Table 15. Sperm Quality and Fertility in Men with SCI

Author Year Country Score Research Design Total Sample Size	Methods	Results
Hamid et al. 2006 UK PEDro=6 RCT Level 1 N=32	**Population:** Men with SCI; Age: mean 40.3-37.1 yrs, range 23-48; Level of injury: above T10; Time since injury: mean 4.8-7.0 yrs, range 0.7-19. **Treatment:** Weekly penile vibratory ejaculation (PVE) for 3 months vs PVE at baseline and at 3 months. **Outcome Measures:** Sperm morphology, forward progression, and motility.	1. Morphology and forward progression improved in the group with weekly PVE. 2. Motility improved in the group with weekly PVE but did not reach statistical significance.
Chalas et al. 2022 France Longitudinal Level 2 N=35	**Objective:** To assess semen parameters over time and inflammation markers in semen **Population:** N=35, Mean age: 29.4 (SD) 6.4, Average time since injury: 8 years **Methodology:** Semen retrieval was scheduled every 6months, allowing analysis of four ejaculates, in association with measurement of gran-ulocyte and seminal plasma elastase concentrations to assess markers in semen for inflammation and spermatozoa DNA fragmentation to assess oxidative stress. **Outcome Measures:** Sperm parameters	1. There was no correlation between time post-SCI and sperm parameters: semen volume, total sperm count, progressive motility, vitality, normal sperm, and morphology. 2. There was no correlation between AIS score and sperm parameters. 3. There is no decline in sperm parameters over time.
Ibrahim et al. 2015 USA Prospective Controlled Trial Level 2 N=45	**Population**: 30 men with spinal cord injury and 15 age-matched control participants. **Treatment**: None. **Outcome Measures:** the present study measured serum concentrations of inhibin B and anti-Mullerian hormone (AMH).	1. Serum concentrations of inhibin B and testosterone were significantly lower in the spinal cord injury group compared to the control group. (22.6±3.2% vs. 63.6±2.8%). 2. A statistically significant negative relationship was observed between serum concentrations of inhibin B and follicle stimulating hormone in both the spinal cord injury group and the control group, and between inhibin B and luteinizing

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		hormone in the spinal cord injury group only. 3. A significant positive relationship was also observed between inhibin B and sperm concentration in the spinal cord injury group. 4. Although serum concentrations of inhibin B were significantly lower in the spinal cord injury group than in controls, inhibin B and anti-Mullerian hormone serum concentrations did not provide an additional diagnostic tool for male infertility in this population.
Ibrahim et al. 2014 USA Prospective controlled trial Level 2 N=32	**Population**: Semen samples from 32 men with SCI (mean age=38 years; level of injury C3 to L1; mean time post-injury=14 years) were collected. All participants were past the period of spinal shock (≥ 12 months) and were in general good health with no active urinary tract infections. **Treatment**: Semen was obtained using the standard methods of penile vibratory stimulation (PVS) or electroejaculation (EEJ), where each subject served as their own control. Each sample was divided and treated with a vehicle control, normal goat IgG-control, or with a polyclonal antibody against ASC. **Outcome Measures:** Sperm concentration, total motile sperm count (TMSC), and four grades of sperm motility using the World Health Organization (WHO) method.	1. After treatment with anti-ASC polyclonal antibodies, mean sperm motility significantly increased from 11.5% (95% CI, 6.3-16.7) to 18.3% (95% CI, 11.8-24.8). 2. 30 patients showed improvement in sperm motility, one patient showed no change in sperm motility, and one had a small decrease in sperm motility. 3. Samples treated with the IgG control did not show significant changes in sperm motility. 4. Improvements were most pronounced in the subgroup whose starting sperm motility ranged from 6-40% and whose mean motility improved from 13.3% (95% CI, 9.3-17.3) to 23.9% (95% CI, 14.7-23.0).
Qiu et al. 2012 China Prospective controlled trial Level 2 N SCI=26	**Population:** 26 infertile men with SCI (primary infertility present in 9), mean(SD) age 33.8(2.9) yrs, mean(SD) DOI 8.6(3.0) yrs (range 1-11 yrs), level of injury: C5-C6 (n=4), T2-T12 (n=22), mean(SD) yrs of infertility 6.8(4.2) yrs;	1. The number of round cells per milliliter of semen obtained from the penile vibratory stimulation (PVS) group was between 1 million and 12 million.

