

Effect of Selenium in Teratospermia and Oligospermia

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ABSTRACT

Selenium, a trace element known for its antioxidant properties, plays a crucial role in male reproductive health, particularly in sperm quality. This study examines the impact of selenium supplementation on two common male fertility issues: teratospermia, characterized by abnormal sperm morphology, and oligospermia, defined by low sperm concentration. Selenium's antioxidative properties help mitigate oxidative stress, a significant factor contributing to sperm dysfunction. Furthermore, selenium is involved in modulating testosterone levels, which is crucial for spermatogenesis. Research indicates that selenium can enhance sperm motility, viability, and overall morphology, thereby improving fertility outcomes in men with teratospermia and oligospermia.

KEYWORDS: Selenium, male reproductive health, teratospermia, oxidative stress, oligospermia.

I. INTRODUCTION

Male infertility is a multifaceted issue, with teratospermia (abnormal sperm morphology) and oligospermia (low sperm count) being two prevalent factors affecting fertility in men. Teratospermia refers to a condition where a high percentage of sperm have abnormal shapes, often resulting in reduced motility and a lower likelihood of successful fertilization. Oligospermia, on the other hand, is characterized by a reduced sperm count, generally less than 15 million sperm per milliliter, which also decreases the chances of conception. While various factors contribute to these conditions, including genetics, lifestyle, and environmental influences, oxidative stress has emerged as a key element influencing sperm health.

Oxidative stress results from an imbalance between reactive oxygen species (ROS) and antioxidants in the body, leading to cellular damage. In sperm cells, oxidative stress can impair DNA integrity, reduce motility, and affect morphology, all of which contribute to reduced fertility. Selenium, a trace mineral essential for human health, has garnered attention for its potent antioxidant properties and its role in male reproductive function. It is a component of selenoproteins, which are crucial in mitigating oxidative damage and supporting various physiological functions, including the maintenance of sperm quality.[1,2,3]

Research has shown that selenium is involved in the development and maturation of spermatozoa. As an essential micronutrient, selenium aids in the formation of selenoproteins, such as glutathione peroxidase, which plays a crucial role in detoxifying peroxides and protecting cells from oxidative damage. Selenium also influences testosterone biosynthesis, which is essential for spermatogenesis—the process by which sperm are produced. Moreover, selenium deficiency has been associated with compromised sperm quality, particularly in terms of morphology, motility, and viability. In men with teratospermia, selenium supplementation may help improve sperm morphology by enhancing the antioxidative defense system, thus reducing oxidative damage to sperm cells. For oligospermic men, selenium's role in supporting spermatogenesis and maintaining optimal testosterone levels can be beneficial for increasing sperm count. Studies have shown that selenium supplementation, often combined with other antioxidants like Vitamin E and Zinc, can improve various parameters of sperm health, including count, motility, and morphology.[4,5]

