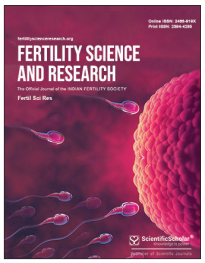
https://fertilityscienceresearch.org

Fertility Science and Research



Review Article

Semen Cryopreservation in Oncofertility

Shruthivishali Muthukumar[1], Prathima Tholeti[1]

[1]Centre of Excellence in Clinical Embryology, Department of Reproductive Science, Kasturba Medical College Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India.

***Corresponding author:**
Miss. Shruthivishali Muthukumar, Centre of Excellence in Clinical Embryology, Department of Reproductive Science, Kasturba Medical College Manipal ,Manipal Academy of Higher Education, Manipal, Karnataka, India.

m.shruthivishali@manipal.edu

Received: 27 January 2024

Accepted: 04 April 2024

Published: 10 May 2024

DOI
10.25259/FSR_46_23

Quick Response Code

ABSTRACT

Oncofertility, an interdisciplinary field, aims at improving the quality of life of cancer patients prone to iatrogenic infertility by offering fertility preservation options for a potentially fertile future. Semen cryopreservation (SC) is a well-established and effective way of preserving fertility in adolescent and young adult cancer-diagnosed males as they face potential fertility loss due to cancer and its treatments. The pathophysiology of certain cancers, such as testicular cancer or Hodgkin's lymphoma, has been shown to have an adverse effect on semen quality. Ablative therapies like chemotherapy and radiotherapy can result in compromised sperm parameters depending on the dose and the type of the drug or radiation. Hence, it is recommended to encourage cancer-diagnosed males to store sperm prior to gonadotoxic therapy to restore potential fertility in the future. Despite the feasibility of SC, this option remains underutilised due to several limitations.

Keywords: Oncofertility, semen cryopreservation, fertility preservation, young adult males

INTRODUCTION

Oncofertility is an emerging multi-disciplinary field that encompasses various fertility preservation strategies for cancer patients at risk of infertility from cancer and its treatments.[1] Fertility preservation (FP) aims at preserving the gametes or gonadal tissue of the cancer-affected individual prior to ablation therapy, thereby facilitating potential parenthood in the future. In adolescent and young adult (AYA) males, semen cryopreservation (SC), which is a well-established and effective way of preserving fertility, is the gold standard method of FP, and the therapeutic applications of frozen sperm are rapidly expanding.[2] With the increasing population of AYA male cancer survivors facing infertility in adulthood, as a consequence of cancer and its treatment, sperm cryopreservation before treatment has received more prominence. It is recommended that all AYA males be offered sperm cryopreservation prior to cancer therapy, irrespective of the toxicity risk.[3] Despite its ease of utility, sperm banking is underutilised in oncofertility due to several challenges. This current review aims to highlight the effect of cancer pathophysiology and its associated therapies on semen quality, the paramount importance of sperm banking in cancer-diagnosed males, laboratory aspects, recommendations, and guidelines, as well as the ethical aspects involved.

Impact of cancer on spermatogenesis and sperm quality

Men with cancer often experience impaired gonadal function and present poor sperm quality.[4] The pathophysiology of cancer can be attributed to metabolic changes, endocrine alterations

and systemic consequences of the disease.[5] In germ-cell cancers, it has been reported that the direct effect of the tumour, hormonal secretions and immune-mediated factors can interfere with spermatogenesis and sperm functions. Tumours can impinge or infiltrate neurologic structures, leading to ejaculatory disorders, or even affect other parts of the male reproductive system, such as the epididymis, vas deferens and ejaculatory duct, thereby impairing fertility potential.[6] In haematological cancers, altered general functions, hyperthermia or testicular infiltration could be additional mechanisms responsible for reduced sperm production.[7] Among various cancers, Hodgkin's lymphoma (HL) and testicular cancer (TC) are the most prevalent cancers affecting men of reproductive age, with an incidence of 6% and 13–15%, respectively.[8] Studies have shown that patients with TC, HL and other genitourinary malignancies more often present altered semen profile, particularly reduced semen volume, sperm concentration, and motility when compared to men with other cancers.[9,10] These variations could be due to the systemic and direct effects of the malignancy, such as inflammation, cytokine production or fever. This could suggest that the mechanisms underlying the decline in sperm quality may be associated with the type and origin of the malignancy.[11]

