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Dental Anthropology and Forensics: Answers to Questions Related to our Past – Review of the Literature

SUMMARY

Dental science is directly correlated to anthropology, which is attributed to teeth's significant advantages and properties. Meanwhile, justice is better and easier served due to the contribution of forensic odontology. The aim of the present literature review is to present the decisive contribution of dental science to the investigation of human species' evolution, as well as to the demystification of criminal cases. A thorough research has been conducted in scientific databases and scientific textbooks related to our review. It is obvious that the assessment of gradual modifications in human dentition as time passes by is indicative of human species' evolution. Nowadays, it is feasible to determine an excavated skeleton's identity and, as far as the ancient civilizations are concerned, to investigate their intercultural relationships, their dietary customs and their oral health's status. With regard to forensics, the structure of cranial bones is of great assistance in demystificating legal cases. Forensic odontology provides forensic medical examiners with the opportunity to faster identify deceased people and more effectively examine abused victims. Certainly, radiographic techniques, such as periapical radiographs as well as modern radiographic methodologies (CT, CBCT, MRI), offer additional diagnostic information in forensics. So, methodologies introduced by dental science have become a remarkable assist in anthropological researches, as well as in forensics. Nevertheless, there can be noticed a limited application of forensic odontology's principles in Greece. This fact may be attributed to the technological capabilities of our country's forensic laboratories rather than the Greek experts' level of expertise.

Key-words: Anthropology, Forensic Odontology, Human Species Evolution

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Introduction

According to the American Dental Association, Dental Anthropology is the sector of anthropology that focuses on the development, evolution and variability of teeth and the surrounding orofacial anatomical structures[1]. Dentistry seems to be directly correlated to archaeology. It provides various academic and research benefits, thus giving answers to questions related to the past based on the historical findings and the technology of three-dimensional reconstruction[1].

The teeth demonstrate a fundamental role with regard to skeleton analyses. They are considered as the rifest fossils deriving from Primates and Anthropoids[2]. This is attributed to their mostly intact structure as time passes by, due to enamel's resistance[2,3]. Teeth's laboratory analysis is easier, faster and financially advantageous in comparison to bones, as they decay and easier absorb environmental substances, thus affecting the laboratory results[4]. Also, teeth can be used as a source of archaic DNA molecules to isolate historically interesting genetic information[5].

The aim of the present literature review is to present the significant contribution of dental science to the investigation and understanding of human species' evolution, as well as to the demystification of criminal justice cases.

Material and Methods

The present review of the literature is based on published scientific papers from databases PubMed and Google Scholar, as well as scientific textbooks. In order to accumulate papers for our review, we used a series of key words and phrases: «forensic odontology», «forensic dentistry», «human teeth evolution», «disaster victim identification» and «human bite marks».

Results

We accepted thirty published papers, with publication dates within the range 1980 – 2023, only eight of which were published before 2014 and the rest 22 of them were published in the last decade (2014 – 2023). All publications chosen to be included as references have been assessed and accepted by all authors of the review, after considering their abstracts, their publication dates, their references and their scientific credibility.

Regarding the scientific textbooks, all authors agreed to include textbooks published within the last twenty years (2003 – 2023). In total, fifteen scientific books with information related to the scope of this particular review were gathered and examined. Three of them were unanimously excluded due to insufficient justification. So, finally, twelve textbooks were included in our literature review, eight of which were published within the last decade (2014 – 2023).

Discussion

Human species evolution from dentistry's perspective

Species during the Permian and Triassic period were characterized by conical non-differentiated teeth[6]. Hundreds of years throughout human evolution were needed, until today's mammals' dentitions with milk and permanent teeth and their anatomical variation[6]. This gradual change pertains to humans as well, and the multiple groups of teeth (incisors, canines, premolars, molars) seem to be the result of the initially conical teeth's fusion as time passed by[6]. This evolutionary fact is more than obvious nowadays if one notices the incisors' mamelons and labial grooves, as well as the posterior teeth's distinct cusps[6]. Moreover, during human species' evolution, there seems to be a gradual decrease in the total number of teeth[7]. It is also worth noting that mammals are divided into groups based on the types of teeth per oral quadrant. For instance, the today's well-known Homo sapiens follows the formula «2-1-2-3», which practically means he has two incisors, one canine, two premolars and three molars per oral quadrant[6,8]. Such observations regarding groups of teeth inform us about the dietary habits and social activity of civilizations of the past in various environmental conditions[9].

Dental science in anthropology

It is widely accepted that multiple data of historical significance can be drawn by anthropological researches on teeth. Specifically, scientists can calculate the age of death and estimate the post-mortem period of time. As far as children and adolescents are concerned, the most accurate methodology to estimate their age of death is the analysis of their teeth's development and eruption in conjunction with the examination of their symphyses[8]. On the contrary, when examining adult skeletons, medical examiners assess the teeth's decaying and attrition, findings mainly observed on non-western skeletons dated before the medieval period, without absolute credibility[8].

