacitation; SCI, spinal cord injury.
* Statistical significance; variables are expressed in median and interquartile range (IQR).

group, in contrast to the one in the non-SCI group (2.5×10^6 vs 0.7×10^6; $P < .01$); conversely, total sperm motility in the SCI group resulted significantly poorer (5.0% vs 80%; $P < .01$).

As shown in Table 2, normal FR was significantly lower in the SCI group compared with the controls (46.0% vs 71.0%; $P < .01$); equally, total FR was 50.0% and 75%, respectively. However, no statistically significant differences were found in median CR between the 2 groups. Regarding the overall pregnancy outcomes, a trend toward higher pregnancy rates per cycle was found in the non-SCI couples, compared to the SCI couples (31.4 % vs 21.4%), or in the live birth rate per couple, which was 27.1% in the non-SCI group and 20.0% in the SCI group. Nevertheless, no significant differences were found in pregnancy, miscarriage and live birth rates per cycle, between the 2 groups ($P = .18$, .31, and .68, respectively).

As displayed in Table 3, comparing different methods, seminal fluid retrieved by PVS showed significantly higher sperm concentration, as well as higher progressive and nonprogressive sperm motility. Moreover, sperm morphology using PVS resulted significantly better than in EEJ (5.5% vs 4.0%, respectively, $P = .01$). Considering all the reproductive outcomes, no significant differences were found between PVS and EEJ. Additionally, given patients who underwent surgical sperm retrieval, median sperm concentration was 0.001×10^6/mL (IQR: 0.001-0.01) and total sperm motility was 2% (IQR: 0-2). Median normal FR was 46% (IQR: 20-80), total FR was 50% (IQR: 20-80), CR was 100% (IQR: 75-100). Neither clinical pregnancies per cycle nor live births were reported.

DISCUSSION

In patients with SCI, fertility potential may be compromised by several factors, including sexual dysfunction, anejaculation, and seminal alterations.[10] However, assisted ejaculation techniques and ARTs give couples whose men suffered from SCI a chance to have a child. Within this framework, only 9%-15% of men with SCI can ejaculate in response to normal stimuli,[11,12] although there is some variability depending on the level of injury.[13,14]

In our study cohort including 70 cycles, EEJ was performed in most cases (74%), proving to be effective in recovering an adequate quantity of seminal fluid. Comparing data reported by other authors, higher percentages of successful EEJ attempts than the ones obtained by PVS could be explained by the different sample size of the study population.[11] Only 3 patients underwent surgical sperm retrieval, because of previous unsuccessful treatments. In all cases, we planned sperm recovery techniques on the same day of oocyte pick-up, since it is widely demonstrated that cryopreservation has been associated with decreased viability and motility, as well as lower pregnancy rates in men with SCI.[15] Consequently, all the SCI patients performed a diagnostic fertility assessment before the day of the fresh cycle.

Table 2. Reproductive and pregnancy outcomes of the study population (n = 193 patients)

Parameter	SCI Group (70 Cycles)	Non-SCI Group (140 Cycles)	*P* Value
Male age (y)	38.0 (36.0-44.0)	34.5 (32.0-37.0)	.20
Female age (y)	34.0 (32.0-36.0)	36.0 (34.0-39.09)	.30
Oocytes retrieved (n)	8.0 (6.0-10.0)	6.0 (4.0-9.0)	.02
Oocytes inseminated (n)	6.0 (5.0-8.0)	5.0 (3.0-7.0)	.30
Oocytes normally fertilized (n)	3.0 (1.0-4.0)	3.0 (2.0-5.0)	.23
Oocytes total fertilized (n)	3.0 (1.0-5.0)	3.0 (2.0-5.0)	.20
Normal fertilization rate (%)	46 (20-66)	71 (50-80)	<.01*
Total fertilization rate (%)	50 (25-75)	75 (50-85)	<.01*
Embryos obtained (n)	3.0 (1.0-4.0)	3.0 (2.0-5.0)	.33
Embryos transferred (n)	2.0 (1.0-3.0)	2.0 (1.0-2.0)	.23
Cleavage rate (%)	100 (75-100)	100 (100-100)	.20
Pregnancy rate per cycle, n (%)	15 (21.4)	44 (31.4)	.18
Miscarriage rate per cycle (%), n (%)	1 (1.4)	6 (4.3)	.31
Live birth rate per cycle (%), mean (SD)	14 (20.0)	38 (27.1)	.68

PN, pro-nuclear; SCI, spinal cord injury.
* Statistical significance; variables are expressed in median and interquartile range (IQR).

Table 3. Seminal parameters and reproductive outcomes comparing different methods of assisted ejaculation (EEJ vs PVS)

Parameter	EEJ (n = 52 Cycles)	PVS (n = 15 Cycles)	*P* Value
Volume (mL)	1.5 (1.0-3.1)	1.6 (1.2-2.7)	.96
pH	7.8 (7.4-7.8)	7.6 (7.6-7.8)	.53
Concentration (sperm/mL)	42.0 (6.0-90.0)	130.0 (28.0-200.0)	<.01*
Total sperm count	60.0 (7.52-180.0)	200.0 (75.6-336.0)	.02
Progressive motility (PR), (%)	5.0 (0.0-10.0)	27.5 (5.0-30.0)	<.01*
Nonprogressive motility (NP), (%)	5.0 (0.0-10.0)	15.0 (10.0-25.0)	<.01*
Immotility (IM), (%)	90.0 (80.0-99.0)	57.5 (50.0-75.0)	<.01*
Total sperm motility	10.0 (0.0-10.0)	42.5 (5.0-60.0)	<.01*
Morphology (%)	4.0 (2.0-4.0)	5.5 (3.0-6.0)	<.01*
Concentration (sperm/mL) AC	2.5 (0.2-10.0)	3.9 (1.8-20.0)	.12
Total sperm motility AC (%)	5.0 (0.1-10.0)	50.0 (10.0-60.0)	<.01*
Oocytes retrieved (n)	8.0 (6.0-10.0)	6.0 (4.0-9.0)	.32
Oocytes inseminated (n)	6.0 (5.0-8.0)	5.0 (3.0-7.0)	.09
Normal fertilization rate (%)	43 (20-67)	54 (17-67)	.60
Total fertilization rate (%)	50 (20-71)	55 (33-80)	.50
Embryos obtained (n)	3.0 (1.0-4.0)	2.0 (1.0-3.0)	.56
Embryos transferred (n)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	.44
Cleavage rate (%)	100 (75-100)	100 (75-100)	.67
Pregnancy rate per cycle, n (%)	12 (22.6)	3 (21.4)	.30
Miscarriage rate per cycle, n (%)	1 (1.9)	0 (0.0)	.26
Live birth rate per cycle (%), mean (SD)	11 (21.1)	3 (21.4)	.98