Consequences of cancer treatment on male fertility

With a focus on cancer cure, over time, cancer treatments have evolved, but the common modalities remain chemotherapy and radiotherapy, which are effective in combating malignancies despite their associated gonadotoxicity resulting in male infertility.[12,13]

Chemotherapy

Chemotherapeutic agents have been shown to cause germinal epithelial damage, resulting in oligo- or azoospermia, as well as Sertoli and Leydig cell damage affecting the hormonal pathways.[14] The impact of chemotherapy on gonadal function is determined by variables such as the type of drugs, combination regimens and the dose administered.[15] Each class of cytotoxic drugs has diverse effects on the germ cell stages and depletion rate depending on their modes of action. As a result, the duration and permanence of induced azoospermia are determined by the dosage of the drug, the frequency and the cumulative impact of the other agents administered. Alkylating drugs such as cyclophosphamide, chlorambucil, procarbazine and busulphan can pose a high risk to fertility. For instance, a single dose of 300 mg/kg cyclophosphamide causes azoospermia in over 80% of males within 50–60 days of treatment, which can lead to irreversible infertility.[16] Cisplatin, at a threshold level of 600 mg/m^2, results in temporary azoospermia with a recovery of spermatogenesis in about 50% of patients in 2 years, whereas vinblastine, at 50 g/m^2, has an intermediate risk of infertility, resulting in temporary oligozoospermia, but is usually administered in conjunction with other sterilising agents.[15,17]

Radiation therapy

The testis is a highly radiosensitive organ as it contains the proliferating spermatogonial stem cells (SSC). The testicular function can be impaired by direct testicular, pelvic, hypothalamic–pituitary axis irradiation or scattered radiation.[18] As radiation directly targets the DNA of proliferating cells, the SSC gets affected as a consequence, but the differentiated spermatocytes, spermatids and spermatozoa are less vulnerable to radiation toxicity. Direct testicular irradiation can result in azoospermia (>2.0 Gy), permanent oligozoospermia (0.8–2.0 Gy) or transient oligozoospermia (<0.8 Gy). A dose of 8 Gy can induce azoospermia in nearly all men, incurring permanent damage to spermatogenesis.[19] The severity and duration of gonadal damage are influenced by a number of variables, such as dose, fraction size and the specific target cell population.[20]

Time for spermatogenic recovery after therapeutic insult

Testicular dysfunction and germinal epithelial damage can result from cytotoxic treatment, SSC quality and their differentiation ability. Gonadotoxic effects and recovery time depend on initial semen quality, delivery method, treatment regimens, as well as the spermatogenesis phase.[21] For instance, recolonisation of surviving SSC can be detected by 6 months after exposure to a dose of 0.2 Gy, or up to 9–18 months following a dose of 1 Gy, and sometimes greater than 4 years after exposure to 10 Gy. Combination regimens of CP with busulphan or thiotepa have shown sperm recovery after 3 years, and in 50 % of cases, sperm were observed in the ejaculate after 7 years.[22] Combination treatment with radiotherapy and chemotherapy can induce further gonadotoxic damage to the testis.

Genetic normalcy of sperm after cancer therapy

Cancer survivors are more likely to have sperm with aneuploidy, DNA damage, aberrant chromatin structure and epigenetic modifications, even after 2 years of initial treatment in addition to alterations to conventional semen parameters.[23] Sperm DNA aberration is a serious clinical concern because male cancer survivors might use gametes with potentially damaged genomes for assisted reproduction technology (ART) cycles, which could result in adverse reproductive outcomes.[24] A study has shown a reduced

pregnancy rate (20%) in ART cycles, which used sperm exposed to cancer treatments compared to the use of sperm that was cryopreserved before cancer therapy, which reported a higher pregnancy rate (51.4%).[25] The altered sperm epigenome of treated males could lead to a transgenerational transmission mechanism affecting the progeny.[26] Sperm chromatin damage resulting in genome instability is one of the most important reproductive side effects owing to the malignancy and/or its treatment[27] which cannot be reversed. Therefore, it's crucial for these individuals to opt for FP before cancer treatment, as the chances of genetic damage to the sperm increase significantly even 1 day post-treatment with alkylating agents.[28]