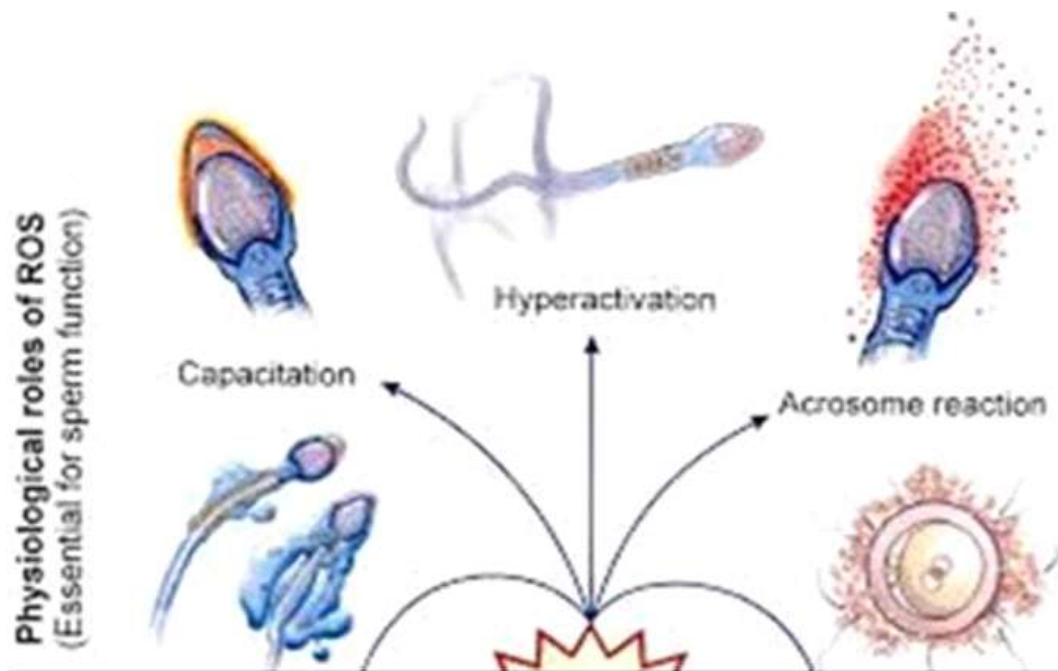


Figure 1: physiological impacts of free radicals (Kothari, et al)
Fig 1. Effect of Selenium on sperm

SELENIUM AND OXIDATIVE STRESS IN MALE INFERTILITY

Oxidative stress is a well-established factor contributing to male infertility. It occurs when there is an imbalance between reactive oxygen species (ROS) and the body's antioxidant defenses, resulting in cellular and DNA damage. In male reproductive health, oxidative stress can significantly impair sperm quality, affecting parameters like motility, morphology, and viability. Due to their high concentration of polyunsaturated fatty acids and relatively low antioxidant defenses, sperm cells are particularly vulnerable to oxidative damage. Elevated ROS levels can compromise the structural integrity of sperm membranes, damage DNA, and ultimately impair the sperm's ability to fertilize an egg. Selenium plays a crucial role in mitigating oxidative stress, making it a vital nutrient for male fertility. This trace mineral is a key component of selenoproteins, which are involved in protecting cells from oxidative damage. One of the most important selenoproteins in the context of male fertility is glutathione peroxidase, an enzyme that detoxifies peroxides and helps neutralize ROS. By bolstering the body's antioxidant defenses, selenium helps to safeguard sperm cells from oxidative stress and maintain their functional integrity.

In the male reproductive system, selenium is essential for maintaining the health of sperm cells as they develop and mature. Adequate selenium levels have been associated with improvements in sperm motility, morphology, and overall viability. In cases of teratospermia (abnormal sperm shape) and oligospermia (low sperm count), oxidative stress is often elevated, leading to increased damage to sperm cells. Selenium's antioxidant properties can help mitigate this damage, potentially improving sperm quality in men affected by these conditions. In addition to its direct antioxidative action, selenium also plays a role in the synthesis and maintenance of testosterone, the primary male sex hormone necessary for spermatogenesis (sperm production). Testosterone levels are critical for the production and development of sperm, and selenium's role in testosterone biosynthesis further contributes to its beneficial effects on male reproductive health. Several studies have demonstrated that selenium supplementation, particularly when combined with other antioxidants like Vitamin E, can enhance sperm parameters by reducing oxidative stress. These improvements include increased sperm count, improved motility, and enhanced morphology.[6,7,8,9]

SELENIUM AND SPERM MORPHOLOGY IN TERATOSPERMIA

Teratospermia, a condition characterized by a high percentage of abnormally shaped sperm, is a significant factor in male infertility, as it reduces the likelihood of successful fertilization. Abnormal sperm morphology can affect the sperm's ability to move efficiently and penetrate the egg, both of which are essential for conception. Selenium, an essential trace mineral, plays a crucial role in supporting normal sperm morphology and mitigating the adverse effects of teratospermia.

The Role of Selenium in Sperm Morphology

Selenium contributes to sperm health primarily through its antioxidant properties. It is a key component of selenoproteins, such as glutathione peroxidase, which help protect cells, including spermatozoa, from oxidative stress. Oxidative stress can damage the structure of sperm cells, leading to morphological abnormalities. By neutralizing reactive oxygen species (ROS) and preventing lipid peroxidation within sperm cell membranes, selenium helps maintain the integrity and function of sperm, thereby reducing the incidence of abnormal sperm shapes associated with teratospermia.

