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ORIGINAL RESEARCH

Semen Quality in Males Suffering From COVID-19

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ABSTRACT

Background: It is well knowledge that various viral illnesses may interfere with a man's ability to father children. Through the angiotensin-converting enzyme-2 receptor, which is highly concentrated in testicular tissue, the corona virus illness known as COVID-19 may cause harm to several organs. On the other hand, there is a paucity of data about the transmission of severe acute respiratory syndrome corona virus -2 (SARS-CoV-2) in sperm, as well as the virus's influence on spermatogenesis and the capacity for fertility. We intended to look into whether or not COVID-19 guys' sperm contained SARS-CoV-2 as well as examine how COVID-19 affected the overall quality of the sperm and the degree to which it's DNA was fragmented.

Material and method: The survey was conducted between May 2022 to October 2022, with the participation of 40 male COVID-19 patients who were between the ages of 19 and 45 and enrolled at the RSDKS, Government Medical College, Ambikapur, Chhattisgarh. We tested each sample of sperm with a real-time reverse transcriptase and found no abnormalities. At the time of the initial sample, which took place during COVID-19, a comprehensive examination of the sperm was carried out. This analysis included the calculation of the sperm DNA Fragmentation Index. After 74 days had passed since the first sample, we were able to get the second specimen and carried out the aforementioned tests once again.

Results: All of the sperm samples that were examined using real-time reverse transcription-polymerase chain reaction (RT-PCR) came back negative for SARS-CoV-2. These samples were taken during the first and second sampling. The initial sample had considerably lower levels of fructose, semen volume, vitality, total motility, sperm concentration, total sperm count, percentage of normal morphology, and cytoplasmic droplet percentage than the subsequent samples. On the other hand, the agglutination of the semen, the percentage of head defects, the DNA Fragmentation Index, the liquefaction time, the viscosity of the semen, and the number of leukocytes all rose. At the second sample, these results were inverted, but not to the level that would be considered optimal. These results all had a p-value less than 0.05, meaning they were statistically significant. As a result, COVID-19 has a detrimental impact on the characteristics of the sperm, including the sperm DNA fragmentation index.

Conclusion: The quality of the semen remained low up until the second time it was sampled, despite the fact that we were unable to discover SARS-CoV-2 in the sample. It is recommended that assisted reproductive technology (ART) clinics and sperm banking

facilities evaluate the quality of the sperm produced by males infected with COVID-19 and exclude men who have a history of being infected with SARS-CoV-2 until the men's sperm quality recovers to normal.

INTRODUCTION

After an outbreak of severe acute respiratory syndrome corona virus -2 (SARS-CoV-2) in December 2019, the World Health Organization (WHO) proclaimed a worldwide pandemic of corona virus disease (COVID-19) on March 11, 2020 [1]. It is well-established that SARS-CoV-2 may transmit from person to person via the respiratory droplets of infected individuals [2]. Recent research found SARS-CoV-2 in samples of faeces, saliva, and urine, which points to the possibility of additional modes of transmission [3]. Kevadiya et al. provided evidence that SARS-CoV-2 could be found in a variety of human secretions, including the throat, saliva, pulmonary alveolar washing, and faeces [4]. According to the findings of yet another investigation [5], shedding of the corona virus is conceivable but quite unlikely. There is evidence suggesting a connection between individuals who are infected with the orchitis-causing corona virus family and people [6] and cats [7]. It is known that the severe acute respiratory syndrome corona virus, often known as SARS-CoV, may cause harm to various organs, including the human testis, which ultimately results in extensive germ cell loss in the seminiferous tubules. Angiotensin-converting enzyme-2 (ACE2) is one of the key receptors that SARS-CoV-2 uses to facilitate its entrance into human cells. This receptor is also present on SARS-CoV-2. The testis and other parts of the male reproductive system have a high concentration of ACE2 receptors [8]. Men are more vulnerable to COVID-19 than women are because to the greater expression of corona virus receptors, ACE2, and lifestyle factors, such as the higher prevalence of smoking and drunkenness among men. Women have lower levels of both of these factors. As a result, the mortality rate associated with COVID-19 is 4.7% among males, but it is just 2.8% among women [9]. Therefore, males are at a greater risk of contracting COVID-19, which includes the effects it has on the male reproductive system.

The detection of the presence of SARC-CoV-2 in semen as well as its influence on the quality of semen is the goal of this study, with the hope of gaining insight into the early impact the virus has on male reproductive function.