Semen cryopreservation: The gold standard

SC is a well-established, non-invasive FP strategy for adolescents and adult males.[29] SC, in conjugation with ART, has revolutionised the FP and restoration options in oncofertility thereby improving the quality of life of cancer survivors.[30] The birth of twins through IVF (in vitro fertilisation) using semen that had been frozen for about 40 years has been chronicled, reassuring that even with long-term cryopreservation, sperm retain the fertilisation ability, resulting in healthy offspring.[31] Some patients may be unable to ejaculate on demand due to various factors such as prevailing illness, age, local pain, psychological issues, cultural factors, or religious concerns. For such patients, penile vibratory stimulation or electroejaculation (EJ) can be performed to obtain the semen sample. Even for patients with time constraints, EJ is more suitable. SC is not just limited to adults; peripubertal boys at around the age of 12 years usually reach spermarche, at which point they acquire secondary sexual characteristics. Depending on their physical capacity and emotional maturity to provide a sample by masturbation, SC can be offered.[32]

SC pre- and post-therapy: Laboratory aspects

Semen banking can be offered to all AYA male cancer patients at the time of diagnosis after thorough counselling for FP. SC involves semen collection, analysis, preparation, and freezing with the addition of cryoprotectants and storage in liquid nitrogen. Among the various cryopreservation techniques, rapid freezing (RF) is the quickest and most effective technique that has shown superior post-thaw motility and cryo-survival than slow freezing.[33] RF involves drop-wise mixing of sample and cryoprotectant in a 1:1 ratio; followed by incubation at 4°C for 10 minutes. After that, the straws are placed in the vapour phase of liquid nitrogen (−80°C) for 15 minutes before being immersed in liquid nitrogen.[34] The protocols for sperm banking have been established globally and any modifications to the freezing protocol would be dependent on the type of commercially available sperm freezing medium.[35]

Typically, 3–5 days of ejaculatory abstinence is followed for routine therapeutic sperm banking. However, such compliance may delay the initiation of the treatment in cancer patients. A study on sperm collected for FP revealed that the post-thaw quality of sperm produced after 24-48 hours of abstinence was comparable to that of longer abstinence.[36] This consideration will allow for a more frequent collection schedule, enabling patients to store multiple samples. The number of samples to be stored is determined by the semen quality, time-to-treatment, health status of the patient and fertility restoration strategy. For patients with mild or severe oligoasthenozoospermia, it is crucial to store multiple samples or aliquots. Nevertheless, in such cases of limitedly available samples, ICSI (intracytoplasmic sperm injection) could potentially enable them to father a child. As it is evident that cancer therapies result in sperm DNA damage and sperm concentration depletion, SC should ideally be performed prior to initiation of the therapy. However, when a patient desires to store sperm after cancer treatment, experts recommend a 1-year waiting period after the completion of the last cycle of chemo- or radiotherapy.[37]

Guidelines for male FP

Due to the negative impact of cancer and/or its treatment on fertility, international organisations such as the American Society of Clinical Oncology (ASCO), ASRM and ESHRE recommend that healthcare professionals should discuss sperm banking with adolescents and young adult males before their cancer treatment.[38–41] Although sperm quality may be reduced even before starting therapy, and there may be a need to start chemotherapy immediately, leaving patients with limited time to provide optimal number of ejaculates for FP; these concerns should not dissuade patients from sperm banking.[42] Individualised oncofertility counselling should be provided with a focus on the patient's interest and understanding capacity, their age, as well as the planned treatment regimen. Wherever possible, patients should be provided with written information or access to online resources during oncofertility counselling.[43]

The indications for oncofertility include childhood malignancy, treatment with high-risk chemotherapy drugs or total body irradiation, or conditioning before haematopoietic stem cell transplantation.[44] However, as there is no absolute threshold of anticancer therapy exposure that determines gonadal failure and infertility, every patient should be regarded as potentially at risk of developing treatment-related gonadotoxicity.[43]

Barriers to FP and ethical considerations

Despite the professional international guidelines and recommendations for FP in cancer patients, timely referrals and the number and patients opting for FP remain low owing to several barriers.[45] The barriers to FP referrals include limited knowledge and training among health care providers, prioritising cancer treatment, additional costs for the patients, emotional impact, limited time to treatment and a lack of familial support. Another aspect is the complexity of FP discussions in the face of life-threatening situations such as a cancer diagnosis.[46] However, it is very important to obtain informed consent from patients or parents of adolescent boys before the procedure.[47]