Additionally, selenium is crucial for the stability of cell membranes, including those of sperm cells. It plays a role in preserving the acrosome, the cap-like structure on the head of a sperm cell that contains enzymes necessary for penetrating the egg. The integrity of the acrosome is essential for the sperm to successfully bind to and penetrate the egg's outer layer during fertilization. By protecting the acrosome from oxidative damage, selenium contributes to the maintenance of normal sperm morphology.[10,11,12,13]

Research on Selenium Supplementation and Sperm Morphology

Several studies have investigated the effects of selenium supplementation on sperm morphology in men with teratospermia. Research indicates that selenium supplementation, particularly when combined with other antioxidants such as Vitamin E, can lead to improvements in sperm morphology. For example, in one clinical study, men with teratospermia who received selenium supplementation showed a significant reduction in the percentage of abnormally shaped sperm compared to those who did not receive supplementation. The antioxidative properties of

selenium are thought to be responsible for this improvement, as they help protect sperm cells from oxidative damage that can lead to structural abnormalities.

Moreover, selenium has been shown to support spermatogenesis, the process by which sperm are produced and mature. By influencing testosterone production and supporting the development of healthy sperm cells, selenium contributes to the overall improvement in sperm quality, which includes morphology. This dual role of selenium in both antioxidative protection and hormone regulation highlights its potential therapeutic value in treating teratospermia.[14,15]

Considerations for Selenium Supplementation

While selenium supplementation has shown promise in improving sperm morphology, it is essential to monitor and manage dosage carefully. Selenium is required in small amounts, and excessive intake can lead to toxicity (selenosis), which can cause adverse health effects such as gastrointestinal disturbances, hair loss, and fatigue. Typical supplementation doses range from 100 to 200 micrograms per day, although individual needs may vary.

It is also worth noting that selenium is most effective when part of a comprehensive treatment approach that includes other antioxidants, like Vitamin E, which work synergistically with selenium to enhance its protective effects on sperm cells. As a result, supplementation should ideally be supervised by healthcare providers to ensure safe and effective use.[16,17]

SELENIUM AND SPERM COUNT IN OLIGOSPERMIA

Oligospermia, characterized by a lower-than-normal sperm count (typically less than 15 million sperm per milliliter), is a common cause of male infertility. Low sperm count reduces the probability of successful fertilization, thus posing a significant barrier to conception. Selenium, a trace element with strong antioxidant properties, has been shown to support spermatogenesis—the process of sperm production—and may offer therapeutic benefits for men with oligospermia.

Selenium's Role in Sperm Production and Testosterone Synthesis

Selenium is essential for male reproductive health and plays a critical role in supporting spermatogenesis. It is a key component of selenoproteins, such as glutathione peroxidase,

that protect developing sperm cells from oxidative damage. Oxidative stress can impair spermatogenesis and negatively impact sperm count. Selenium's antioxidative function helps maintain an optimal environment for sperm production by reducing levels of reactive oxygen species (ROS) that can damage sperm cells and disrupt the process.

Additionally, selenium is involved in the biosynthesis of testosterone, a hormone crucial for maintaining spermatogenesis and overall reproductive health. Testosterone is produced in the Leydig cells of the testes, and selenium helps modulate the activity of enzymes involved in testosterone production. Adequate testosterone levels are essential for promoting sperm production, and selenium's role in supporting hormonal balance further contributes to its positive effects on sperm count.[18,19,20]

Research on Selenium Supplementation and Sperm Count

Several studies have examined the impact of selenium supplementation on sperm count in men with oligospermia. Research suggests that selenium, often administered alongside other antioxidants such as Vitamin E and Zinc, can significantly improve sperm count. In one study, oligospermic men who received selenium supplements experienced a notable increase in sperm concentration compared to those who did not receive supplementation. The antioxidative properties of selenium are thought to contribute to these improvements by reducing oxidative stress within the testes, thereby supporting healthy spermatogenesis.