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N controls=16	Controls: 16 non-SCI fertile donors (all had previously fathered at least one child), mean(SD) age 32.9(2.1) yrs. **Treatment:** Collection of semen samples in SCI men using penile vibratory stimulation (PVS) (n=14), percutaneous vasal sperm aspiration (PVSA) (n=12); collection of semen samples in non-SCI donors all by masturbation (n=16). **Outcome measures:** sperm vitality and DNA integrity, sperm chromosomal aneuploidy.	2. The rate of sperm DNA fragmentation was higher in the PVS group than in the percutaneous vasal sperm aspiration (PVSA) group. 3. Aneuploidy rates for SCI patients were 1.5 to 1.6-fold higher for chromosomes 13, 18, and 21, and were 2.3- to 2.4-fold higher for chromosomes X and Y than for the control group.
Ibrahim et al. 2009 USA Prospective controlled trial Level 2 N=24	**Population:** 12 men with traumatic SCI and 12 non-SCI men as controls. **Treatment:** Sperm sample from each participant was divided into 4 groups: Group 1: no treatment; Group 2: added phosphate buffered saline (PBS); Group 3: monoclonal antibodies (MAB) against target cytokines IL-6, IL-1β, and TNF-α; Group 4: receptor interference agents (RI) against the same cytokines. **Outcome Measures:** Sperm concentration; sperm motility; sperm viability; Sperm DNA damage (DFI).	1. The mean sperm motility and viability was significantly lower in the SCI group compared to the controls. 2. The sperm from the SCI group had a significantly higher DFI than the controls. 3. After treatment with MAD or RI, the DFI decreased slightly in 70% of samples (difference not significant). 4. No difference in viability between treatment groups was found. 5. Sperm motility of treatment groups was not compared.
Brackett et al. 2007a USA Prospective controlled trial Level 2 N SCI=11 N controls=5	**Population:** 11 men with SCI and 5 men without SCI; Age: mean(SD) range 31.9(2.3)-30.7(3.6) yrs; Level of injury: C4 to T11; mean(SD) time since injury 9(2.0) yrs. **Treatment:** Agents added to sperm to neutralize cytokines (IL-1beta, IL-6, and TNF-alpha) at the receptor level. **Outcome Measures:** Percentage sperm motility.	1. Significantly improved sperm motility in men with SCI when there was interference with receptors to all 3 cytokines. No significant improvement when only 1 or 2 cytokines are neutralized. 2. Neutralizing agents had no effect in men without SCI
Salsabili et al. 2006 Iran Prospective controlled trial	**Population:** 89 men with SCI and 49 men without SCI; mean(SD) age: (SCI) 34(3.7) yrs, (AB controls) 36(4.76) yrs; Injury levels C4-L2, all complete; Time since injury range 11-	1. Normal form, motility, and viability were significantly lower in men with SCI than neurologically intact men.

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Level 2 N SCI=89 N controls=49	18 yrs. **Treatment:** 1) Semen collection by electro-ejaculation (EE), masturbation penile vibratory stimulation (PVS) or percutaneous epididymal sperm aspiration (PESA); 2) Intracytoplasmic sperm injection (ICSI). **Outcome measures:** Quality and quantity of sperm, including sperm count, volume, PH, density, motility, viscosity, and white blood cells.	2. In men with SCI, there was no difference in sperm parameters produced by EE and other methods of sperm collection. 3. Rate of oocytes fertilization in the SCI group by EE/ICSI was 60%.
Giulini et al. 2004 Italy PEDro=5 RCT Level 2 N=34	**Population:** 34 couples (males with SCI), 21-37 yrs (females), 28-46 yrs (males), paraplegia, tetraplegia, C6-L1. **Treatment:** The male partner was randomly assigned to single transrectal electroejaculation or multiple (baseline, 1-month, 3-month) transrectal electroejaculation before intracytoplasmic sperm injection (ICSI). **Outcome Measures:** Sperm concentration, morphology, and motility.	1. Electroejaculation was successful in 32 of 34 cases. The rate of normal sperm morphology was not different between groups. 2. The mean sperm concentration and rate of total sperm motility increased at 1- and 3-month in multi-transrectal electroejaculation group. 3. A fertilization rate of 63.6% was observed and the pregnancy rate per patient was significantly higher in multi-transrectal electroejaculation group.
Monga et al. 2001 USA Prospective controlled trial Level 2 N=12	**Population:** 7 participants with SCI, 5 fertile age matched donors, age range=27-54 yrs, 5 to 31 yrs post-injury, C4-C7, 5 incomplete, 2 complete. **Treatment:** Electrovibratory stimulation. **Outcome Measures:** semen quality.	1. The majority of sperm (65%) exhibited degenerative changes and significant axonemal defects. 2. A significant percentage of sperm (65%) demonstrated disappearance of fiber doublets. 3. Incubation of normal sperm with seminal fluid of participants with SCI induced a significant 43% decrease in motility within 15 min.
Brackett et al. 2000 USA Prospective	**Population:** 12 men with SCI, 14 non-SCI controls; Age (men with SCI): range 29-40 yrs; Injury level: C4-L1; Mean time since injury: 14.6 yrs;	1. Sperm was obtained from 9/12 patients with SCI and 12/14 non-SCI patients having a vasectomy.