The barriers at the level of the institution include a lack of trained professionals, insufficient resources or a lack of infrastructure.[45,48] The disposition of cryopreserved samples is another critical consideration, especially for pre- or peripubertal boys who might require long-term storage. Other barriers such as underutilisation of stored samples, decision-making for disposal and a lack of follow-up can also pose a significant ethical burden on the FP units.[49] By bridging care gaps and addressing access barriers, providing oncofertility education, resources, support and timely access to fertility-related care, FP can be easily implemented as part of standard cancer care.[50]

CONCLUSION

Cancer, related chemotherapy and radiation therapy can elicit a negative impact on sperm production, its quality and sexual functions in cancer-affected males. As these individuals are susceptible to fertility loss, FP, prior to treatment is crucial. SC is considered the gold standard strategy for FP in adolescents and young adult males. However, even with well-established storage protocols and international guidelines, FP is not widely implemented in oncofertility due to several limitations, such as lack of awareness among the patients or physicians, limited time to therapy and financial burden.

Ethical approval

Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCE

1. Trost LW, Brannigan RE. Oncofertility and the Male Cancer Patient. Curr Treat Options Oncol 2012;13:146–60.
2. Depalo R, Falagario D, Masciandaro P, Nardelli C, Vacca MP, Capuano P, *et al*. Fertility Preservation in Males with Cancer: 16-year Monocentric Experience of Sperm Banking and Post-Thaw Reproductive Outcomes. Ther Adv Med Oncol 2016;8:412–20.
3. Rives N, Courbière B, Almont T, Kassab D, Berger C, Grynberg M, *et al*. What should be Done in Terms of Fertility Preservation for Patients with Cancer? The French 2021 Guidelines. Eur J Cancer 2022;173:146–66.
4. Dohle GR. Male Infertility in Cancer Patients: Review of the Literature. Int J Urol 2010;17:327–31.
5. Agarwal A, Allamaneni SS. Disruption of Spermatogenesis by the Cancer Disease Process. J Natl Cancer Inst Monogr 2005: 9–12.
6. Brannigan RE, Fantus RJ, Halpern JA. Fertility Preservation in Men: A Contemporary Overview and a Look Toward Emerging Technologies. Fertil Steril 2021;115:1126–39.
7. Auger J, Sermondade N, Eustache F. Semen Quality of 4480 Young Cancer and Systemic Disease Patients: Baseline Data and Clinical Considerations. Basic Clin Androl 2016;18:26:3.
8. Reedijk AMJ, Zijtregtop EAM, Coebergh JWW, Meyer-Wentrup FAG, Hebeda KM, Zwaan CM, *et al*. Improved Survival for Adolescents and Young Adults with Hodgkin Lymphoma and Continued High Survival for Children in the Netherlands: A Population-based Study during 1990–2015. Br J Haematol 2020;189:1093–106.
9. Xu R, Centola GM, Tanrikut C. Genitourinary Cancer Patients have Worse Baseline Semen Parameters than Healthy Sperm Bankers. Andrology 2019;7:449–453.
10. Caponecchia L, Cimino G, Sacchetto R, Fiori C, Sebastianelli A, Salacone P, *et al*. Do Malignant Diseases Affect Semen Quality? Sperm Parameters of Men with Cancers. Andrologia 2016;48:333–40.
11. Amjad MT, Chidharla A, Kasi A. Cancer Chemotherapy. 2023 Feb 27. In: Botchan A, Hauser R, Gamzu R, Yogev L, Lessing JB, Paz G, Yavetz H. Sperm Quality in Hodgkin's Disease Versus Non-Hodgkin's Lymphoma. Hum Reprod 1997;12:73–6.
12. StatPearls. Treasure Island (FL): StatPearls Publishing; 2023.
13. Meistrich ML. Male Gonadal Toxicity. Pediatr Blood Cancer 2009;53:261–6.