MATERIALS & METHODS

SIZE OF THE STUDY'S SAMPLE

This pilot research that we carried out lasted for a whole year since there were so many restrictions placed on us during the initial wave of COVID-19. The prospective longitudinal cohort research included a total of 40 participants in its sample.

PARTICIPANTS IN THE STUDY

Men who tested positive for COVID-19 and were treated at the RSDKS, Government Medical College, Ambikapur, Chhattisgarh. Were included in our study. After receiving clearance from the IRB participants in the research were sequestered from May 2022 to October 2022. The participants' ages varied from 19 to 45 years old. Laboratory confirmation for COVID-19 was carried out in accordance with the recommendations provided by the WHO [10]. Participants in the research were contacted by phone, and their informed permission was obtained over the phone.

EXCLUSION CONDITIONS

History of infertility, severe COVID-19 disease, negative real-time reverse transcription-polymerase chain reaction (RT-PCR) test of SARS-CoV-2 of their nasopharyngeal swab sample, sexually transmitted diseases based on the history and earlier investigations, history

of immunosuppression, history of smoking, alcohol intake, diabetes, and varicocele. History of sexually transmitted diseases based on the history and earlier investigations.

INSTRUMENTS OF INSTRUCTION

PRECAUTIONARY MEASURES

The collection of sperm and the treatment of sperm samples were carried out in accordance with all applicable bio safety regulations.

BACKGROUND ON THE PARTICIPANTS

We gathered information on the previous stages of the COVID-19 project and located sexually active men who were eager to take part in the research. In addition to the standard history taking that we do in our lab, we also conducted an assessment of the COVID-19 history and the reproductive quality of life with the sex partner by utilising the FERTIQOL (Fertility Quality of Life) questionnaire. Participants who had a sufficient score of more than 70 were allowed to continue with the research [11]. Other aspects of the patient's clinical history as well as information about their tests, such as the results of their complete blood count, blood biomarkers, and chest x-ray, were gathered.

FUNDAMENTAL ASPECTS OF THE SPERM

Masturbation was used to capture samples of the participants' sperm, which were then placed in a sterile container and subjected to a period of abstinence ranging from two to seven days. The examination of the sperm was carried out in the andrology laboratory in accordance with the WHO laboratory handbook for the 'Examination and Processing of Human Semen' 5th edition 2010, which was carried out immediately after the liquefaction of the sperm at room temperature [12].

THE SELIWANOFF TEST FOR THE ESTIMATION OF THE SEMINAL FRUCTOSE

The presence or absence of fructose in seminal plasma may be determined qualitatively via the use of a simple colour change test. For the purpose of this test, Seliwanoff's reagent, which consists of resorcinol dissolved in hydrochloric acid, was employed. After injecting seminal fructose in an adequate quantity and then adding sperm to a test tube containing Seliwanoff's reagent in a hot water bath, the colour of the seminal fructose changes to a bright cherry red [13]. The sugar fructose provides spermatozoa with their source of energy and also serves as a marker of the functioning of seminal vesicles, both of which may be affected by viral infection [14].

SIMPLE TEST FOR LEUKOCYTOPENIA FROM TEST SIMPLE

For this experiment, a ready-made glass slide that had been pre-coated with a stain comprising methylene blue-N and cresyl violet acetate was used. After just 15 minutes, a preliminary microscopic examination is performed after a drop of the semen ejaculate has been put in the middle of a microscope slide that has been covered with a staining solution, a cover glass has been applied to the microscope slide, and the procedure has been completed. If more than one million leukocytes per millilitre are detectable in the ejaculate or if, during microscopic differentiation at 400x magnification, more than four leukocytes are detectable in each high-power field (HPF), then it is determined that the patient has leukocytospermia [15]. Leukocytospermia can also be diagnosed if more than one million leukocytes per millilitre are detectable in the ejacul.

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SPERM HEALTH AND VITALITY

A drop of the sperm was placed on a glass slide and then two drops of 1% aqueous Eosin Y was added to the slide. After giving it a thorough stir, wait for a minute and a half. Add two drops of the 10% aqueous solution of nigrosin to this mixture. Again, ensure that everything is well combined, and then place ten microliter drops of the mixture on the fresh glass slide. Create a thin layer that is consistent throughout, and then let it dry naturally. Count the white and pink sperm while seeing the sample via an objective lens that has been immersed in oil. Sperm that are alive do not get discoloured and seem white, but sperm that have died will become discoloured because the integrity of their cell membrane has been compromised. Make an estimate of the proportion of white sperm based on the results of counting a total of 200 sperm. The vitality of normal sperm should be more than 58% [16], and the same information may be found in the WHO handbook of sperm analysis [17].