AC, after capacitation; PN, pro-nuclear; SD, standard deviation.
* Statistical significance; variables are expressed in median and interquartile range (IQR).

Nevertheless, in SCI patients with successful ejaculation rates, several seminal abnormalities could be observed. According to literature, the most common alteration is the lower sperm motility in the setting of normal to high sperm counts.[16,17] As a confirmation of these findings, in our study, SCI patients showed high total sperm count, low sperm volume, and low sperm progressive motility. Although the cause of the poor semen quality is unknown, there is evidence that recurrent urinary tract infections or inflammatory processes in the semen, such as accessory gland dysfunction due to SCI-related dyssinervation, may contribute to the problem.[3] Moreover, it is widely demonstrated that the long-lasting obstruction could impair the spermatogenic tubules,[18] likely due to the overexpression of reactive oxygen species.[19] As such, the quality of spermatozoa may be damaged because the distal epididymis contains a high quantity of sperm fragments with macrophages and abnormal levels of activated lymphocytes T.[20] Furthermore, alterations in the hypothalamic-pituitary-gonadal axis or higher scrotal temperature, due to pronged sitting in a wheelchair could have detrimental effects on semen quality in men with SCI.[21,22]

Comparing techniques of assisted ejaculation, the quality of seminal liquid was found to be considerably better when PVS was performed. Probably, these findings occur because EEJ may alter the relative proportions of seminal fluid proteins by the testis, prostate and seminal vesicles in the ejaculate, and affect sperm quality.[23] To support our results, only 1 previous study analyzed IVF/ICSI outcomes among SCI patients, comparing the 2 assisted ejaculation techniques.[24] The authors found a trend toward lower sperm concentration, sperm motility, fertilization, pregnancy, and live birth rates in the EEJ group compared with the PVS group, even if it was not significant. Other authors have reported differences in IVF/ICSI outcomes by EEJ vs masturbation, showing similar FRs but lower pregnancy rates in the EEJ group.[25] In the present study, no differences were found in reproductive and pregnancy outcomes between the 2 methods.

Overall, our study found reduced FRs in SCI patients. This could be a consequence of the lower fertility potential in spermatozoa of SCI patients, probably due to lower acrosin activity and lower hyaluronic acid-binding, as suggested in literature.[26] Since total sperm motility was considerably low, performing ICSI with immotile spermatozoa in SCI patients, means injecting nonviable spermatozoa and influencing the overall FR.

Although a strong trend toward reduced PR/C was recorded in SCI patients, the reproductive outcomes were similar among groups. Supporting our theories, Shieh et al found similar pregnancy rates when comparing 10 ICSI cycles in SCI couples ~~and~~ to 214 ICSI cycles in non-SCI couples.[27] Kathiresan et al also yield lower FRs but similar pregnancy and live births outcomes in men with SCI compared to non-SCI patients with male factor infertility.[24] In another study examining IVF/ICSI outcomes using fresh testicular sperm, pregnancy rates were similar in couples whose male partners were SCI-affected vs couples whose male partners suffered from obstructive azoospermia.[28] In this study, we were not able to compare TEFNA outcomes to other techniques, due to the inconsistent number of patients applying for this procedure. However, even though in all cases spermatozoa were successfully retrieved in the semen, pregnancy was not achieved.

To strengthen our findings, this study includes the largest population of SCI patients undergoing assisted ejaculation techniques, in which ARTs outcomes were described.

In our country very few centers practice these treatments; therefore, our team has a longstanding experience with SCI patients who desire to be fathers. Furthermore, we only took into account fresh IVF/ICSI cycles, as using post-thawed spermatozoa might have affected the overall reproductive outcomes. A possible limitation of the study is the lack of determination of the sperm DNA fragmentation test in both SCI and non-SCI groups, in that oxidative stress represents a crucial factor that may influence semen quality.[29,30]

Although several studies argue that spermatozoa directly retrieved from the testis with respect to ones in induced ejaculated sperm have lower oxidative stress levels, in our study no significant differences have been reported in outcomes. This probably occurs because of the low amount of patients who underwent surgical sperm retrieval. Nevertheless, further larger studies are required to recommend the most cost-effective treatment options to retrieve sperm in order to conceive.

CONCLUSION

Assisted ejaculation methods, including PVS and EEJ, proved to be safe and effective to obtain sperm viable for ARTs purpose, and no significant differences were found among techniques in terms of reproductive outcomes. Most men with SCI had a semen profile characterized by normal sperm concentration but abnormal sperm progressive motility. Despite reduced fertility potential, pregnancy and live birth rates were similar to those of non-SCI patients suffering from male factor infertility. Thus, SCI men have the same opportunity to father biological children as men without SCI.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.urology.2020.03.043.

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