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controlled trial Level 2 N=26	non-SCI controls all had vasectomy and biological children. **Treatment:** 1) sperm retrieved by electrical stimulator or vibratory stimulation for participants with SCI, 2) sperm retrieval before exposure to the seminal and prostatic fluids during vasectomy surgery in controls and vas aspiration surgery in participants with SCI. **Outcome Measures:** Sperm quality.	2. Aspirated sperm had greater motility (54.4%) and viability (74.1%) compared to ejaculated sperm (14.1%) motility and viability (26.1%) among patients with SCI. 3. Controls showed no difference between aspirated and ejaculated sperm. 4. The seminal plasma in men with SCI is likely abnormal and toxic to sperm.
Brackett et al. 1997a USA Prospective controlled trial Level 2 N=77	**Population:** 77 males, 45% cervical, 51% thoracic, 4% lumbar. **Treatment:** 1) vibration (n=23), 2) electroejaculation (n=44) or 3) underwent both procedures (n=10). **Outcome Measures:** Sperm quality.	1. Increased motile sperm with vibratory stimulation compared to electroejaculation. 2. No difference in total sperm count.
Brackett et al. 1997b USA Case-control Level 3 N=19	**Population:** 10 men with SCI, 9 age-matched men without SCI; Age: mean 33.1 yrs; Injury level: C4-C5 (n=5), T5-T6 (n=4), T12 (n=1); Time since injury 11.4 yrs. **Treatment:** Electroejaculator (Seager model 14, 1-10 Volts) or laboratory stimulation. Specimens stored at room temperature (23°C) or body temperature (37°C). **Outcome Measures:** Semen quality, fertility rates.	1. Heat did not affect the rate of degradation in motility in control specimens, but body temperature reduced sperm motility in SCI specimens compared to room temperature.
Ohl et al. 1997 USA Prospective controlled trial Level 2 N=11	**Population:** All males. **Treatment:** n=5 FertiCare Clinic Vibrator (2.5 mm, 100Hz, for 3 min) or electroejaculation (Seager model 11). **Outcome Measures:** Sperm quality.	1. No difference in antegrade sperm count, but penile vibratory stimulation specimens had greater motility, viability and motile sperm count compared to EE. 2. No difference in sperm functional assessment (mucus or sperm penetration assay). 3. Electroejaculation was more painful and less preferred than penile vibratory stimulation.