14. Delessard M, Saulnier J, Rives A, Dumont L, Rondanino C, Rives N. Exposure to Chemotherapy during Childhood or Adulthood and Consequences on Spermatogenesis and Male Fertility. Int J Mol Sci 2020;21:1454.
15. Howell SJ, Shalet SM. Spermatogenesis after Cancer Treatment: Damage and Recovery. J Natl Cancer Inst Monogr 2005:12–7.
16. Hsiao W, Stahl PJ, Osterberg EC, Nejat E, Palermo GD, Rosenwaks Z, *et al*. Successful Treatment of Postchemotherapy Azoospermia with Microsurgical Testicular Sperm Extraction: The Weill Cornell Experience. J Clin Oncol 2011;29:1607–11.
17. Loren AW, Mangu PB, Beck LN, Brennan L, Magdalinski AJ, Partridge AH, *et al*. American Society of Clinical Oncology. Fertility Preservation for Patients with Cancer: American Society of Clinical Oncology Clinical Practise Guideline Update. J Clin Oncol 2013;31:2500–10.
18. De Felice F, Marchetti C, Marampon F, Cascialli G, Muzii L, Tombolini V. Radiation Effects on Male Fertility. Andrology 2019;7:2–7.
19. Qu N, Itoh M, Sakabe K. Effects of Chemotherapy and Radiotherapy on Spermatogenesis: The Role of Testicular Immunology. Int J Mol Sci 2019;20:957.
20. Meistrich ML. Effects of Chemotherapy and Radiotherapy on Spermatogenesis in Humans. Fertil Steril 2013;100:1180–6.
21. Ghafouri-Fard S, Shoorei H, Abak A, Seify M, Mohaqiq M, Keshmir F, *et al*. Effects of Chemotherapeutic Agents on Male Germ Cells and Possible Ameliorating Impact of Antioxidants. Biomed Pharmacother 2021;142:112040.
22. Pening D, Constant M, Bruynbroeck M, Delbaere A, Demeestere I. Impact of Cancer on Cryopreserved Sperm Quality and Fertility: A Cohort Study. Health Sci Rep 2022;5:e726.
23. Beaud H, Tremblay AR, Chan PTK, Delbes G. Sperm DNA Damage in Cancer Patients. Adv Exp Med Biol 2019;1166:189–203.
24. Paoli D, Pallotti F, Lenzi A, Lombardo F. Fatherhood and Sperm DNA Damage in Testicular Cancer Patients. Front Endocrinol (Lausanne) 2018;9:506.
25. Fernández-González MJ, Radauer-Plank AC, Stelzer C, Geiger W, Goranova I, Borgmann-Staudt A, *et al*. Sperm and Testicular Tissue Cryopreservation and Assisted Reproductive Technology Outcomes in Male Cancer Patients: A 15-year Experience. J Cancer Res Clin Oncol 2023;149:5321–30.
26. Shnorhavorian M, Schwartz SM, Stansfeld B, Sadler-Riggleman I, Beck D, Skinner MK. Differential DNA Methylation Regions in Adult Human Sperm Following Adolescent Chemotherapy: Potential for Epigenetic Inheritance. PLoS One 2017;12:e0170085.
27. Morris ID. Sperm DNA Damage and Cancer Treatment. Int J Androl 2002;25:255–61.
28. Meistrich ML. Risks of Genetic Damage in Offspring Conceived using Spermatozoa Produced during Chemotherapy or Radiotherapy. Andrology 2020;8:545–58.
29. Tran KTD, Valli-Pulaski H, Colvin A, Orwig KE. Male Fertility Preservation and Restoration Strategies for Patients Undergoing Gonadotoxic Therapies†. Biol Reprod 2022;107:382–405.
30. Katz DJ, Kolon TF, Feldman DR, Mulhall JP. Fertility Preservation Strategies for Male Patients with Cancer. Nat Rev Urol. 2013;10:463–472.
31. Szell AZ, Bierbaum RC, Hazelrigg WB, Chetkowski RJ. Live Births from Frozen Human Semen Stored for 40 Years. J Assist Reprod Genet 2013;30:743–4.
32. Rodriguez-Wallberg KA, Anastacio A, Vonheim E, Deen S, Malmros J, Borgström B. Fertility Preservation for Young Adults, Adolescents, and Children with Cancer. Ups J Med Sci 2020;125:112–20.
33. Vutyavanich T, Piromlertamorn W, Nunta S. Rapid Freezing Versus Slow Programmable Freezing of Human Spermatozoa. Fertil Steril 2010;93:1921–8.
34. Di Santo M, Tarozzi N, Nadalini M, Borini A. Human Sperm Cryopreservation: Update on Techniques, Effect on DNA Integrity, and Implications for ART. Adv Urol 2012;2012:854837.
35. Raad G, Lteif L, Lahoud R, Azoury J, Azoury J, Tanios J, *et al*. Cryopreservation Media Differentially Affect Sperm Motility, Morphology and DNA Integrity. Andrology 2018;6:836–45.
36. Agarwal A, Sidhu RK, Shekarriz M, Thomas AJ Jr. Optimum Abstinence Time for Cryopreservation of Semen in Cancer Patients. J Urol 1995;154:86–8.
37. Fosså SD, Magelssen H. Fertility and Reproduction After Chemotherapy of Adult Cancer Patients: Malignant Lymphoma and Testicular Cancer. Ann Oncol 2004;15:iv259–65.
38. Oktay K, Harvey BE, Partridge AH, Quinn GP, Reinecke J, Taylor HS, *et al*. Fertility Preservation in Patients with Cancer: ASCO Clinical Practise Guideline Update. J Clin Oncol 2018;36:1994–2001.
39. Lee SJ, Schover LR, Partridge AH, Patrizio P, Wallace WH, Hagerty K, *et al*. American Society of Clinical Oncology Recommendations on Fertility Preservation in Cancer Patients. J Clin Oncol 2006;24:2917–31. doi: 10.1200/JCO.2006.06.5888. Epub 2006 May 1. Erratum in: J Clin Oncol 2006;24:5790.
40. Ethics Committee of American Society for Reproductive Medicine. Fertility Preservation and Reproduction in Patients Facing Gonadotoxic Therapies: A Committee Opinion. Fertil Steril 2013;100:1224–31.
41. Clinical Management Planning for Fertility Preservation in Female Cancer Patient. Stockholm: European Society of Human Reproduction and Embryology (ESHRE); 2011.
42. Nangia AK, Krieg SA, Kim SS. Clinical Guidelines for Sperm Cryopreservation in Cancer Patients. Fertil Steril 2013;100: 1203–9.
43. Lambertini M, Peccatori FA, Demeestere I, Amant F, Wyns C, Stukenborg JB, *et al*; ESMO Guidelines Committee. Electronic Address: Clinicalguidelines@esmo.org. Fertility Preservation and Post-treatment Pregnancies in Post-pubertal Cancer Patients: ESMO Clinical Practise Guidelines†. Ann Oncol 2020;31:1664–78.
44. Poorvu PD, Frazier AL, Feraco AM, Manley PE, Ginsburg ES, Laufer MR, *et al*. Cancer Treatment-related Infertility: A Critical Review of the Evidence. JNCI Cancer Spectr 2019;3:pkz008.
45. Dorfman CS, Stalls JM, Mills C, Voelkel S, Thompson M, Acharya KS, *et al*. Addressing Barriers to Fertility Preservation for Cancer Patients: The Role of Oncofertility Patient Navigation. J Oncol Navig Surviv 2021;12:332–48.
46. Nahata L, Gerhardt CA, Quinn GP. Fertility Preservation Discussions with Male Adolescents with Cancer and their