Furthermore, selenium's influence on sperm count is often seen in combination with improved sperm motility and morphology. These improvements are critical for fertility, as healthy sperm must be both abundant and functionally competent to reach and fertilize an egg. Selenium's contribution to enhancing overall sperm quality makes it an important consideration in the management of oligospermia.[21,22,23]

Dosage and Safety Considerations for Selenium Supplementation

The benefits of selenium supplementation in oligospermia are evident, but proper dosage and monitoring are essential. Selenium is required in small amounts, and excessive intake can lead to selenosis, a condition of selenium toxicity that can cause symptoms such as gastrointestinal

disturbances, hair loss, and fatigue. Typical supplementation doses for addressing male fertility issues range from 100 to 200 micrograms per day, though individual needs may vary based on health status and dietary intake.

To maximize its benefits and minimize risks, selenium supplementation should ideally be conducted under medical supervision. This ensures that appropriate dosages are administered and that selenium levels remain within a safe range. Additionally, combining selenium with other antioxidants like Vitamin E can enhance its effects on sperm count while reducing oxidative stress more effectively than selenium alone.[24,25]

MECHANISMS OF ACTION: SELENOPROTEINS AND TESTOSTERONE REGULATION

Selenium, a crucial trace element, exerts its biological effects primarily through selenoproteins, which are essential for various cellular processes, including antioxidant defense, immune function, and hormone synthesis. In the context of male fertility, selenoproteins play a significant role in protecting sperm from oxidative stress and regulating testosterone synthesis, both of which are critical for maintaining healthy sperm production and function.

1. Selenoproteins and Antioxidant Defense

Selenium is a key component of several selenoproteins, including glutathione peroxidase (GPx) and thioredoxin reductase, which are essential for reducing oxidative stress. Oxidative stress occurs when there is an imbalance between reactive oxygen species (ROS) and antioxidants, leading to cellular damage. In sperm cells, oxidative stress can cause lipid peroxidation of the cell membrane, DNA damage, and reduced motility, all of which can impair fertility.

Glutathione Peroxidase (GPx): One of the most studied selenoproteins, GPx plays a crucial role in detoxifying peroxides and protecting cells, including sperm cells, from oxidative damage. GPx converts harmful peroxides into water and alcohol, thereby neutralizing ROS and protecting the integrity of sperm membranes. By reducing oxidative stress, GPx helps maintain sperm motility, viability, and morphology, which are essential for successful fertilization.

Thioredoxin Reductase: This selenoprotein also contributes to cellular redox balance by maintaining the activity of thioredoxin, a protein involved in the reduction of ROS. Thioredoxin

reductase helps regenerate antioxidants and repair oxidatively damaged proteins, thus further protecting sperm cells from oxidative damage. Together, these antioxidant functions of selenoproteins support the survival and functionality of sperm, offering a protective mechanism in conditions like teratospermia and oligospermia.[26,25,28]

2. Selenoproteins and Testosterone Synthesis

Selenium also plays a role in testosterone regulation through its influence on enzymes involved in steroidogenesis, the process by which testosterone is synthesized. Testosterone is essential for the development, maturation, and function of sperm, making it a vital hormone for male fertility.

Leydig Cells and Selenium: Testosterone is produced in the Leydig cells of the testes. Selenium contributes to the health and function of Leydig cells by supporting selenoprotein activities that are essential for steroidogenesis. Studies have shown that selenium deficiency can lead to reduced testosterone levels, which can impair spermatogenesis and lower sperm count. By maintaining healthy selenium levels, selenoproteins help ensure that testosterone production remains optimal, thereby promoting healthy sperm production.

Steroidogenic Enzymes: Selenium influences enzymes involved in testosterone biosynthesis, such as cytochrome P450 enzymes, which are critical in the conversion of cholesterol to testosterone. By modulating these enzymes, selenium indirectly supports testosterone production and, consequently, the overall spermatogenic process. This support is crucial for men with oligospermia, as adequate testosterone levels are necessary to maintain sufficient sperm count and quality.[29,30,31,35]

3. Synergistic Effects and Selenoprotein P

Selenoprotein P: Another important selenoprotein, selenoprotein P, serves as a transporter of selenium throughout the body, including to the testes. This function ensures that sufficient selenium is available for synthesizing other essential selenoproteins involved in antioxidant defense and testosterone regulation. The presence of selenoprotein P helps deliver selenium to reproductive tissues, thereby facilitating sperm health and fertility.[36,37]

CLINICAL EVIDENCE AND OPTIMAL DOSAGE OF SELENIUM FOR MALE INFERTILITY

Research has highlighted selenium's potential in improving male fertility parameters, particularly in cases of teratospermia and oligospermia. Clinical trials have demonstrated that selenium supplementation can enhance sperm quality by increasing sperm count, improving morphology, and boosting motility. However, determining the optimal dosage for selenium supplementation is crucial, as both deficiency and excess can lead to adverse effects.

