An Overview Of The Biological Methods Used To Assess DNA Damage In Humans

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ABSTRACT
The purpose of this work is to summarize the biological methods available for assessing DNA damage in humans at present. There are several methods for determining single-strand DNA breaks, alkali-labile sites, and crosslinks, including comet assays, micronucleus assays, cytogenetics (which include sister chromatid exchange and chromosomal aberration assays), DNA repair assays, oxidative DNA damage assays (measuring oxidized bases such as 8-oxo-7, 8-dihydro-2'-deoxyguanosine), and oxidized bases. There are many factors to consider when determining the best method, including how to achieve the study's objectives, what type of DNA damage to measure, and what resources are available. Combining different techniques may also contribute to a more comprehensive understanding of DNA damage and its effects on human health. By standardizing assays and advancing technology, we will be able to determine DNA damage in humans more accurately.

KEYWORDS: DNA Damage, Oxidized Bases, Comet Assay, Humans.

ABBREVIATIONS
DNA: Deoxyribonucleic Acid; UV: Ultra Violet; ELISA: Enzyme-Linked Immunosorbent Assay; HPLC: High-Performance Liquid Chromatography.

1. INTRODUCTION

DNA damage occurs as a result of endogenous and exogenous factors such as metabolic processes, UV radiation, and environmental pollutants. Knowing the degree of DNA damage is necessary for determining potential health risks and identifying individuals who may be at a higher risk of contracting specific diseases. Consequently, numerous techniques have been developed to assess DNA damage in humans, enabling a better understanding of the damage mechanisms and possible mitigation techniques [1,2]. A summary of the various biological approaches employed to assess DNA damage in humans, as well as their advantages and disadvantages, is presented in this editorial.

2. THE ASSESSMENT OF DNA DAMAGE IN HUMANS BY BIOLOGICAL MECHANISMS

One of the most popular and reliable techniques for determining single-strand DNA breaks and alkali-labile sites is the comet assay, which can also be called a single-cell gel electrophoresis test. Electrophoresis, alkaline unwinding, and lysis are performed on the embedded cells on a slide covered with agarose. When damaged DNA migrates away from the nucleus, a comet-like tail forms. Fluorescent dyes can be used to visualize the tail. There is a correlation between the length of the comet's tail and the amount of DNA damage. In addition to using relatively little biological material, this process is reasonably easy to execute and is economical to execute. Furthermore, the system can be modified to work with a wide variety of human cell types, including sperm, buccal and peripheral blood lymphocytes. Because of the subjective nature, time-consuming constitution, and susceptibility to interindividual variation of the comet assay, large-scale studies using this method are limited [3].

As a result of chromosome breakage or spindle dysfunction, micronuclei form during cell division, which is a factor that contributes to the formation of micronuclei. The micronucleus assay can be used to assess DNA damage in human cells as a result of this process. A micronucleus can be seen by immunofluorescent staining, and its frequency can be determined using immunofluorescence staining. Through the use of this technique, one can detect a variety of DNA damage types, including chromosomal breaks, aneuploidy, and clastogenic events. The technology can be used on a wide variety of cell types, including buccal cells, blood cells, and tissues. In spite of these limitations, the micronucleus assay is not suitable for large-scale studies because it is labor-intensive, time-consuming, and requires skilled personnel [4].

In addition, cytogenetic assays, such as chromosomal aberration assays and sister chromatid exchange assays, provide information about structural and numerical chromosomal aberrations caused by DNA damage. As part of these assays, cells are exposed to a mutagen for a period of time before being removed from it and stained to observe any alterations in their chromosomal structure or exchanges between sister chromatids. Many types of DNA damage can be detected by these sensitive methods, including point mutations, deletions, duplications, and translocations. In large-scale

studies, though, they are not appropriate because they require specialized equipment, are time-consuming, and are inconsistent between individuals [5,6].

