

Journal of Andrology, Vol 21, Issue 1 33-44, Copyright © 2000 by The American Society of Andrology

JOURNAL ARTICLE

DNA integrity in human spermatozoa: relationships with semen quality

D. S. Irvine, J. P. Twigg, E. L. Gordon, N. Fulton, P. A. Milne and R. J. Aitken
Centre for Reproductive Biology, Edinburgh, Scotland.
d.s.irvine@edinburgh.ac.uk

The literature contains conflicting evidence regarding the existence of DNA damage in spermatozoa from infertile male patients. To examine this phenomenon, we have studied ejaculated spermatozoa from normozoospermic semen donors and from a group of the unselected male partners of couples attending an infertility clinic for initial investigation. Classical semen analysis according to World Health Organization (WHO) guidelines was undertaken with computer-assisted sperm analysis (CASA). Spermatozoa were prepared by sequential washing and centrifugation and were analyzed for DNA fragmentation using three assays: 1) a single-cell gel electrophoresis (comet) assay, 2) in situ nick translation with prior chemical decondensation (ISNT-decondensed), and 3) in situ nick translation without prior chemical decondensation (ISNT-condensed). In addition, reactive oxygen species (ROS) generation by spermatozoa was measured, and seminal plasma was analyzed for its total reactive antioxidant potential (TRAP). When the donor and patient groups were compared, the latter had lower levels of semen quality and higher levels of DNA damage, which was particularly apparent using the comet assay. Highly significant negative correlations were observed between DNA fragmentation, detected by all three assays, and semen quality, particularly sperm concentration. In addition, multiple regression analysis indicated that other attributes of semen quality, such as sperm movement and ROS generation, were also related to DNA damage. We conclude that a significant proportion of infertile men have elevated levels of DNA damage in their ejaculated spermatozoa.

This article has been cited by other articles:



HUMAN REPRODUCTION

[HOME](#)

A. Zini, J. M. Boman, E. Belzile, and A. Ciampi
Sperm DNA damage is associated with an increased risk of pregnancy loss after IVF and ICSI: systematic review and meta-analysis

Hum. Reprod., December 1, 2008; 23(12): 2663 - 2668.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

This Article

- ▶ [Full Text \(PDF\)](#)
- ▶ [Alert me when this article is cited](#)
- ▶ [Alert me if a correction is posted](#)

Services

- ▶ [Similar articles in this journal](#)
- ▶ [Similar articles in PubMed](#)
- ▶ [Alert me to new issues of the journal](#)
- ▶ [Download to citation manager](#)

Citing Articles

- ▶ [Citing Articles via HighWire](#)
- ▶ [Citing Articles via Google Scholar](#)

Google Scholar

- ▶ [Articles by Irvine, D. S.](#)
- ▶ [Articles by Aitken, R. J.](#)
- ▶ [Search for Related Content](#)

PubMed

- ▶ [PubMed Citation](#)
- ▶ [Articles by Irvine, D. S.](#)
- ▶ [Articles by Aitken, R. J.](#)



M. Hamilton and A. Pacey
Sperm donation in the UK

BMJ, November 11, 2008; 337(nov11_3): a2318 - a2318.

[\[Full Text\]](#)



C. Paul, A. A Murray, N. Spears, and P. T K Saunders

A single, mild, transient scrotal heat stress causes DNA damage, subfertility and impairs formation of blastocysts in mice

Reproduction, July 1, 2008; 136(1): 73 - 84.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



S. E. M. Lewis and I. M. Agbaje

Using the alkaline comet assay in prognostic tests for male infertility and assisted reproductive technology outcomes

Mutagenesis, May 1, 2008; 23(3): 163 - 170.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



M. Muratori, S. Marchiani, L. Tamburrino, V. Tocci, P. Failli, G. Forti, and E. Baldi

Nuclear staining identifies two populations of human sperm with different DNA fragmentation extent and relationship with semen parameters

