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Review Article

Legal Validity of Criminal Identification from the Comparative Analysis of Bitemarks

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Abstract

Human bitemarks are normally associated with violent crimes, and when recorded, they can be the basis for the constitution of forensic evidence in a legal context. The recording and the comparative analysis of these marks, allied with data on the suspects, enable the elaboration of forensic reports that lead to the exclusion or non- exclusion of suspects, and they also contribute to the unfolding of a criminal proceeding in which the court is responsible for issuing a sentence to a defendant. The legal validity of the comparative analysis of bitemarks in human identification is a widely discussed topic in the scientific community. The numerous publications on this subject reveal different opinions regarding its contribution in crime situations and whether or not it is legally valid. The objective of this literature review is to determine the legal significance of bitemarks in the identification of criminals, considering the methods used to study bitemarks and the reliability of their results.

This review is based on the analysis of bibliographic contents available at the PubMed database, which resulted from a search with the terms "bitemark", "human identification", "forensic dentistry" and "legal dentistry", written in English and published over the course of the last 10 years.

We concluded that, in spite of the controversy around this topic, the comparative analysis of bitemarks is currently regarded as valid whenever the guidelines of the American Board of Forensic Odontology (ABFO) are followed. These guidelines ensure the evolution of the methods of analysis and an objective distinction between the cases that are predisposed to a comparative analysis and those that are not; besides, they also reduce the occurrence of false positives while regulating the contents of forensic reports and the findings of forensic dentists, preventing the drawing of conclusions that would otherwise lead to the wrongful conviction of innocents, as it has been observed in the past.

Keywords: *Human Bitemarks; Human Identification; Criminal Identification; Forensic Dentistry; Forensic Criminal Investigation*

Abbreviation

ABFO: American Board of Forensic Odontology

Introduction

Bitemarks are injuries normally associated with kidnapping, murder, physical abuse and sex crimes involving children, adults or seniors. Human identification through the study of these injuries can be a valuable contribution to the outcome of a criminal proceeding.

The skin is the substrate where bitemarks are found more often, and they may be the result of the criminal's intent or an attempt at self-defense from the victim. The identification of these injuries and the existence of sufficient valid evidence make way for a study

based on the comparative analysis between bitemark records and the dental information collected from suspects. The purpose of this study is to gather results presented in the form of a forensic report that may assist in the identification of criminals, together with the remaining physical and circumstantial evidence inherent to a criminal proceeding [1,2].

Bitemarks are defined by patterns on skin, food or objects resulting from a force applied by the teeth and oral structures of an adult, child or animal during the act of biting. The identification of criminals can be sustained by evidence of a person's bite on his victim or by the presence of a bitemark in the offender as a result of self- defense against assault, with the victim marking his or her teeth on the criminal. The resulting pattern depends on the position of the tongue, the occlusion of the dental arches, the intention of the bite, the reaction of the person who is bitten, the type of resulting injury and the substrate. The confirmation of the injury as a human bitemark allows its treatment as a physical sample and enables the identification and consequent exclusion or non-exclusion of a suspect, or also an inconclusive analysis [1,3,4].

Bitemarks can be quite useful as a physical type of evidence in the course of a criminal proceeding, considering that they can:

- Indicate signs of aggression and violence,
- Indicate the infliction of pain,
- Signal cases of abuse among children, adults or seniors,
- Have an offensive, defensive or consensual nature,
- Be voluntarily or involuntarily self-inflicted,
- Have an anatomical location that suggests the injury was not self-inflicted,
- Offer information about the offender's head position in relation to the organ affected by the bite,
- Establish a space and time connection between the biter and the addressee,
- Reveal if the biter is an adult or a child,
- Allow the dentist to establish a dental profile of the biter,
- Exclude or not exclude suspects,
- Exclude or not exclude the testimony of a potential victim [4].

This method of human identification has some limitations, so it requires a study supported by specific expert evidence necessary for a forensic analysis. The inability to obtain enough data that allows experts to exclude or not exclude a suspect undermines the conduction of a forensic study and compromises the contribution of this forensic subfield to criminal investigation [1,2,4].

The focus of this literature review is human bitemarks on skin found at crime scenes, how their identification and analysis can contribute to the identification of criminals and how valid the results of such forensic analysis can be in a legal setting.