Moreover, data can be gathered regarding the intercultural relationships of the past. The geographic distribution of a civilization is revealed by teeth's number, dimensions and morphology, the dental arch's shape and the geopolitical prevalence of those statistical sizes[10]. Quantifiable variables, such as teeth's mesiodistal and buccolingual diameter, have shown that Neanderthals and Homo erectus as well as Australian, North American and Sub-Saharan African natives possibly have the biggest crown size[10,11]. On the other hand, Scandinavian Sami, South African Bushmen and today's East Asians, Indians and Europeans are believed to have the smallest crown size[10]. However, researches and their results based on non-quantifiable variables, such as teeth's anatomical characteristics, seem to be of greater credibility. For example, Carabelli's cusp is found at almost 85% of European's molars, whereas it is rarely observed in Pacific Islanders[12]. Also, the existence of a three-rooted mandibular premolar in the dentition of early Americans divides them into Eskimos, Na-Dene and the so-called «other» Americans[11]. Last but not least, shovel-shaped incisors were most frequently observed at regions of Eastern and Southeastern Asia and America[9].

Apart from these, anthropological researches can also conclude on past civilizations' dietary habits and health status by examining their skeletons' teeth. Certainly, any pathological alterations or intentional interventions in the dentition reflect the identity, the customs, the diet and the general health status of both the investigated individual and the whole population. Intentional tooth extractions and posterior teeth's occlusal grooves inform about an individual's occupation and the social status[13]. In African, American and Asian populations, the shortening of teeth's crowns was nothing but usual for cultural and beautification reasons[14]. With regard to dietary habits, hunters and foragers, who consumed unprocessed leather, had disfigured occlusal and incisal edge anatomy[10]. On

the other side, farmers had significantly abraded posterior teeth with more and deeper pits, as their diet was full of grinded food[15]. After the medieval period, there can be seen a gradual reduction of tooth attrition and a concurrent increase of caries lesions and non-caries cervical abrasions, because of the consumption of industrially processed food[15]. At the same time, anthropologists often find teeth calculus and bone loss due to periodontal disease[15].

Throughout a laboratory anthropological research, chemical substances and isotopes may be detected and so, conclusion may be drawn regarding an individual's living circumstances, especially its dietary habits, migrations, change of geopolitical circumstances and exposure to toxic factors. A characteristic example is lead and strontium isotopes, which reveal a population's origin and migration movements[16]. The barium to calcium ratio is correlated to the time of a newborn's wean[17]. According to certain researches, this time seems to be the same for today's and archaic humans[18,19].

Forensic Odontology

Dental anthropology composes the biological profile of an unidentified individual, which explains its direct correlation with forensic science[20]. Forensic anthropology uses methodologies of describing and analyzing human body parts in order to determine an individual's identity. Its practices are useful in the demystification of criminal justice cases, in situations of identifying victims from fatalities, as well as in cases of corpse repatriation and investigation of humanitarian criminal crises[21,22,23].

Forensic odontology, known as forensic dentistry as well, is a sector of forensic anthropology. It is capable of identifying a victim or skeleton, determining whether the found remains belong or not to a human being, and whether the organism is herbivore, a carnivore or an omnivore[20,24,25]. Forensic odontology is not a newly introduced scientific sector, as there are historical references deriving from two millenniums ago. Indicatively, in 66 BC, a corpse's identification by examining its dentition was reported for the first time[26]. In 1814 AD, it was the first time a dentist was asked to testify at a trial as an expert[26]. In 1932 AD, the technique of cheiloscopy was introduced in forensics and in 1975 AD the methodology of bite marks analysis was applied for the first time[26].

The dental pulp can be used as a source of DNA molecules via the isolation of pulp cells, as it is well preserved despite extreme pH, humidity and temperature conditions[27]. Concurrently, the dental pulp assists in the determination of the blood type, according to the blood group systems ABO and Rhesus[28]. Furthermore, an individual's dentition and maxillofacial development may reveal their genetic background. As it is very well known, many syndromes are related to intraoral and extraoral phenotypic traits, such as Patau syndrome, Turner syndrome, Klinefelter syndrome, Marfan syndrome, Crouzon syndrome and the most often observed Down syndrome[29].