Hum. Reprod., May 1, 2008; 23(5): 1035 - 1043.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



R. Fernandez-Gonzalez, P. N. Moreira, M. Perez-Crespo, M. Sanchez-Martin, M. A. Ramirez, E. Pericuesta, A. Bilbao, P. Bermejo-Alvarez, J. d. D. Hourcade, F. R. d. Fonseca, *et al.*

Long-Term Effects of Mouse Intracytoplasmic Sperm Injection with DNA-Fragmented Sperm on Health and Behavior of Adult Offspring
Biol Reprod, April 1, 2008; 78(4): 761 - 772.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



M. Perez-Crespo, P. Moreira, B. Pintado, and A. Gutierrez-Adan

Factors From Damaged Sperm Affect Its DNA Integrity and Its Ability to Promote Embryo Implantation in Mice

J Androl, January 1, 2008; 29(1): 47 - 54.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



S. E M Lewis

Is sperm evaluation useful in predicting human fertility?

Reproduction, July 1, 2007; 134(1): 31 - 40.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

A.M. Codrington, B.F. Hales, and B. Robaire

Exposure of male rats to cyclophosphamide alters the chromatin structure and basic proteome in spermatozoa

Hum. Reprod., May 1, 2007; 22(5): 1431 - 1442.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Reproduction

▶ HOME

M. Long, A. Stronati, D. Bizzaro, T. Kruger, G.-C. Manicardi, P. S. Hjelmberg, M. Spano, A. Giwercman, G. Toft, J. P. Bonde, *et al.*

Relation between serum xenobiotic-induced receptor activities and sperm DNA damage and sperm apoptotic markers in European and Inuit populations

Reproduction, February 1, 2007; 133(2): 517 - 530.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

A. Borini, N. Tarozzi, D. Bizzaro, M.A. Bonu, L. Fava, C. Flamigni, and G. Coticchio

Sperm DNA fragmentation: paternal effect on early post-implantation embryo development in ART

Hum. Reprod., November 1, 2006; 21(11): 2876 - 2881.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



CMAJ

▶ HOME

A. Zini and J. Libman

Sperm DNA damage: clinical significance in the era of assisted reproduction.

Can. Med. Assoc. J., August 29, 2006; 175(5): 495 - 500.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION UPDATE

▶ HOME

R. Oliva

Protamines and male infertility

Hum. Reprod. Update, July 1, 2006; 12(4): 417 - 435.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

A.A. Pacey

Is quality assurance in semen analysis still really necessary? A view from the andrology laboratory

Hum. Reprod., May 1, 2006; 21(5): 1105 - 1109.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

R. Smith, H. Kaune, D. Parodi, M. Madariaga, R. Rios, I. Morales, and A. Castro

Increased sperm DNA damage in patients with varicocele: relationship with seminal oxidative stress

Hum. Reprod., April 1, 2006; 21(4): 986 - 993.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Biophysical Journal

▶ HOME

Y. Yoshikawa, K. Hizume, Y. Oda, K. Takeyasu, S. Araki, and K. Yoshikawa
Protective Effect of Vitamin C against Double-Strand Breaks in Reconstituted Chromatin Visualized by Single-Molecule Observation
Biophys. J., February 1, 2006; 90(3): 993 - 999.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Journal of ANDROLOGY

▶ HOME

K. R. Chohan, J. T. Griffin, M. Lafromboise, C. J. De Jonge, and D. T. Carrell
Comparison of Chromatin Assays for DNA Fragmentation Evaluation in Human Sperm

J Androl, January 1, 2006; 27(1): 53 - 59.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

A. Zini, J. Meriano, K. Kader, K. Jarvi, C. A. Laskin, and K. Cadesky
Potential adverse effect of sperm DNA damage on embryo quality after ICSI

Hum. Reprod., December 1, 2005; 20(12): 3476 - 3480.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