Materials and Methods

This article was written out the analysis of bibliographic contents available at the PubMed database, which resulted from a search with the terms "bitemark", "human identification", "forensic dentistry" and "legal dentistry", written in English and published over the last 10 years. We started by selecting papers based on their title and abstract, and then we proceeded to read them in full, excluding those that were unrelated to the topic of this review. Out of all these articles, we selected 11 that proved more useful to the gathering of information about the legal validity of the comparative analysis of bitemarks in the identification of suspects. The analysis of the guidelines of the American Board of Forensic Odontology (ABFO) for the evaluation of bitemarks found in crime situations was fundamental throughout this study.

Historical and legal background

The legal system is supported by forensic, documentary and testimonial evidence that allow the identification of criminals and their punishment, ensuring justice and safety to population. As a result, this system is entirely dependent on different domains of Law that ensure the provision of true and admissible claims. Forensic Odontology is one of the areas of forensic medicine that has contributed for the identification of criminals over the years. The forensic report obtained from the comparative study of bitemarks may be an added value to the expert evidence that may exist for the identification of a suspect. Unfortunately, nowadays, the prominence of this discipline lies in small-rooted pillars and its relevance in a legal context is controversial both within the scientific community and among the general public [4,5].

The legal validity of bitemark studies was called into question due to their association with court proceedings that culminated in the conviction of innocents. The most famous ones occurred in the United States of America and in Australia, and they concern Raymond Krone, Michael Lewis and Raymond John Carroll [4-6]. The case of Raymond Krone, who was convicted of murder in the United States of America, has been largely diffused by the media and became particularly popular for revealing how dubious the analysis of human bitemarks can be in legal contexts, turning it into a subject of criticism among the public. The case was reopened and Krone ended up being released in 2002 after spending 10 years serving a sentence for a crime he did not commit [5,7].

The revision of these cases proved how questionable the contribution of dentists can be for crime investigation, but it has been proven that they contributed a lot more than the results of their studies suggest. The legal records show that these professionals defended their opinion on the identification of a criminal before a judge often based on assumptions that lacked scientific foundation [1,5]. As for Raymond Krone, it seems that a lot of forensic evidence was disregarded in the first review of his case, which led to his wrongful conviction. Besides giving his opinion based on his instincts, the forensic odontologist who was responsible for the case may have manipulated the results of his study to present them as accurate and irrefutable. The analysis of the case records led to the identification of some errors made by those who were involved in it, which may be enough to preserve or at least reconsider the importance and the validity of bitemarks.

A criminal investigation results from the analysis of evidence which, when put together, leads to the understanding of a crime as to the circumstances and individuals responsible for and/or involved in it. In this regard, forensic evidence is analyzed and weighed against other information on the crime, or the case is filed if there isn't enough evidence to condemn a suspect. The results of the forensic reports are assumed to be true, scientifically proven and clear as to their probative value in relation to the existing expert evidence. In the case of Raymond Krone, it is clear that many of these measures were disregarded. The forensic dentists did not comply with the ABFO guidelines when this case took place and it is quite clear that there was a lack of scientific foundation to support the claims they made in court [1,4,8].

Incidentally, a critical analysis of these documents allows us to identify the errors committed either by the dentist to whom the case was assigned or by the court. Awareness of past mistakes led to the creation of a list of measures to prevent them from happening again:

- The contribution of the dentist consists in determining whether the forensic study is conclusive or inconclusive. If it is found to be conclusive, the term 'excluded' or 'not excluded' should be used in the forensic report to reference the suspect as a result of the study of the comparative analysis between the bitemark and the suspect's records,
- The terms "excluded" and "not excluded", attributed to a suspect, should be based on scientific evidence,
- The forensic study should be conducted by a dentist with no access to additional information on the case besides the forensic samples shown at the lab. It is also suggested that the study is reviewed by another dentist before submitting the final forensic report to the legal authorities,
- Forensic Sciences are expected and required to ensure that all the evidence and reports presented in court are either evidence-based or inconclusive, in case there isn't enough data to support a true and scientifically- proven conclusion,
- The scientific community is responsible for ensuring an adequate and sufficient training of experts to perform under the guidelines of the American Board of Forensic Odontology (ABFO),
- The scientific authorities should be responsible for sanctioning those who do not act according to the approved and current scientific guidelines,
- The legal authorities should be aware of the limitations of forensic contribution to the unfolding of a legal proceeding,
- The legal authorities should not let a scientifically unfounded opinion to be used as evidence in the course of a legal proceeding,
- The final sentence is the sole responsibility of the magistrate, so it is vital that he clearly acknowledges the relevance and the grounds of each claim added to the proceeding.