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Brackett et al. 1996 USA Prospective controlled trial Level 2 N=26	**Population:** 12 men with SCI; Age: range 18-42 yrs; Injury level: thoracic; Time since injury: range 3-28 yrs; Age matched controls (n=14). **Treatment:** Vibratory stimulation (SCI) or masturbation (controls). Effect of SCI seminal plasma was tested on control sperm and vice versa. **Outcomes Measures:** Seminal parameters.	1. At 5 minutes, seminal plasma from men with SCI reduced motility of sperm from control. 2. Seminal plasma from controls improved motility of sperm from men with SCI. 3. At 60 minutes the values were not different from each other.
Vargas-Baquero et al. 2020 Spain Case-control Level 3 N=37 N=27 men with SCI	**Objective:** To determine the incidence and probable etiology of sperm DNA fragmentation (SDF) in a sample of males with spinal cord injury (SCI). **Population:** N=27, Mean age: 32.1, 13 Thoracic, 14 Cervical, AIS: 15A/7B/3C/2D **Methodology:** Semen collected by vibro-stimulation from 27 males with various levels of spinal cord injury. Classical semen parameters, SDF, leukocytospermia and pro-oxidant capacity were assessed and compared with a cohort of normozoospermic fertile donors (n = 10) **Outcome Measures:** Classical semen parameters, SDF, leukocytospermia and pro-oxidant capacity	1. Progressive motility was lower in SCI (19%) patients than control (52.5%) (p=0.0002). 2. SDF, Pro-oxidant Capacity, and Leukocyte Concentration were higher in SCI (83.3%, 177.0, 2.6) than control (15.5%, 116.0, 0.4) (all p<0.01). 3. Greater abstinence periods are positively associated with SDF (p=0.041). 4. Time since injury was not significantly correlated with any semen parameter. 5. No observed differences between cervical and thoracic lesions and sperm parameters. 6. Complete lesions had ejaculates that were lower in progressive motility than those with incomplete injuries (p=0.004).
da Silva et al. 2016 Brazil Case Control Level 3	**Population**: 23 individuals; 12 SCI patients (mean age=38±10 years) and 11 controls; level of injury ranged from C4 –T6. **Treatment**: Antegrade semen specimens were collected using penile vibratory stimulation (PVS). Controls collected semen by masturbation in specific sterile containers after at least 3 days, but	1. Alpha-2-macroglobulin (A2M) is three times more abundant in the seminal plasma (SP) of SCI patients but no direct correlation between motility and A2M levels were observed. 2. Approximately 41% of all characterized protease inhibitors elevated in SCI are members of the largest family - the serpin family - 12 serpins were

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N=23	not longer than 7 days, of ejaculatory abstinence. **Outcome Measures:** Sperm concentration (millions of sperm/ml ejaculate), total sperm count, sperm motility (% with forward progression), seminal white blood cell (WBC) concentration (millions of WBC/ml ejaculate).	quantified and it was observed that SERPINB9 and SERPINB13 were exclusively identified in the SP of SCI patients. 3. SERPINA5, the main serpin in human SP (seminal concentrations ranging between 150–200g/ml) 4. (35–37) is three times more abundant in SCI. 5. Results indicate no relationship between sperm motility and the concentration of leukocytes in the semen of men with SCI. 6. Antibiotics used to treat UTIs resulted in little or no change to the semen parameters of SCI patients suggesting that non-infectious causes of an inflammatory response in the semen may be of more importance than previously thought.
Matthews et al. 1996 USA Case control Level 3 N=40	**Population:** 18 men with SCI and 22 men without SCI; Injury level: 2 cervical, 15 thoracic, 1 lumbar, 33 of 40 men were in a relationship with a female. **Treatment:** Retrospective review of electrical stimulator with rectal stimulation followed by intrauterine insemination (126 cycles in n=33) or in vitro fertilization (n=7 total 14 cycles). **Outcome Measures:** Fertility rates, seminal parameters, ejaculatory rates, cycle function, pregnancy rates.	1. Motile sperm were obtained in 95% of men. Semen quality improved with subsequent rectal probe ejaculation in 23/35 men. 2. Antegrade ejaculations produced greater percentage sperm motility in 59% of procedures in which both types of ejaculation were obtained in a patient. 3. However, total motile sperm in retrograde samples exceeded antegrade in 57% of the cases. 4. Pregnancy rate: 15/33 couples achieved pregnancy (45%), of which, 10/15 were achieved through intrauterine insemination.