M. Sergerie, G. Laforest, L. Bujan, F. Bissonnette, and G. Bleau
Sperm DNA fragmentation: threshold value in male fertility

Hum. Reprod., December 1, 2005; 20(12): 3446 - 3451.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Journal of ANDROLOGY

▶ HOME

V. W. Aoki, S. I. Moskovtsev, J. Willis, L. Liu, J. B. M. Mullen, and D. T. Carrell
DNA Integrity Is Compromised in Protamine-Deficient Human Sperm

J Androl, November 1, 2005; 26(6): 741 - 748.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

R. Sukanuma, R. Yanagimachi, and M. L. Meistrich
Decline in fertility of mouse sperm with abnormal chromatin during epididymal passage as revealed by ICSI

Hum. Reprod., November 1, 2005; 20(11): 3101 - 3108.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION UPDATE

▶ HOME

E. Seli and D. Sakkas
Spermatozoal nuclear determinants of reproductive outcome: implications for ART

Hum. Reprod. Update, July 1, 2005; 11(4): 337 - 349.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

M. Sergerie, G. Laforest, K. Boulanger, F. Bissonnette, and G. Bleau
Longitudinal study of sperm DNA fragmentation as measured by terminal uridine nick end-labelling assay

Hum. Reprod., July 1, 2005; 20(7): 1921 - 1927.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Reproduction

[▶ HOME](#)

S. Banks, S. A King, D S. Irvine, and P. T K Saunders
Impact of a mild scrotal heat stress on DNA integrity in murine spermatozoa

Reproduction, April 1, 2005; 129(4): 505 - 514.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



OCCUPATIONAL AND ENVIRONMENTAL MEDICINE

[▶ HOME](#)

Q Bian, L C Xu, S L Wang, Y K Xia, L F Tan, J F Chen, L Song, H C Chang, and X R Wang

Study on the relation between occupational fenvalerate exposure and spermatozoa DNA damage of pesticide factory workers

Occup. Environ. Med., December 1, 2004; 61(12): 999 - 1005.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



BIOLOGY of REPRODUCTION

[▶ HOME](#)

U. Paasch, R. K. Sharma, A. K. Gupta, S. Grunewald, E. J. Mascha, A. J. Thomas Jr, H.-J. Glander, and A. Agarwal

Cryopreservation and Thawing Is Associated with Varying Extent of Activation of Apoptotic Machinery in Subsets of Ejaculated Human Spermatozoa

Biol Reprod, December 1, 2004; 71(6): 1828 - 1837.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

[▶ HOME](#)

J. Erenpreiss, K. Jepson, A. Giwercman, I. Tsarev, Je. Erenpreisa, and M. Spano

Toluidine blue cytometry test for sperm DNA conformation: comparison with the flow cytometric sperm chromatin structure and TUNEL assays

Hum. Reprod., October 1, 2004; 19(10): 2277 - 2282.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Mutagenesis

[▶ HOME](#)

M. M. Dobrzynska, A. Baumgartner, and D. Anderson

Antioxidants modulate thyroid hormone- and noradrenaline-induced DNA damage in human sperm

Mutagenesis, July 1, 2004; 19(4): 325 - 330.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Journal of ANDROLOGY

[▶ HOME](#)

G. Huszar, C. Celik-Ozenci, S. Cayli, T. Kovacs, L. Vigue, and E. Kovanci
Semen Characteristics After Overnight Shipping: Preservation of Sperm Concentrations, HspA2 Ratios, CK Activity, Cytoplasmic Retention, Chromatin Maturity, DNA Integrity, and Sperm Shape

J Androl, July 1, 2004; 25(4): 593 - 604.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

L. Gandini, F. Lombardo, D. Paoli, F. Caruso, P. Eleuteri, G. Leter, R. Ciriminna, F. Culasso, F. Dondero, A. Lenzi, *et al.*
Full-term pregnancies achieved with ICSI despite high levels of sperm chromatin damage
Hum. Reprod., June 1, 2004; 19(6): 1409 - 1417.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