The forensic dental specialist deals not only with corpses, but also with abused victims. During the medical forensic examination, experts assess traumas on teeth, jaws, temporomandibular joints and oral soft tissues, check for bite marks and any teeth remains and, last but not least, evaluates the condition of dental restorations and prostheses[30,31]. So, bearing in mind the fact that teeth can be used as a means of both assault and defense, the laboratory analysis of the microbial load onto the bite marks provides forensics with the opportunity to find the offender[32,33]. Also, the examination of dental and maxillofacial traumas usually reveals the time and the way the injury or death happened[34]. Except for these, the medical examiner can estimate the age of victims with significant credibility, with the assistance of dental translucency method as a scientific indicator[35,36].

The analysis of occlusal impressions also plays a significant role in forensic dentistry. It is considered a simple method that brings fast results and at the same time, the occlusion and the function of temporomandibular joints are unique for each individual[37]. Nevertheless, justification and consent are required and its conjunction with DNA analysis is suggested, in order to apply such methodology at its maximum accuracy[31]. In humans, palatal rugae are asymmetrical and their shape seems to be related to ethnicity, thus having equal value with the analysis of occlusal impressions in forensics[38,39]. The examination of palatal rugae is mostly applied in cases of massive fatalities and disasters, while its contribution is greater in edentulous victims' identification[38]. The human palatal rugae are unique and very well preserved after death, which make them an ideal forensic finding in an effort to determine victims' identities[38,39].

Finding in forensic odontology derive not only from crania's clinical examination, but also from radiographies of the teeth and maxillofacial structures, as they provide plenty information regarding the victims' identity and the cause of death[40]. Radiographic methodologies inform about the teeth's number, anatomy and arrangement in the dental arches, the existing restorations, the maxillomandibular relationship, the bone anatomy and any osseous pathologies, the presence of foreign bodies, the periodontal status, the temporomandibular joints and the maxillary sinuses[41,42]. Moreover, in cephalometric radiographs, the angle of the mandible helps in age estimation and gender determination[41]. For instance, male frontal sinuses usually appear to be larger than the female ones[41]. It is also remarkable that the radiographic examination of the bone parts of temporomandibular joints may lead to a safe estimation of a victim's height[41]. In cases of massive fatalities, a certain radiographic protocol is to be applied, in order to identify the victims.

This protocol has been formulated by ISFRI and clearly states the requirement of 14 periapical radiographic (full mouth radiographic examination) along with 2 or 4 bitewing radiographs[41]. In general, radiology offers simple, direct, low cost and highly accurate methodologies n forensic dentistry. For that reason, their conjunction with dental impressions, DNA analysis and the customized properties of each victim's medical record, such as total hip arthroplasty, are a valuable tool in forensics for identification in cases of massive fatalities[40].

Future technological advancements in forensics

One should also bear in mind the modern radiographic methodologies that have been developed. Until today, all researches confirm that computed tomography (CT), magnetic resonance imaging (MRI) and cone beam computed tomography (CBCT) are insufficiently effective[40]. However, their future technological upgrade is promising of encouraging results[40]. CT is correlated to bone findings, thus allowing the digital assessment of hard tissues of the skull[43]. MRI is usually complementary to computed tomography in order to determine the shell's path inside the injured or dead body as well as to examine soft tissue injuries[40,43]. CBCT provides scientists with the opportunity to estimate the victims' age, based on the dimensions of pulp chambers, the development stage of 3rd molars and the structural status of petro-occipital synchondroses[43]. Gender determination is also feasible with CBCT via the examination of the mandible, the foramen magnum, the paranasal sinuses and the mastoid processes[43]. Finally, scientists can analyse occlusal impressions, reconstruct a victim's face digitally and examine injuries caused by firearms[43].

Another promising advancement is the contribution of artificial intelligence in forensic odontology, though its application is until today very limited. To name some of its future capabilities in forensic dentistry, dental radiographs may be processed, age and gender may be determined, face characteristics may by reconstructed in three dimensions through cranial remains, occlusal impressions may be analyzed and types of dental implants may be recognized (implant backtracking)[44]. But artificial intelligence is still at a primary level and it needs to conform to bioethical rules, so that personal data is secured and protected[44].

Conclusions

It is obvious, that dental science has numerous applications in anthropology and forensics, thus contributing to the better understanding of humanity's past and to the more effective serving of justice. Modern dentists should bear in mind the capabilities of forensic odontology and dental anthropology as developing scientific sectors. What is needed nowadays is scientific cooperation at a national and worldwide scale, along with sufficient financial support. Despite the numerous capabilities of forensic odontology, this sector is not quite ubiquitous in Greek forensic science. This may be attributed to the technological limitations of some of university forensic laboratories, along with the absence of a well organized system of keeping dental records with valuable contribution to forensic investigations. At the same time, it is worth underlining the constant and high level of education and expertise of Greek forensic medical examiners, whose service is respected by the Greek justice system when it comes to demystificating criminal cases.

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