INDEX OF THE FRAGMENTATION OF DNA (DFI)

Utilizing the Qwik sperm chromatin dispersion test kit for analysis, the results were as follows: Check the DFI kits that were made in Chennai, Tamil Nadu, India by Medical Electronic Systems India Private Limited.

RT-PCR ON THE SPERM

In order to determine whether or not the sample included SARS-CoV-2, the volume of the semen was first measured, and then a portion of the sample was moved in viral transport medium to the microbiology laboratory of our institution for the purpose of detecting viral RNA by RT-PCR. We kept the seminal samples at a temperature of -20 degrees Celsius and carried out qualitative RT-PCR using a one-step real-time PCR reaction combination and primer-probe mixture that had been authorised by the Indian Council of Medical Research, which is part of the Government of India. The COVID-19 RT-PCR kit that was developed by AB Diagnopath Mfg. Pvt. Ltd. in Delhi, India was the one that we utilised. For the purpose of validation, we processed each of the sperm samples, together with a positive control and a control without a template. We carried out the RT-PCR procedure by using a real-time machine, either a Biorad CFX96 or an ABI Quant studio 5 Dx, and establishing the reaction protocol in accordance with the guidelines provided in the kit insert. When performed using the Pure MagNA method, the nucleic acid extraction is appropriate for use with sperm. Only the sperm samples taken from individuals whose nasopharyngeal swabs were positive for SARS-CoV-2 were used for the subsequent analysis. After 74 days had passed since the first nasopharyngeal RT-PCR findings came back negative, we carried out all of the aforementioned assays on the sperm again. Semen samples were tested and found to be free of SARS-CoV-2 in both the acute and post-COVID-19 phases.

A STATISTICAL LOOK AT THE DATA

The information gathered was input into Microsoft Excel, and the SPSS (Statistical Package for the Social Sciences) version 20.0 programme was used to do the analysis. We applied A "paired t-test" was performed on all normally distributed variables, denoted by a single asterisk (*), and the results were presented in terms of the mean and standard deviation. The Wilcoxon signed-rank test was used for all of the variables that were not normally distributed. These variables were denoted with a double asterisk (**) and were characterised by their median and interquartile range. A p-value of less than 0.05 was considered to be statistically significant.

RESULTS

Every single person who took part in the trial (40/40) had high-grade fever. Other frequent symptoms were cough (33 out of 40), dyspnea (00 out of 40), headache (31 out of 40), muscular pain (30 out of 40), anosmia, which is the loss of taste (29 out of 40), and the common cold (34 out of 40), weakness (37 out of 40), and weight loss (37 out of 40). After the subjects in the study had recovered from COVID-19 and before the second semen analysis, we gave each of them a comprehensive andrological clinical evaluation. Because everyone who participated in the research study was in good health, the study itself was not interrupted. The demographic information on the people who took part in the trial is included in Table 1, together with the therapies that each participant had.

Table 1: Distribution of the demographic data of the participants during COVID-19 (n=40)

Characteristics	Values mean (range)
Age range (years)	29.11 (19 – 43)
BMI range (kg/m^2)	21.22 (18 – 24)
Number of days of symptoms	5 (3 – 7)
Number of participants home quarantined	40
Semen RT-PCR	Negative in all participants
Medical treatment for COVID−19	Doxycycline, Azithromycin, Paracetamol, Montelukast, Multivitamins, and vitamin C

During the first sample of sperm, the quality of the sperm was compromised in the following ways: 20 patients in the research had a volume of sperm that was less than 1.5 millilitres. Viscosity of sperm was more than 0.2 cm in 36 of the subjects. The time needed for liquefaction was extended for all 24 participants. The sperm agglutination ranged from grade I to grade IV among the group of forty subjects. Sperm vitality was lower than 58% in 39 out of the total individuals. In 32 of the subjects, the rate of sperm motility (both progressive and total) was lower than the average value. The total number of sperm in each of the 24 individuals was lower than 15 million per millilitre. 22 of the subjects had a total sperm count that was lower than 39 million per ejaculate. The percentage of individuals who had abnormal sperm morphology was < 4%. The number of leukocytes in each of the fourty subjects was more than 04/HPF, and the DFI in each of the 40 participants was greater than thirty percent. The effects of COVID-19 on various sperm parameters are outlined in Table 2.