Clinical Evidence Supporting Selenium Supplementation

Numerous studies have investigated the effects of selenium on sperm quality and male fertility:

- 1. Improvement in Sperm Motility and Morphology:** In a study involving men with teratospermia, supplementation with selenium at doses of 100–200 micrograms per day for several weeks significantly improved sperm morphology and motility. These improvements are attributed to selenium's antioxidative effects, which reduce oxidative stress and protect sperm from damage.
- 2. Enhanced Sperm Count in Oligospermia:** Another study focused on men with oligospermia who received 200 micrograms of selenium daily. After several weeks, participants showed an increase in sperm count and overall improvements in semen quality. These effects are likely due to selenium's role in testosterone synthesis and support for spermatogenesis.
- 3. Combination Therapy with Other Antioxidants:** Research indicates that selenium is particularly effective when used in combination with other antioxidants, such as Vitamin E and Zinc. For example, a study found that men with various forms of male infertility who received a combination of selenium (200 micrograms) and Vitamin E (400 IU) daily experienced significant improvements in sperm motility, count, and morphology compared to those who received either nutrient alone. The synergistic effects of these antioxidants enhance selenium's ability to reduce oxidative damage and support sperm health.
- 4. Improvements in Pregnancy Rates:** Some studies have reported increased pregnancy rates among couples where the male partner

received selenium supplementation. This is indicative of selenium's broader impact on sperm quality, beyond just morphology and count, as these parameters directly affect fertilization potential.[36,37,38]

OPTIMAL DOSAGE AND SAFETY CONSIDERATIONS

While selenium supplementation can benefit male fertility, it is essential to adhere to safe dosage guidelines to avoid toxicity.

- 1. Recommended Dosage Range:** The effective dose of selenium for addressing male infertility typically ranges from 100 to 200 micrograms per day. This range is generally considered safe and sufficient to provide therapeutic benefits without risking toxicity. For specific conditions, clinicians may adjust the dosage based on individual needs, though doses should not exceed 400 micrograms per day, as this is the established tolerable upper intake level (UL) for selenium.
- 2. Risks of Selenium Toxicity (Selenosis):** Excessive selenium intake can lead to a condition known as selenosis, characterized by symptoms such as nausea, gastrointestinal upset, hair loss, fatigue, and in severe cases, neurological damage. These symptoms underscore the importance of careful dosage management. Regular monitoring of selenium levels through blood tests can help ensure that supplementation remains within safe limits.
- 3. Duration of Supplementation:** While short-term supplementation of selenium (several weeks to a few months) has shown benefits, long-term supplementation should be approached cautiously and under medical supervision. Continuous, excessive intake over prolonged periods can increase the risk of selenosis.
- 4. Individual Variations and Medical Supervision:** Factors such as age, baseline selenium levels, dietary intake, and individual health conditions can affect how a person responds to selenium supplementation. Therefore, it is advisable for men considering selenium supplementation for fertility purposes to consult with a healthcare provider who can tailor the dosage to their specific needs and monitor their selenium status over time.[39,40,41,42]

IMPLICATIONS FOR MALE FERTILITY TREATMENT

The role of selenium in male fertility treatment is increasingly recognized due to its beneficial effects on sperm quality, particularly in conditions such as teratospermia and oligospermia. By enhancing sperm morphology, count, and motility, selenium supplementation can be a valuable adjunct to male fertility treatment protocols. Here's a look at the key implications of selenium for treating male infertility:

1. Targeted Antioxidant Therapy

Selenium's antioxidative properties make it a vital component of antioxidant therapy for male infertility. Oxidative stress is a significant contributor to impaired sperm function, and selenium, through its role in selenoproteins like glutathione peroxidase, helps neutralize reactive oxygen species (ROS).