The clarification about the probative value and contribution of the study of bitemarks allows the legal authorities to adopt a conservative and realist approach toward the results of forensic reports and the need to find other supporting evidence for a more precise and reliable identification. Therefore, the final sentence granted by a court may or may not rely on forensic findings to terminate the proceeding, always bearing in mind that these are additional techniques and not conclusive of the identification procedure. However, there is still an implicit need for the scientific community to ensure the proper and sufficient certification of experts to act in accordance with the guidelines of relevant scientific authorities. The role of the forensic dentist in court should limit itself to the elaboration of the forensic report according to the guidelines of the authorities that govern this field, with the possibility of being summoned later on to testify about the obtained results [1,3,4,8]. Dentists should avoid making assumptions on conclusive results regarding the identification of suspects in legal contexts, since the methods of analysis only serve to exclude or not exclude a suspect [3,5].

In a scientific context, the entity responsible for governing forensic odontology is the American Board of Forensic Odontology (ABFO), which implements guidelines for the practice and applicability of this profession. The constant updating of this topic by this organization (the last update occurred in 2018) is aimed at meeting the need to change past measures. The ABFO is also responsible for suspending, temporarily or permanently, all professionals whose work methodology goes against the new guidelines and are therefore considered unreliable or outdated [3,4].

For some authors, the responsibility for past legal mistakes should not be exclusive of the forensic dentists, but also of the legal bodies that followed such cases, and the non-fulfillment of professional duties should not fully discredit the study of bitemarks [4,8]. However, some critics claim that such study should be removed from legal contexts [5,7].

Nowadays, certified dentists seem to have adopted a more conservative approach, having accepted the limits of such study and neutralizing the possibility of presenting erroneous or exaggerated conclusions.

There is a point in which all authors seem to agree: forensic reports should only include results that may be scientifically deduced out of the records obtained from evidence that is valid for a certain crime scene, excluding or not excluding the suspect but never providing an unsupported opinion on the identity of a criminal, thus avoiding, at all costs, playing a part in the wrongful conviction of innocents [4,5].

New guidelines of the American Board of Forensic Odontology

The American Board of Forensic Odontology (ABFO) is an authority responsible for governing forensic odontology and for implementing guidelines on the practice and applicability of this profession. Updates on these guidelines are published on a regular basis, with the objective of reinforcing the credibility and the validity of this field in legal contexts.

The controversy around the study of bitemarks has reinforced the need to conduct more studies to test the methods applied in the processing of samples obtained at crime scenes and their results in human identification. The evolution of forensic practice and the new supporting methods of analysis also prove to be relevant, as they represent a new hope for the development of this forensic medicine subfield.

The ABFO is dedicated to ensure and preserve the certified training of its members, requiring them to continuously upgrade their certification and recommending an independent confirmation of the results of a bitemark analysis by qualified peers before submitting a forensic report to the legal bodies [4,9,10].

In a crime situation, the expert is responsible for characterizing an injury as: 1) a human bitemark; 2) not a human bitemark; 3) inconclusive. If it is indeed a human bitemark, the expert should determine if there is enough evidence to conduct a comparative study and if such evidence is valid. If there is enough valid evidence, he should proceed to gather dental information about the suspects and compare it to the samples obtained at the crime scene. At the end of the study, it is recommended that the findings are reviewed by other expert in a way to ensure that they are well-founded. The new guidelines, published in 2018, introduced some limitations to the testimony of professionals, prohibiting the positive identification of suspects and presenting three options of conclusion for forensic reports: 1) there isn't enough evidence to draw a conclusion (i.e., inconclusive); 2) not excluded (possible biter); or 3) excluded as the possible biter [1,3].

The protocol suggested in the new guidelines of the American Board of Forensic Odontology (ABFO), published in 2018, is illustrated in figure 1.