S.E.M. Lewis, M. O'Connell, M. Stevenson, L. Thompson-Cree, and N. McClure
An algorithm to predict pregnancy in assisted reproduction
Hum. Reprod., June 1, 2004; 19(6): 1385 - 1394.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**Journal of ANDROLOGY**[▶ HOME](#)

C.-H. Chen, S.-S. Lee, D.-C. Chen, H.-H. Chien, I.-C. Chen, Y.-N. Chu, J.-Y. Liu, W.-H. Chen, and G.-J. Wu
Apoptosis and Kinematics of Ejaculated Spermatozoa in Patients With Varicocele
J Androl, May 1, 2004; 25(3): 348 - 353.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**Journal of ANDROLOGY**[▶ HOME](#)

A. M. Codrington, B. F. Hales, and B. Robaire
Spermiogenic Germ Cell Phase-Specific DNA Damage Following Cyclophosphamide Exposure
J Androl, May 1, 2004; 25(3): 354 - 362.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**Molecular Human Reproduction**[▶ HOME](#)

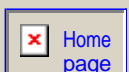
S. Cayli, D. Sakkas, L. Vigue, R. Demir, and G. Huszar
Cellular maturity and apoptosis in human sperm: creatine kinase, caspase-3 and Bcl-XL levels in mature and diminished maturity sperm
Mol. Hum. Reprod., May 1, 2004; 10(5): 365 - 372.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

C. Lachaud, J. Tesarik, M. L. Canadas, and C. Mendoza
Apoptosis and necrosis in human ejaculated spermatozoa
Hum. Reprod., March 1, 2004; 19(3): 607 - 610.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

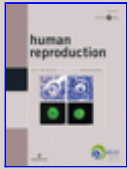
M. H. Moustafa, R. K. Sharma, J. Thornton, E. Mascha, M. A. Abdel-Hafez, A. J. Thomas, and A. Agarwal
Relationship between ROS production, apoptosis and DNA denaturation in spermatozoa from patients examined for infertility
Hum. Reprod., January 1, 2004; 19(1): 129 - 138.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**OBSTETRICS & GYNECOLOGY**[▶ HOME](#)

D. T. Carrell, A. L. Wilcox, L. Lowy, C. M. Peterson, K. P. Jones, L.

Erickson, B. Campbell, D. W. Branch, and H. H. Hatasaka
Elevated Sperm Chromosome Aneuploidy and Apoptosis in Patients
With Unexplained Recurrent Pregnancy Loss
Obstet. Gynecol., June 1, 2003; 101(6): 1229 - 1235.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

M. Benchaib, V. Braun, J. Lornage, S. Hadj, B. Salle, H. Lejeune, and J. F. Guerin

Sperm DNA fragmentation decreases the pregnancy rate in an assisted reproductive technique

Hum. Reprod., May 1, 2003; 18(5): 1023 - 1028.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Journal of ANDROLOGY

▶ HOME

M. Muratori, M. Maggi, S. Spinelli, E. Filimberti, G. Forti, and E. Baldi
Spontaneous DNA Fragmentation in Swim-Up Selected Human Spermatozoa During Long Term Incubation

J Androl, March 1, 2003; 24(2): 253 - 262.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

L. Migliore, A. Naccarati, A. Zanello, R. Scarpato, L. Bramanti, and M. Mariani

Assessment of sperm DNA integrity in workers exposed to styrene

Hum. Reprod., November 1, 2002; 17(11): 2912 - 2918.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



Journal of ANDROLOGY

▶ HOME

J. Erenpreiss, S. Hlevicka, J. Zalkalns, and J. Erenpreisa
Effect of Leukocytospermia on Sperm DNA Integrity: A Negative Effect in Abnormal Semen Samples

J Androl, September 1, 2002; 23(5): 717 - 723.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