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		5. Pregnancies leading to live birth were recorded in 5/7 couples undergoing IVF.
Bartolomé-Nebreda et al. 2020 Spain Case series Level 4 N=15	**Objective:** To study the presence of cell-free DNA (cfDNA) and DNase activity in males with spinal cord injury (SCI) with elevated sperm DNA fragmentation **Population:** N=15, Mean age: 29.2, 9 Cervical, 6 Thoracic, AIS level: 8A/4B/2C/1D **Methodology:** The presence and concentration of cfDNA was assessed using standard gel electrophoresis and microfluidic electrophoresis **Outcome Measures:** cfDNA	1. Standard gel electrophoresis revealed a cfDNA band of ~150 bp in all samples from males with SCI. 2. No correlation was observed between the intensity of the two bands and the level of SDF in males with SCI. 3. DNase activity was present in the seminal plasma of both normozoospermic donors and men with SCI; it did not digest cfDNA.
Reignier et al. 2018 France Case series Level 4 N=78	**Objective:** This study aimed to describe spinal cord injured patients' semen characteristics before and after cryopreservation, and assisted reproductive technology cycles outcome compared to the infertile population **Population:** N=77, Mean age at injury: 25.2 **Treatment:** Sperm cryopreservation **Outcome Measures:** Volume, Numeration, Sperm Motility	1. There was no significant decline in sperm parameters with delayed sperm cryopreservation. 2. No difference was observed in pregnancy rates in patients who had undergone cryopreservation.
Ibrahim et al. 2017 USA Pre-post Level 4 N=20	**Population**: 20 men with SCI who ejaculated regularly by penile vibratory stimulation (PVS) or ejaculation. **Treatment**: Probenecid was administered for 4 weeks (250 mg twice a day for 1 week, followed by 500 mg twice a day for 3 weeks). Semen quality was assessed at three time points: pre-treatment, post-treatment (immediately after the 4-week treatment), and follow-up (4 weeks after the last pill was ingested). **Outcome Measures:** Sperm motility	1. Sperm motility improved in each subject after 4 weeks of oral probenecid. The mean percent of sperm with progressive motility increased from 19% to 26% ($p < 0.05$) and the mean percent of sperm with rapid linear motility went from 5% to 17%, and the improvement continued into the four week follow up period ($p<0.001$). 2. Similar improvements were seen in the total motile sperm count (15 million, 28 million, and 27 million at pre-treatment, post-treatment, and follow-up,

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		respectively), but sperm concentration was not significantly different at pre-treatment, post-treatment, and follow-up, (52 million, 53 million and 53 million).
Ibrahim et al. 2015 USA Pre-Post Level 4 N=18	**Population**: 18 men with SCI who ejaculated regularly by penile vibratory stimulation (PVS) or ejaculation. **Treatment**: Probenecid was administered in phases. Phase 1 had participants receive 250 mg orally twice a day for 1 week. Phase 2 had participants who completed phase 1 with no complications were given 500 mg orally twice a day for 3 weeks. Semen was analyzed at three time points: Pre-treatment (Pre-Rx), 1-2 days before Phase 1; Post-treatment (Post-Rx), 1-2 days after completion of Phase 2; Follow-up (F/U), 4 weeks after completion of Phase 2. **Outcome Measures:** sperm motility	1. Probenecid treatment resulted in improved sperm motility in 17 of 18 men, where sperm motility increased from 18% to 25%. 2. Linear sperm motility increased rapidly significantly after 4 weeks of treatment (5% vs 16%) and continued after the end of treatment (5% vs. 15%). 3. The improvement in motility continued 4 weeks after the end of probenecid treatment but did not reach statistical significance (18% vs. 22%).
Kathiresan et al. 2012 USA Case-control Level 3 N SCI=444 N controls=61	**Population:** 444 men with SCI with no known causes of infertility other than SCI; level of injury: 176 cervical, 193 T1-T10, 70 T11-caudal; 115 complete, 126 incomplete. Controls: 61 non-SCI men, healthy with no history of infertility. **Treatment:** Retrospective chart review of Male Fertility Research Program participants from 1991 to 2011. Sperm retrieval methods included masturbation, penile vibratory stimulation (PVS), and electroejaculation (EEJ). **Outcome measures:** sperm retrieval method (masturbation, PVS, EEJ), semen volume, sperm concentration, sperm motility, total sperm count.	1. Sperm retrieval method in SCI participants: masturbation (n=43), PVS (n=243), EEJ (n=158). Sperm retrieval method in non-SCI control group: masturbation (n=61). 2. Sperm motility was significantly higher in the SCI-masturbation group (36.9%) than the PVS group (25.9%) or EEJ group (15.0%), but lower compared with a control group of 61 non-SCI healthy men who collected their semen by masturbation (58.0%). 3. The SCI-masturbation group had similar antegrade sperm concentration as the PVS group, and control group, but