Table 2: Number of participants with their semen parameters outside the reference values as per WHO manual (2010)

Semen parameters (Reference value as per WHO 2010)	Number of participants with their semen parameters affected during first sampling (COVID-19) (n=40)	Number of participants with their semen parameters affected during second sampling (74 days post-COVID-19) (n=40)
Volume < 1.5 mL/ejaculate	20	12
Viscosity > 2 cm	36	31
Liquefaction time > 60 min	24	20
Agglutination > grade 4	40	39
Vitality < 58 %	39	36
Progressive motility < 32 %	32	20

Total motility < 40 %	32	20
Sperm concentration < 15 million/ml	24	15
Total sperm count < 39 million/ ejaculate	22	13
Normal morphology < 4 %	31	15
Leucocytes > 4 cells/HPF	40	33
DFI > 30 %	40	37

During the second sample of sperm, the quality of the sperm was changed in the following ways: 12 of the subjects had a volume of sperm that was less than 1.5 millilitres. The viscosity of the sperm was more than 2 cm in 31 of the subjects. The time needed for liquefaction was extended for all 20 subjects. The sperm agglutination ranged from grade I all the way up to grade IV among the 39 individuals. Sperm vitality was lower than 58% in 36 out of the total subjects. In 20 of the subjects, the rate of sperm motility (both progressive and total) was lower than the average value. The total number of sperm in each of the 15 subjects was lower than 15 million per millilitre. 13 of the subjects had a total sperm count that was lower than 39 million per ejaculate. The percentage of subjects whose sperm had morphology below 4% was 15. Leukocyte counts in 33 of the patients were higher than 04/HPF, and the DFI was higher than 30% across the board for all 37 subjects. The comparison of sperm parameters during the COVID-19 era and the period 74 days after COVID-19 is shown in Table 3.

Table 3: Comparison of semen parameters during COVID-19 and 74 days post-COVID-19 period (n=40)

Semen parameter (Normal values)	**First sampling (COVID-19)**	**Second sampling (Post-COVID-19)**	**p-value**
	Mean	Mean	
Volume (> 1.5 ml/ejaculate)*	2.12	2.88	0.001
Viscosity (1 – 2 cm)**	4.33	2.89	0.002
Liquefaction time (20 – 60 min)**	41.1	29.11	0.033
Agglutination (grades 1 -4)*	3.22	2.78	0.001
pH (7.2 – 7.8)*	8.22	7.89	0.45
Vitality (> 58%)*	33.22	43.33	0.012
Progressive motility (≥ 32 %)*	20.22	31.12	0.001
Total motility (≥ 40 %)*	26.12	38.22	0.001
Sperm count (> 15 millions/ml)**	26.67	58.45	0.001
Total sperm count (> 39 millions/ejaculate)**	46.34	161.23	0.001
Normal morphology (> 4 %)**	5.11	9.12	0.045
Head defect (%)*	43.34	38.13	0.001
Neck defect (%)*	14.89	16.67	0.33
Tail defect (%)*	26.22	23.88	0.21
Cytoplasmic droplet (%)**	6.11	9.2	0.024
WBC (< 4/HPF)**	9.11	6.4	0.001
Fructose (present)*	2.22	2.78	0.001

DFI (<30 %)*	74.35	66.45	0.001

At the time of the initial sample of the semen, the results for semen volume, sperm vitality, total motility, sperm concentration, total sperm count, % normal morphology, % cytoplasmic droplet, and semen fructose were all lower than their usual levels. During the second sample of the sperm, all of these semen parameters showed an upward trend in their levels. There was a statistically significant rise in all of these characteristics of the sperm (p less than 0.05 for each one). The parameters of semen agglutination, % head defect, DFI, semen liquefaction time, semen viscosity, and leukocytes in the semen were all below their normal limits during the second sample. There was a statistically significant drop in all of these characteristics of the sperm (p less than 0.05 for each). pH, percentage of neck defect, and percentage of tail defect were not statistically significant during any of the samplings.

DISCUSSION

Numerous researchers, including Jin et al., demonstrated that despite the fact that the prevalence of COVID-19 is identical in men and women, men's overall health is at a high risk, which can result in deteriorated outcomes and death [8]. Differences in lifestyles between the sexes, such as an addiction to smoking, which is more common in men than in women, are thought to be a potential risk factor for the development of COVID-19. A higher level of oestrogen in females plays a protective role, and the presence of XX chromosomes in females provides a higher level of innate immunity than in males.