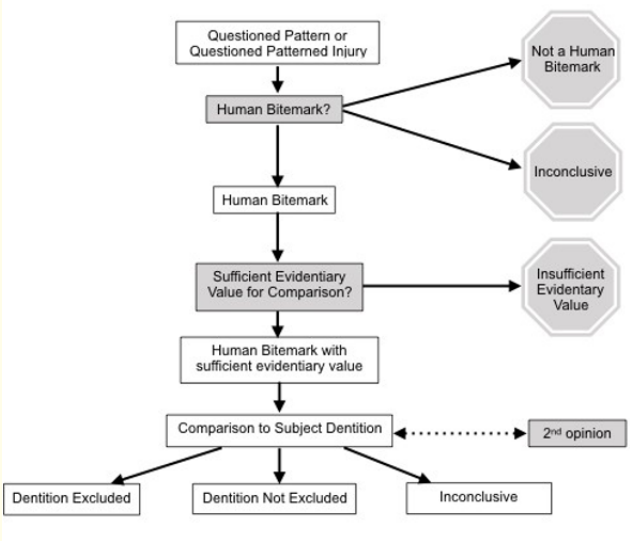

Figure 1: ABFO algorithm for analysis and comparison of bitemarks.

Limitations of the study of bitemarks

- Quality of photographic records
- Objectivity of the forensic study
- Individualization of the human bite
- Physiological response of the skin to a bite
- Scientific evidence on the methods of analysis.

Quality of photographic records

In a crime investigation, the confirmation of an injury as being a human bitemark requires its legal recording and the assessment of the quality and quantity of the available expert evidence. The confirmation that there is enough evidence determines the conduction of a forensic study to analyze such evidence. The analysis of the evidence is dependent on the gathering and processing of forensic evidence at the crime scene and, as a result, it must comply with the ABFO guidelines.

The photographic recording is the most widely used method to gather evidence. The documentation process must be meticulous, as it enables a permanent legal recording of the injury and a comparative analysis between its features and those of the suspects. The default technique for the photographic recording of bitemarks includes photos with a suitable orientation that show the location of the bitemark, macrophotography, right angulation of the camera lens with the injury plane and the use of the ABFO #2 scale [3,10].

The findings of a forensic study are entirely dependent on the quality and quantity of evidence that gets to a forensic dentist. Unfortunately, studies in this area show that most of this evidence arrives at forensic labs with decreased quality, showing also a non-compliance with the sample processing guidelines of the ABFO. In their articles, Barsley and Page reinforced the need to educate and inform the police officers that are responsible for the photographic records of a crime scene regarding these guidelines and their importance [3-5].

In one of his studies, Page reviewed the legal records captured between 2000 and 2010 and concluded that the majority of the studies on bitemarks were based on forensic evidence of poor quality. A number of epidemiological studies revealed that most of the photographs had poor quality, which undermines the conduction of a forensic study [4,5].

Nowadays, experts are encouraged by the ABFO to refuse taking part in investigations that involve poor quality evidence; this conservative position results in the abandonment of most investigations due to the lack of valid forensic evidence [4,5]. In this regard, Pretty developed a scale to classify photographic records according to their gravity and forensic significance. Such scale can be a strong additional method to differentiate valid and invalid evidence and make a decision on the (non-)conduction of a specific forensic study. However, additional research is still needed to validate this scale and determine its usefulness in forensic practice.

Objectivity of the forensic study

The objectivity of the forensic study refers to the fact that it results from an impartial and independent observation of the operator's subjectivity. Such category is possible by applying methods that convert the scientific study into a "blind" study and by dissociation from the criminal context associated with the forensic evidence at the moment of its analysis.

With this in mind, the ABFO suggests that the comparative analysis of human bitemarks is carried out by an expert who is unaware of the criminal history and context, in order to ensure the objectivity of the research. The review of the forensic study by a peer, as well as the call for a second opinion on the results, are other measures that meet the need of ensuring the expert's (and therefore the study's) impartiality [3-6].

However, this scientific objectivity applied to forensic sciences is a subject of controversy to some authors. Most of them argue that objectivity is essential for the credibility of a scientific study and even agree with the guidelines of the ABFO; however, as Olivier points out in his 2017 study, knowledge on the criminal history and context is helpful. Still, it is important to bear in mind the limitations of this study and the need for more research around this topic, especially because other studies have demonstrated that there is a greater risk of bias when a researcher is exposed to information and opinions on a criminal, which may lead to results based on subjective and erroneous conclusions that rely on his expectations, beliefs and motivations.