Parents: "Ultimately, it's his Decision". JAMA Pediatr 2018;172:799–800.
47. Wyns C, Kanbar M, Giudice MG, Poels J. Fertility Preservation for Prepubertal Boys: Lessons Learned from the Past and Update on Remaining Challenges Towards Clinical Translation. Hum Reprod Update 2021;27:433–59.
48. Frederick NN, Klosky JL, Meacham LR, Quinn GP, Kelvin JF, Cherven B, *et al*. Infrastructure of Fertility Preservation Services for Pediatric Cancer Patients: A Report from the Children's Oncology Group. JCO Oncol Pract 2022;18:e325–e333.
49. Adam C, Deffert C, Leyvraz C, Primi MP, Simon JP, Beck Popovic M, *et al*. Use and Effectiveness of Sperm Cryopreservation for Adolescents and Young Adults: A 37-year Bicentric Experience. J Adolesc Young Adult Oncol 2021;10:78–84.
50. Anazodo A, Laws P, Logan S, Saunders C, Travaglia J, Gerstl B, *et al*. How can we Improve Oncofertility Care for Patients? A Systematic Scoping Review of Current International Practise and Models of Care. Hum Reprod Update 2019;25:159–79.

How to cite this article: Muthukumar S, Tholeti P. Semen Cryopreservation in Oncofertility. Fertil Sci Res. 2024;11:4. doi: 10.25259/fsr_46_23