Further, oxidative DNA damage is one type of DNA damage that frequently results in mutations, genomic instability, and cell death. Due to this, numerous assays are currently available to quantify oxidative DNA damage, including the determination of oxidized bases such as 8-oxo-7, 8-dihydro-2'-deoxyguanosine (8-oxodG). A variety of methods, such as ELISA and HPLC, are used in these assays to quantify the amount of oxidized bases in biological samples. It is possible to measure the level of oxidative DNA damage in various human biological samples, such as blood, urine, and tissues, with these techniques. Besides being sensitive and specific, they are also very accurate. It's important to note that they can't be used for large-scale studies because they require specialized equipment and skills [7].

An individual's ability to repair DNA damage can also be used as a measure of DNA damage. It is essential for genomic stability and to prevent mutations that can cause diseases that could be caused by DNA damage. There have been a number of assays developed to assess the level of DNA repair capacity in cells, for example, the host cell reactivation assay, which measures how well cells can repair damaged DNA after being exposed to UV radiation [8]. A number of additional methods have been developed since single-cell gel electrophoresis assays have been developed, and the unscheduled DNA synthesis assay has been applied to measure the rate of DNA repair by introducing labeled nucleotides into the damaged DNA [9,10]. In large-scale studies, these assays may be useful due to their high specificity, but specific equipment and expertise are required.

3. CONCLUSION

In conclusion, various biological techniques are available to evaluate human DNA damage. Each has its strengths and weaknesses. In choosing the best approach, factors such as the purpose of the study, the type of DNA damage being measured, the resources available, and the size of the study all play a part. It is also possible to gain a more comprehensive understanding of DNA damage and its possible health implications by combining various techniques. In conjunction with the advancement of technology and standardization of assays, we will further enhance our ability to assess DNA damage in humans with increasing precision.

CONFLICT OF INTEREST

None.

ORCID

Not available.

REFERENCES

1. Ward JF. DNA damage and repair. Basic Life Sci. 1991;58:403-415. https://doi.org/10.1007/978-1-4684-7627-9_15
2. Atha DH, Reipa V. Standards for quantitative measurement of DNA damage in mammalian cells. Int J Mol Sci. 2023;24(6):5427. https://doi.org/10.3390%2Fijms24065427
3. Møller P, Stopper H, Collins AR. Measurement of DNA damage with the comet assay in high-prevalence diseases: Current status and future directions. Mutagenesis. 2020;35(1):5-18. https://doi.org/10.1093/mutage/gez018
4. Fenech M, Knasmueller S, Bolognesi C, Holland N, Bonassi S, Kirsch-Volders M. Micronuclei as biomarkers of DNA damage, aneuploidy, inducers of chromosomal hypermutation and as sources of pro-inflammatory DNA in humans. Mutat Res Rev Mutat Res. 2020;786:108342. https://doi.org/10.1016/j.mrrev.2020.108342
5. Ishidate M Jr, Miura KF, Sofuni T. Chromosome aberration assays in genetic toxicology testing in vitro. Mutat Res. 1998;404(2):167-172. https://doi.org/10.1016/s0027-5107(98)00110-9
6. Tumini E, Aguilera A. The sister-chromatid exchange assay in human cells. Methods Mol Biol. 2021;2153:383-393. https://doi.org/10.1007/978-1-0716-0644-5_26
7. Halliwell B. Why and how should we measure oxidative DNA damage in nutritional studies? How far have we come? Am J Clin Nutr. 2000;72(5):1082-1087. https://doi.org/10.1093/ajcn/72.5.1082
8. Bassi E, Perucca P, Guardamagna I, Prosperi E, Stivala LA, Cazzalini O. Exploring new potential role of DDB2 by host cell reactivation assay in human tumorigenic cells. BMC Cancer. 2019;19(1):1013. https://doi.org/10.1186/s12885-019-6258-0
9. Pimpley MR, Foley ML, Latimer JJ. New perspectives on unscheduled DNA synthesis: Functional assay for global genomic DNA nucleotide excision repair. Methods Mol Biol. 2020;2102:483-507. https://doi.org/10.1007/978-1-0716-0223-2_27
10. Azqueta A, Langie SAS, Boutet-Robinet E, Duthie S, Ladeira C, Møller P, *et al*. Working Group 5 of the hCOMET project (CA15132). DNA repair as a human biomonitoring tool: Comet assay approaches. Mutat Res Rev Mutat Res. 2019;781:71-87. https://doi.org/10.1016/j.mrrev.2019.03.002