The methods used to increase the objectivity and precision of scientific fields have evolved over the years. Blind studies involving bitemarks are the most conservative approach to adopt at this moment, and also a way to ensure the credibility of this domain of forensic medicine [4-6,11].

Individualization of the human bitemark

One of the limitations of the study of bitemarks is the controversy around the reliability of the concept of individualization of the human bite, and how it can affect the validity of bitemark analyses.

The concept of individualization of the human bitemark means that there aren't two individuals with the same bitemark, there never were, and never will be. That is to say, the human bitemark is a unique characteristic of each individual. Some authors have accepted this concept; however, their studies are diminished and criticized by other authors due to the mathematical impossibility of proving such notion.

The individualization of a bitemark becomes especially difficult to prove when we are in the presence of samples taken from twins or individuals who were submitted to orthodontic or oral rehabilitation treatments (fixed or removable), in which the bitemarks can be quite similar. The individualization of a bitemark would also require the recording of all dental pieces, which doesn't occur in most crime situations. Consequently, the doubts arising from the concept of individualization may turn the comparative analysis of a bitemark into a dubious method for some authors [1,2,8].

The authors also express different opinions on the importance of the individualization of bitemarks for the results of a forensic analysis. While some authors, such as Bowers, defend that the individualization is fundamental for the identification in a crime context, others, such as Page, believe that it is not a core requirement to draw conclusions in a forensic report.8 Page supports his opinion by emphasizing that the objective of forensic science is to exclude or not exclude a suspect, therefore the concept of worldwide individualization is irrelevant. Since it doesn't have the capacity to identify at 100% who the biter is, its role is to contribute to the advancement of a criminal investigation by excluding or not excluding suspects within a closed and small sample. Considering that one of the suspects is the responsible for the bitemark, one can exclude all the suspects whose bitemark would never lead to the obtained evidence. As a result, Page states that the validity of a comparative analysis does not rely on the truthfulness of the assumption that the human bite is a unique feature. However, most critics bear in mind the position of the National Academy of Sciences (NAS), which alerted, in its 2009 report, that the lack of evidence on individualization may result in the wrong and unfair identification of an innocent, thus demanding more studies on the methods of analysis of bitemarks.

The validity of human identification through bitemarks requires enough proof and claims to carry out a forensic study by comparing the data of a small and controlled sample of suspects, so the scientific impossibility of the concept is not a reason to exclude the involvement of this field of expertise in the identification of criminals [1,2,4,8].

Physiological response of the skin to a bite

Bitemarks are the result of a temporary or permanent deformation derived from the force applied by the teeth on skin, so the analysis of the physiological response of this substrate to the bite is crucial.

The inherent difficulties of this science continue to be the accuracy of the obtained records, including the limitations associated with aspects of the substrate that intercepts the aggression, as well as the anatomical and morphological context and the three-dimensional profile of the bite [4,5].

The skin is a complex organ with limitations as a substrate for dental registration due to its elastic, plastic or permanent deformation properties. Its physiological response varies according to aspects related to the victim, including the specificities of each skin type, the ethnicity, age and gender; it also varies according to circumstantial aspects of the crime, including the reason for the bite, its duration, the victim's reaction, its anatomical location and the physical characteristics of the aggressor. In fact, two bitemarks caused by the same individual, with the same pressure and duration, can cause different injuries when exerted in different anatomical locations. Such assumption comes from the fact that the injury depends on the thickness and amount of the underlying tissues, both the connective and adipose, among other anatomical features of the location of the mark.

In this type of violent crimes, the research requires the collaboration of experts in Forensic Psychology who are able to link the aggression by biting to a demonstration of power, to inflict pain or as a sexual gratification of the aggressor. In the cases where the victim is the responsible for the bite, the teeth are normally used as a self- defense instrument. The motivation behind the aggression is linked to the location of the injury and to the force applied during the bite. For this reason, some epidemiological studies reveal that the anatomical parts that are more affected by bites are the nipples and legs among women and shoulders and arms among men.