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		significantly higher than the EEJ group.
McGuire et al. 2011 Ireland Case series Level 4 N=31	**Population:** 31 men, 29 with acquired spinal cord injury (complete lesion (n=18), incomplete lesion (n=11). Injury levels: C3-C7; T1-T5; T11-L3), 2 with congenital spinal abnormality. **Treatment:** Electroejaculatory stimulation (EES) done with Seager model rectal probe; n= 27 (87%) underwent EES once, n=4 (13%) underwent EES several times. **Outcome measures:** The Mann-Whitney U test, semen analysis (volume, density, motility, normal morphology and live sperm); pregnancy rate.	1. Of the 25 patients whose partners underwent insemination with the EES semen, 9 (36%) became pregnant. All pregnancies resulted in live births. 2. 1 patient developed autonomic dysreflexia necessitating stopping EES before obtaining any ejaculate. No other side effects or complications were reported. 3. Semen analysis findings in 15 patients showed that mean semen volume and mean density were within the normal World Health organization reference ranges. 4. 30 patients produced antegrade, retrograde, or both types of ejaculate. 5. Only 1 patient failed to produce any ejaculate.
Caremel et al. 2011 Canada Case series Level 4 N=11	**Population:** 11 men with SCI; mean age 29 yrs (range 21-40); 11 complete C5-T6; mean DOI 74 mos, (range 18-163 mos). **Treatment:** cystoscopic intradetrusor botulinum neurotoxin A injections were performed with 300 units of Botox (n=10) or 1000 units of Dysport (n=3) for overactive bladder. Two patients received two BT injections at 7 months intervals using different dosages, and were therefore treated as independent tests. Ejaculation tests were done pre- and post-BT injections using penile vibrator stimulation or electroejaculation combined as needed with oral midodrine and/or	1. Antegrade ejaculations dropped from 77% pre-BT to 54% post-BT. The proportion of retrograde ejaculation or anejaculation increased from 23% pre-BT to 46% post-BT. There was a statistically significant drop in average volume of semen from 1.8 mL pre-BT to 1 mL post-BT. 2. Sperm mobility, sperm count and vitality were unaffected by Botox treatment, though vitality showed a trend for improvement. 3. Semen culture improved following Botox treatment with 72% of semen samples infected pre-BT compared with 29% post-BT.

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	intracavernous injection or phosphodiesterase inhibitors. **Outcome Measures:** Ejaculation type and volume, sperm count, mobility, vitality.	
Hibi et al. 2008 Japan Post-test Level 4 N=8	**Population:** 8 participants with cervical SCI and neurogenic anejaculation (age 26 – 46, mean 35.6). **Treatment:** Retrograde vasal sperm aspiration (ReVSA). **Outcome Measures:** Presence of motile sperm.	1. Motile sperm was recovered in all participants who underwent ReVSA (11 procedures total). 2. The retrieved sperm concentration was 109.4(64.7) × 10^6 /mL (range 31.2-156.3 × 10^6 /mL). 3. The retrieved motility of sperm was 69.8(16.8%-range 50-91%). 4. Clinical pregnancies were achieved in 8 cases.
Das et al. 2006 UK Case series Level 4 N=16	**Population:** 16 men with SCI; Age: median 37 yrs, range 24-46; Level of injury: C4-L1; Impairment: complete (n=9), incomplete (n=7); Time since injury: median 12.5 yrs, range 5-43. **Treatment:** Repeated electro-ejaculation (3 successive EE at 2-4 week intervals). **Outcome measures:** Semen volume, sperm concentration, sperm motility, sperm variability, and total motile sperm concentration.	1. No improvement in sperm volume, motility, or total motile count in successive samples.
Cohen et al. 2004 USA Pre-Post Level 4 N = 17	**Population:** 17 men with SCI, mean age 35.2 yrs. **Treatment:** Antegrade semen specimens from all participants split into 8 groups. Group 1: no treatment. Group 2 to 8: semen treated with different combinations of monoclonal antibodies to IL1-β, IL6, and TNF-α. **Outcome Measures:** mean sperm motility.	1. Sperm motility increased in all groups 2-8 but the increase attained significance only in group 8 (group receiving antibodies against all 3 cytokines). 2. Groups with pre-treatment sperm motility between 11-30% showed greatest improvement after treatment.
Mallidis et al. 2000 Australia Post-test	**Population:** 9 men; Age: mean 28 yrs, range 22-36 yrs. **Treatment:** Electroejaculation using	1. Mean sperm motility increased 23% on days 2 and 3; however,