Implication: Selenium can be strategically included in treatment plans to reduce oxidative damage to sperm, supporting improved sperm morphology and motility. For men with elevated oxidative stress, selenium supplementation may help restore a healthier balance, potentially increasing the likelihood of successful fertilization.[43,44]

2. Combination with Other Antioxidants and Micronutrients

Studies suggest that selenium works best in synergy with other antioxidants, such as Vitamin E and Zinc, to maximize sperm quality improvements. This combination therapy can amplify the antioxidative effects, further supporting sperm health and enhancing the efficacy of treatment.

Implication: Fertility specialists can consider recommending selenium as part of a broader antioxidant regimen, particularly for patients with confirmed oxidative stress or suboptimal sperm parameters. Such combinations have shown promise in enhancing outcomes and can be tailored to individual needs.

3. Support for Hormonal Health and Testosterone Levels

Selenium is also involved in testosterone synthesis, which is crucial for spermatogenesis. Adequate testosterone levels are necessary for maintaining normal sperm production, making selenium supplementation beneficial for men with hormonal imbalances contributing to infertility.

Implication: Selenium can be included in treatment protocols for men with low testosterone levels or other hormonal deficiencies affecting sperm production. It offers a natural way to support hormonal health and bolster spermatogenesis, thus addressing infertility from multiple angles.[45,46]

4. Adjunct to Assisted Reproductive Technologies (ART)

For couples undergoing Assisted Reproductive Technologies (ART) like in vitro fertilization (IVF) or intracytoplasmic sperm injection (ICSI), sperm quality is critical to success rates. Selenium supplementation can improve sperm morphology and motility, which are essential for the success of these procedures.

Implication: Including selenium supplementation as part of pre-ART preparation could enhance sperm quality, potentially improving ART outcomes. Fertility clinics and specialists can consider selenium as an adjunct therapy to optimize sperm health prior to procedures, increasing the chances of successful fertilization and implantation.[47,48]

5. Cost-Effective and Accessible Intervention

Selenium is relatively affordable and widely available, making it an accessible option for many patients. Given its low cost and ease of supplementation, it can be a practical addition to fertility treatment plans, particularly for patients seeking non-invasive and cost-effective interventions.

Implication: Selenium offers an inexpensive approach to improving sperm quality and can be used either as a standalone supplement or in conjunction with more intensive fertility treatments. Its affordability allows it to be recommended to a broad range of patients, including those in resource-limited settings.

6. Personalized Treatment Approach

Selenium's benefits can vary based on individual health status, baseline selenium levels, and specific infertility issues. Personalized assessment and dosage adjustments are essential to avoid toxicity and achieve optimal outcomes.

Implication: Fertility specialists should consider conducting initial assessments of selenium status and other relevant health markers to tailor supplementation plans. Personalized dosing ensures that patients receive the correct amount of selenium based on their unique needs, optimizing treatment efficacy and minimizing risks.[50,51,52,53]

II. CONCLUSION

Selenium plays a pivotal role in male reproductive health, particularly in addressing conditions such as teratospermia and oligospermia. Its antioxidant properties help protect sperm cells from oxidative damage, improving sperm morphology and enhancing overall sperm count. By supporting the activity of selenoproteins like glutathione peroxidase, selenium reduces oxidative stress, which is a known contributor to abnormal sperm shape and low sperm production. Furthermore, selenium's involvement in testosterone synthesis aids in the regulation of spermatogenesis, providing a hormonal boost that can further enhance sperm count and quality. Clinical studies have demonstrated that selenium supplementation, particularly when combined with other antioxidants, can significantly improve sperm parameters in men with fertility issues. Improvements in sperm morphology and count can increase the likelihood of successful fertilization, offering a non-invasive and cost-effective approach to male infertility treatment. In conclusion, selenium offers therapeutic potential for men facing fertility challenges related to teratospermia and oligospermia. As an adjunct to comprehensive fertility treatments, selenium supplementation can provide significant benefits, contributing to better reproductive health and improving the chances of conception.

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