ACE2 is highly expressed in the heart, kidneys, and lungs, and it is shed into the plasma [18]. ACE2 functions as an enzyme as well as a functional receptor on the cell surface through which SARS-CoV-2 enters the host cells. The expression of ACE2 is increased in the cells that make up the renal tubular system, as well as the cells that make up the Sertoli and Leydig glands, and the cells that make up the seminiferous ducts in the testis [9]. The testis is one of the organs that have high levels of constitutive expression of ACE2. Because of this, there is a possibility that the SARS-CoV could enter testicular cells and cause damage [19]. The testis is also one of the organs that have high levels of constitutive expression of ACE2. In addition, the expression of TMPRSS2 (transmembrane protease, serine 2) was elevated in spermatogonia and spermatids, just like ACE2 expression was. Single-cell RNA-sequencing analyses have been performed on goblet secretory cells (found in the nasal mucosa), type-2 pneumocytes (found in the lungs), and absorptive enterocytes (found in the small intestine) in order to characterise potential initial target sites for SARS-CoV-2 replication in humans [20]. This has resulted in the detection of the co-expression of the ACE2 and TMPRSS2 genes. When considered as a whole, SARS-CoV-2 infection can cause damage to the testes as well as a reduction in testosterone levels; however, the underlying mechanisms that cause these effects are unknown, and there is no evidence that the virus replicates in testicular cells.

All of the evidence that was presented earlier demonstrates that men are more susceptible to COVID-19 than women are. In light of the high likelihood of sexual transmission of SARS-CoV-2 [21], we planned and carried out an RT-PCR test on the participants' sperm samples as part of the research. The real-time polymerase chain reaction (RT-PCR) is widely regarded as the test of choice for investigating SARS-CoV-2 in the secretions of COVID-19 patients [4]. Despite the fact that SARS-CoV-2 was still present in the upper respiratory tract, all of the RT-PCR tests that were carried out during the first and second semen sampling came back negative for the virus. It was demonstrated by the research carried out by Rawlings and colleagues [22] and Pavone and colleagues [23].

In the course of our research, we discovered that the semen parameters, including sperm vitality and total motility, dropped to levels that were significantly lower than the normal upper and lower limits. During the second sample, however, the levels of semen agglutination, sperm DFI, semen viscosity, and semen leukocytes were all higher above the

usual limits for their respective categories. Other sperm characteristics, such as semen volume, sperm concentration, total sperm count, and percentage of normal sperm morphology, as well as semen fructose levels, were lower in the first sample of sperm compared to the second sampling, although they were still within normal ranges. On the other hand, the time it took for the semen to liquefy was longer for the first semen sample compared to the second semen sampling, although it still fell within the acceptable range. This is verified by the research that was carried out by Best et al. [24], in which they showed that SARS-CoV-2 was not present in the sperm, but that the total sperm number (TSN) was reduced due to COVID-19 illness.

This demonstrates without a reasonable doubt that COVID-19 illness has an effect on the male reproductive system, lowering the quality of sperm. In addition, we found that the quality of the sperm that was evaluated after 74 days had improved, although it was still of low quality overall. After 74 days post-COVID-19, the metrics that have been most significantly impacted include the viscosity of the sperm, agglutination, vitality, and DFI%. Eosin-Nigrosinsupravital staining is used to measure the percentage of living spermatozoa that have their membranes intact, which is referred to as the vitality of the sperm. The accumulation of reactive oxidative stress is the root cause of the decline in vitality that might be seen (ROS). In a healthy condition, the male reproductive system maintains a balance between the generation of ROS and the action of antioxidants. The overproduction of ROS, which may occur in stressful conditions like COVID-19, might have an adverse effect on sperm and seminal plasma [25]. The disruption of sperm chromatin caused by oxidative stress results in DNA damage and a rise in DFI percentage.

When a virus enters the body, it raises the number of leukocytes already present there, including those in the seminal plasma, which causes the sperm to become agglutinated [26]. During their lives after being infected with COVID-19, it is recommended that all young guys who were afflicted with COVID-19 have their sperm examined. They should have a followup assay of their sperm performed once every 74 days until the quality of their sperm returns to normal. In light of the fact that SARS-CoV-2 is not released in the semen of COVID-19 patients, the question naturally arises as to how the virus is impacting the process of spermatogenesis. A high-grade fever is one of the primary symptoms of COVID-19. This high-grade fever may disrupt the blood-testis barrier, which exposes the sperm cells and testicular tissues to circulating cytokines and other inflammatory mediators generated by the body. Another one of the primary symptoms of COVID-19 is a headache. It is possible that this may lead to a systemic inflammatory condition as well as an immunological reaction against the seminiferous epithelium and accessory glands, which will ultimately result in poor quality sperm. Autopsies performed on the testicles of males who passed away as a result of COVID-19 revealed the presence of interstitial orchitis with mononuclear inflammatory cells, interstitial edoema, and a disarrangement of Leydig cells [27].