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Level 4 N=9	CGS Electroejaculator with progressively increasing sine wave current at 20 Hz over 4 consecutive days. **Outcome Measures:** Semen quality.	sperm concentration and volume decreased. 2. In 3 of 7 patients sperm motility still remained low. 3. Major gains in sperm motility and viability were achieved by day 2 with some improvements in day 3 for three patients.
Chen et al. 1999 USA Post-test Level 4 N=14	**Population:** 14 men; Age: range 25-41 yrs, Injury level: 8 cervical, 6 thoracic; Impairment grade: Frankel A (n=8), B (n=4), and C (n=2); Hip flexion reflex in 13 (93%) and spasticity in 12 (86%). **Treatment:** Antegrade sample obtained using Ling vibrator. Bladder catheterized for collection of any retrograde ejaculate. Vibratory stimulation at clinic every 2-4 wks. **Outcome Measures:** Sperm quality.	1. Antegrade specimens collected in 51 trials (84%) and retrograde specimens obtained in all 61 trials (100%). 2. Non-statistically significant trend toward higher sperm counts in the antegrade samples (mean=74.1 million) than in retrograde (40 million). 3. No difference in sperm motility and morphology between antegrade and retrograde specimens. 4. Fructose and zinc were present in all antegrade and retrograde specimens.
Rutkowski et al. 1995 Australia Case series Level 4 N=70	**Population:** 70 men with SCI, Age: mean 30 yrs, range 19-59 yrs; Injury level: C1-C8 (n=36), T1-T9 (n=19), T1-T9 (n=15), T10-L2 (n=15); Mean time since injury: 6 yrs. **Treatment:** Vibroejaculation at 10-50Hz, 3 cycles for 45seconds (n=36) or electroejaculation (n=34). **Outcome Measures:** Seminal parameters, type of catheterization, method of ejaculation.	1. Neurological level and method of bladder management were found to be significant variables that influenced 70% of the patients' sperm sample quality. 2. As neurological level became more caudal, motile sperm decreased. Use of a catheter greatly increased the number of motile sperm. 3. Intermittent self-catheterization was superior to suprapubic catheter or no catheter (reflex voiding).
Padron et al. 1994 USA Case-control Level 3 N SCI=9	**Population:** 9 men with SCI and 10 men without SCI; Age: (SCI) mean 30.2 yrs, SEM=1.2, (controls) mean 24.3 yrs, SEM=3.6; Injury level: cervical 33%, thoracic 55%, lumbar	1. Mean percent motility of fresh sperm samples for participants with SCI (21.0%) was lower than for control participants (55.7%). 2. After thawing, the mean percent

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N controls=10	11%; Time since injury >1yr. **Treatment:** Cryopreservation of sperm by liquid nitrogen vapor only (V) vs vapor for 12 minutes followed by submersion into liquid nitrogen (V+N2) vs direct submersion into liquid nitrogen (N2). **Outcome measures:** Mean percent motility in fresh sperm samples, post-thaw percent and grade of motility.	drop in motility for men with SCI was 64.7% (V), 74.5% (V+N2), and 81.6% (N2) respectively, with no difference between control and men with SCI by method of freezing. 3. Vapor only as a freezing method was superior to V+N2 and N2 for retention of sperm motility in both control and men with SCI.
Siösteen et al. 1990 Sweden Post-test Level 4 N=32	**Population:** 32 men; Age: range 18-40 yrs; Injury level: C4-L1, 23 tetraplegia, 9 paraplegia, 5 incomplete, 27 complete **Treatment:** Vibrator stimulation (29/32 participants with hip flexion reflex) or electrostimulation (3 participants), 4-6 months of 'at-home' treatment, 1x/week stimulation. **Outcome Measures:** Semen quality.	1. Initial stimulation yielded semen in 29 men (91%; 22 had antegrade and 7 retrograde ejaculation). 2. 16 with antegrade ejaculation started 4-6 months of home stimulation which resulted in a rise of semen volume and fructose and acid phosphatase levels in seminal plasma (improved function of the seminal vesicles and prostate). 3. Sperm motile % was low (before and after treatment period). 4. 11 men (69%) showed normal or nearly normal penetration tests after the period of regular stimulation.
Sarkarati et al. 1987 USA Post-test Level 4 N=34	**Population:** 34 men with SCI; Age: range 16-36 yrs; Injury level: 14 cervical (3 complete, 11 incomplete), 13 thoracic T1-T9 (all complete), 7 T10-L3 (3 complete, 4 incomplete). **Treatment:** Vibratory stimulation and/or electrostimulation. **Outcome Measures:** Ejaculation response, semen quality.	1. Semen obtained during the first 6 months after injury was not of a quality consistent with successful fertilization, owing to poor motility. 2. Semen quality and motility were better in patients who had been injured for more than 6 months. 3. Repeated electro-ejaculation did not improve the quality of semen.
Halstead et al. 1987 USA Post-test	**Population:** 12 men with SCI; Age: range 23-38 yrs; Injury level: C5-C6 (n=4), T3-T12 (n=7), L1 (n=1), paraplegia (n=8), tetraplegia (n=4);	1. Anterograde ejaculation occurred in 9 patients with improvement in % motility and total live sperm count on