BIOLOGY of REPRODUCTION

▶ HOME

G. A. Haines, J. H. Hendry, C. P. Daniel, and I. D. Morris

Germ Cell and Dose-Dependent DNA Damage Measured by the Comet Assay in Murine Spermatozoa after Testicular X-Irradiation

Biol Reprod, September 1, 2002; 67(3): 854 - 861.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

▶ HOME

D. Perera, A. Pizzey, A. Campbell, M. Katz, J. Porter, M. Petrou, D.S. Irvine, and R. Chatterjee

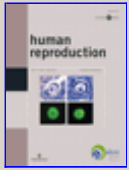
Sperm DNA damage in potentially fertile homozygous {beta}-thalassaemia patients with iron overload

Hum. Reprod., July 1, 2002; 17(7): 1820 - 1825.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

H.-M. Shen, J. Dai, S.-E. Chia, A. Lim, and C.-N. Ong
Detection of apoptotic alterations in sperm in subfertile patients and their correlations with sperm quality
Hum. Reprod., May 1, 2002; 17(5): 1266 - 1273.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

S.M. Duty, N.P. Singh, L. Ryan, Z. Chen, C. Lewis, T. Huang, and R. Hauser
Reliability of the comet assay in cryopreserved human sperm
Hum. Reprod., May 1, 2002; 17(5): 1274 - 1280.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

I.D. Morris, S. Hott, L. Dixon, and D.R. Brison
The spectrum of DNA damage in human sperm assessed by single cell gel electrophoresis (Comet assay) and its relationship to fertilization and embryo development
Hum. Reprod., April 1, 2002; 17(4): 990 - 998.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**BIOLOGY of REPRODUCTION**[▶ HOME](#)

D. Sakkas, O. Moffatt, G. C. Manicardi, E. Mariethoz, N. Tarozzi, and D. Bizzaro
Nature of DNA Damage in Ejaculated Human Spermatozoa and the Possible Involvement of Apoptosis
Biol Reprod, April 1, 2002; 66(4): 1061 - 1067.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

M.J. Tomlinson, O. Moffatt, G.C. Manicardi, D. Bizzaro, M. Afnan, and D. Sakkas
Interrelationships between seminal parameters and sperm nuclear DNA damage before and after density gradient centrifugation: implications for assisted conception
Hum. Reprod., October 1, 2001; 16(10): 2160 - 2165.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

E.V. Younglai, D. Holt, P. Brown, A. Jurisicova, and R.F. Casper
Sperm swim-up techniques and DNA fragmentation
Hum. Reprod., September 1, 2001; 16(9): 1950 - 1953.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

**HUMAN REPRODUCTION**[▶ HOME](#)

L. Ramos and A. M. M. Wetzels
Low rates of DNA fragmentation in selected motile human spermatozoa assessed by the TUNEL assay
Hum. Reprod., August 1, 2001; 16(8): 1703 - 1707.
[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

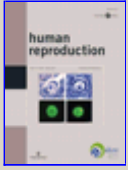
[▶ HOME](#)

P. Sutovsky, Y. Terada, and G. Schatten

Ubiquitin-based sperm assay for the diagnosis of male factor infertility

Hum. Reprod., February 1, 2001; 16(2): 250 - 258.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)



HUMAN REPRODUCTION

[▶ HOME](#)

K.L. Larson, C.J. DeJonge, A.M. Barnes, L.K. Jost, and D.P. Evenson

Sperm chromatin structure assay parameters as predictors of failed pregnancy following assisted reproductive techniques

Hum. Reprod., August 1, 2000; 15(8): 1717 - 1722.

[\[Abstract\]](#) [\[Full Text\]](#) [\[PDF\]](#)

[HOME](#) [HELP](#) [FEEDBACK](#) [SUBSCRIPTIONS](#) [ARCHIVE](#) [SEARCH](#) [TABLE OF CONTENTS](#)

[Copyright © 2000 by The American Society of Andrology.](#)