The characteristics of an injury resulting from a bite also vary as to whether the victim is dead or alive, since the soft tissues' behavior changes at the post mortem [1,2,4].

The need to validate bitemark interpretation techniques through scientific studies is approached in a report published by the National Academy of Sciences (NAS) in 2009. Such validation would lead to the reduction or to the overcoming of the limitations associated with the distortion and unpredictability of a skin-engraved bitemark [1].

Scientific evidence on the methods of analysis

Despite the fact that Medicine and Forensic Sciences are not exact sciences, they always strive for accuracy by conducting scientific studies to test the methods applied in forensic analyses and turn them into quantifiable and reliable tools.

In fact, the way how dentists interpret bitemarks has been tested by several studies, which resulted in increased rates of false-positives and in disagreement between professionals as to if such marks were indeed bitemarks. Therefore, new research studies are needed to validate the techniques used in the comparative analysis of bitemarks, to determine error rates or to develop reliability tests so that they can continue to be used in legal contexts [1,5,7].

Gianelli and Imwinkelried wrote about the need for studies capable of validating the premises and techniques of this field, adding that there is no reason why such studies could be regarded as impractical [10]. Saks ended his literature review in 2016 by reinforcing that: "The scientific community, and society generally, expects that before being offered to courts, and before courts grant broad and unqualified admission, the claims for a field's techniques will have been validated" [7].

Nowadays, the debate persists among members of the scientific community: while some persevere in their attempts at ensuring fair and conservative conclusions in order to preserve the status of bitemarks as a useful tool in judicial environments, others manifest their disapproval in publications, arguing that these methods should be entirely removed from courts [5-7]. The one thing these authors have in common is that they all share a need to formulate scientific studies that support the truthfulness and the reliability of the results of forensic reports, so that they can be regarded as a legitimate contributor in legal contexts [4,5].

Practical evolution and new supporting methods of analysis

Technological progress in the Health field brought along the evolution and enhancement of bitemark analysis methods, so that their contribution to criminal investigations could be simpler, more effective and accurate [10]. In this regard, new scientific studies are being developed to assess the feasibility of a protocol for the three-dimensional analysis of bitemarks by way of reaching for digital records through intraoral scanners.

Intraoral scanners enable a fast recording of the bitemark and dentition of suspects. Such scanners can be used to obtain 3D images out of bitemarks, which will then be compared with the available evidence on these marks, i.e. dental impressions or photographs of the suspects [9]. The advent of new software that allows a comparative analysis through 3D images may be able to reduce the practical errors inherent to the techniques applied nowadays. Such software needs to be tested and legalized in the context of forensic odontology before being implemented, and its results should first be accepted as a central part of the forensic study submitted to the legal authorities [10].

In a study conducted in 2019, Fournier analyzed bitemarks inflicted on three different substrates for a sample of 8 individuals. The dentitions and bitemarks were scanned using the digital intraoral scanner PlanMeca Emerald, and the Romexis1 software was used to develop a digital 3D design of the teeth. The results of his study didn't show a perfect match between dental records and bitemarks; however, with this protocol, the exclusion of incorrect dentitions linked to a bitemark proved much easier, effective and fast. The analysis out of digital 3D records seems to be more objective than the analysis through photographic records. However, the protocol suggested in this study should be tested in a larger and more diverse sample of individuals, in order to assess the possibility of adapting the method to the daily practice of forensic dentists [9].

Conclusion

Despite the current controversy around this topic, we've found that the comparative analysis of bitemarks is currently regarded as a valid method whenever it complies with the guidelines of the American Board of Forensic Odontology (ABFO). These guidelines and their updating ensure the evolution of the methods of analysis and the objective distinction between cases that may or may not be subject to a comparative analysis; moreover, they reduce the occurrence of false positives while regulating the contents of forensic reports and the findings of forensic dentists, in a way to avoid drawing erroneous conclusions that would otherwise contribute to the wrongful conviction of innocents, as it has been observed in the past.

More studies on the limitations of this field of forensic medicine are still needed, and also on the feasibility of adopting new 3D recording techniques to increase the scientific reliability and the legal credibility of this area and ultimately proving its usefulness to the analysis of forensic evidence in crime investigation contexts.

Conflict of Interest

The authors have no conflicts of interest to declare.

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