Author Year Country Score Research Design Total Sample Size	Methods	Results
Level 4 N=12	Impairment grade: AIS A (n=7), B (n=1), C (n=3), D (n=1); Time since injury: range 0.5-18 yrs. **Treatment:** Rectal probe electroejaculation on 38 occasions. **Outcome Measures:** Ejaculation response and sperm quality.	repeated stimulations in 5 patients. 2. Significant retrograde ejaculation occurred in 1 patient. 3. Sperm acceptable for artificial insemination from 4 patients.
Krebs et al. 2015 Switzerland Cross-Sectional Level 5 N=16	**Population**: 16 men with SCI and suffering from anejaculation. 28 semen samples underwent long term cryopreservation of more than 3 years and total sperm motility of >5% or viability of >10%. **Treatment**: None. Semen quality analysis both prior to and after a median of 11 years of cryopreservation. **Outcome Measures:** Semen quality, motility, and viability.	1. Cryopreservation resulted in a decrease in total sperm motility (median=2.5%, 95% CI 0-4%) and viability (median=7%, 95% CI 6-13%). Long-term cryopreservation of semen from SCI men results in essentially immotile sperm with minimal viability. 2. Complete SCI had a negative effect on sperm viability ($p<0.0001$) and tetraplegia had a negative effect on pre-cryopreservation sperm viability and post-cryopreservation motility ($p<0.035$). 3. There were no differences between the semen parameters of samples collected early (up to 3 weeks) after SCI, those collected later, or those collected using assisted ejaculation techniques.
Soler et al. 2016 France Post test Level 4	**Population:** 33 males with anejaculation during sexual stimulation; mean age=29.0±9.1 years; mean time since the onset of the neurological disorder was 6.6±6.4 years; 19 have complete motor lesion (AIS A or B), 1 had incomplete motor lesion (AIS C). **Treatment** Penile vibratory stimulations were carried out following bladder catheterization and instillation of a pink buffering medium (Ferticult) and then PVS. If they failed to ejaculate, PVS was combined with oral midodrine 5mg	1. A total of 42 trials were obtained from 22 patients. Sperms were found in the prostatic urethra in 21 samples (50%) from 12 patients (11 with spinal cord injury, 1 with diabetes). 2. The colour of all 21 prostatic urethra sperm samples differed from the Ferticult. 3. Sperm motility was greater in 8 prostatic samples, sperm count was higher in 10 prostatic samples and pH was different in 10 prostatic samples, compared with the bladder samples.

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N=33	up to 30mg until the patient ejaculated. The urethra was then milked manually to ensure that as much semen as possible was collected. Two-step catheterization was then performed: a catheter was inserted through the urethral sphincter into the prostatic urethra to aspirate its content, and then bladder catheterization was performed to collect the Ferticult. The procedure was repeated in some patients after at least 1 week. **Outcome Measures:** Type of ejaculation, quality of sperm, antegrade/retrograde fraction, prostatic urethra fraction, motility, viability, and pH of sperm.	4. The higher overall quality of the sperm allowed cryopreservation in 10 prostatic urethra samples compared with only 5 bladder samples. 5. Four of the five patients who underwent repeated trials had a reproducible pattern of prostatic urethra ejaculation 6. The presence of sperm in the prostatic urethra most probably results from 'ejaculation dyssynergia', a lack of coordination between bladder neck and external sphincter. 7. Sperm from the prostatic urethra should be systematically sought to improve the outcome of assisted reproduction.