Oligozoospermia, leukospermia, and higher levels of interleukin-6 were detected by the researchers in some of the individuals who had recovered from COVID-19. The presence of a higher number of apoptotic cells and elevated cytokine levels is suggestive of the presence of autoimmune orchitis in the background of the current manifestation [28]. Recent research has shown that there is a favourable link between the activity of ACE2 and apoptotic factors with pro-and anti-inflammatory cytokines as well as ROS. The pathological alterations that were seen in the testes of 12 COVID-19 sick individuals were described by Yang et al. [29]. Antibody deposition in testicular tissue was discovered during the laboratory examinations of these individuals; however, the genome of the SARS-CoV-2 virus was unable to be recovered from the samples of testicular tissue. This suggests that the orchitis caused by SARS-CoV-2 was likely the result of an immune response rather than the direct effect of the virus [6]. The overproduction of inflammatory cytokines, which can be caused by viral infections, can lead

to autoimmune reactions and the infiltration of leucocytes, which can disrupt the process of spermatogenesis and interfere with the secretion of hormones related to sexual activity [30]. When an infection is caused by a virus, the antigens that are expressed on spermatozoa are not recognised by the immune system. Anti-sperm antibodies (ASA) can be produced as a consequence of a variety of different aetiologies, including the destruction of the blood-testis barrier, orchitis, and inflammation of the genital tract [31]. The disruption of the ACE2/Ang (1-7)/Mas and phosphatidylinositol-3-kinase (PI3K)-Akt signalling pathway may be one of the possible mechanisms by which SARS-CoV-2 infection causes sperm DNA damage, abnormal motility, systemic oxidative stress, inflammation, and male infertility. Other possible mechanisms include: The overproduction of reactive oxygen species (ROS) can cause oxidative stress, which can have a profound impact on the plasma membrane of sperm and, as a consequence, the functional integrity of the sperm. Increased levels of reactive oxygen species (ROS) are cytotoxic, which leads to a loss of sperm motility and vitality as well as an increase in sperm agglutination and DNA damage. A recent research that was carried out by Salonia et al. [32] revealed that SARS-CoV-2 infection may result in lower circulating testosterone levels in males who are suffering from SARS-CoV-2 sickness.

In general, the pathophysiology of the SARS-CoV-2 infection, as well as its immediate and long-term effects on male fertility, remain unknown. Because of this, we recommend doing a follow-up research to determine how long the impact of SARS-CoV-2 on the quality of sperm will continue to be felt. A pH level that falls between between 7.2 and 7.8 is considered to be normal. A result that is lower than the usual level may suggest that the sample was contaminated, while a result that is higher than the normal level may indicate that an infection is present. Leukocytospermia was reported to have a correlation with PH levels higher than 8 [33].

According to research done in the past, sperm with an aberrant morphology may have weak or no motility, and as a result, they use less fructose. [13] This was shown to be the case. Because of the low quantities of fructose in the sperm, coagulation and the migration of sperm are disrupted, which may be attributed to inflammation in the genital tract [34].

The research has several obvious drawbacks.

A low total number of people took part in the study, there was no control group included in the investigation, and none of the people included in the research had their hormone levels checked. Because of the limitations of our data, an accurate interpretation of ACE2 and TMPRSS2 levels as disease severity predictions is not possible. After that, prospective studies have to be carried out in order to more thoroughly investigate the predictive influence of these parameters on the severity of COVID-19. In order to further identify the effect of ACE2 and TMPRRS2 expression levels on male reproductive outcome severity, we suggest future studies with larger sample numbers to do research along these lines.

CONCLUSIONS

Since SARS-CoV-2 is not transmitted through sexual contact because it is not present in the sperm during the COVID-19 and post-COVID-19 periods, it does not pose a risk of sexual transmission. Even though SARS-CoV-2 was not found in the semen, it still had an effect on spermatogenesis, which resulted in low-quality semen. According to the findings of this study, assisted reproductive technology (ART) clinics and facilities for sperm banking should think about conducting detailed semen analyses on male patients who have a history of COVID-19.

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