

Genetics and Molecular Biology Techniques Applications in Forensic Dentistry-A Review

Moumita Sinha and I. Arjun Rao

Department of Forensic Science, Guru Ghasidas University, Bilaspur (C.G.), India

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Abstract

Forensic skills are regularly utilized as a part of various criminal examination and medico-legal area, for example, blood classification, anthropological investigations and legal dentistry (dental records, X-rays, bite marks) unravelled and will keep solving numerous criminal offences. In any case, since the advancement of molecular biology techniques there were an expansion in number and nature of solved cases. The present work indicates the significant role of forensic methods over the conventional techniques in human identification particularly with forensic dentistry. It likewise demonstrates that in a few circumstances, teeth are a critical source to molecular genetic studies. After a detailed review of scientific literatures it was inferred that it is required to understand the molecular biological and genetic techniques before employing with customary examination strategies, this hidden depth would deliver an expansion of data to Justice delivery system.

Keywords: Forensic dentistry, forensic anthropology, molecular biology, forensic identification

1. Introduction

Forensic dentistry can be characterized as the field to determine the physical, chemical and biological changes that occur in living or dead man's skeleton and even human parts or facts. Additionally, it inquires about human injuries that may happen incompletely or absolutely, reversible or irreversible. Forensic dentistry is typically related to the field of Dental Surgeons activities where it comprises of examination, expertise, and assessment of dentistry related scenes, yet it additionally can help to different fields to discover reality inside for Justice delivering systems.

In this way, Dental Surgeons acts as a legal expert fathoms lawful matters in a couple Lawsuit domains, for instance, civil and criminal which are the ones for the most part house. (1). The most surely understood and considered region is to set up the relationship between the action and bruises that may have been achieved by dental treatment. Others related findings are identified for oral maxillo facial harm made by different sources, for occurrence, mechanical, physical and chemical and dental examination used for human identification confirmations (2). A couple of suitable and specific individual qualities may be used as a piece of human identification, among the different identification evident techniques; fingerprint impression technique is the most widely used one, when the sensitive tissue is in good conditions (3). When the body is in the advanced stage of deterioration or

disintegration and when only bones are only left then forensic dentistry showing trustable results (4).

In any case, awesome improvement in molecular genetics in the 80's permitted developments to medical field as well as to forensic sciences with the advent of STRs (Short tandem Repeats) in human genome which had the alleged DNA (deoxyribonucleic acid) (5). Its investigation prompted data generation for individualization. Molecular genetics studies dealing with DNA polymorphism have been incredibly improved with ability of individualization and this human individualization procedure mainly depends upon three vital steps: extraction of DNA, amplification of DNA utilizing PCR method (Polymerase Chain Reaction) and generation of DNA profiles (6).

Human uniqueness distinguishing proof tests utilizing DNA are endless supply of a few smaller than normal and miniaturized scale satellite loci. This polymorphism in autosomal chromosomes (not sexual chromosomes) is viewed as an awesome independence indicator (7). To start with, keeping in mind the end goal to do the enhancement stage it was created very particular tests which permit synchronous checking in a few loci of the example. After the material intensification utilizing PCR system, they are examined in agarose or polyacrilamid gel or in programmed sequencer. Contingent upon the quality and amount of the acquired example, examination should be possible from atomic DNA or mitochondrial

(mtDNA), both shows points of interest and limitations (8).

Computerized labs for association with biotechnology and legal science increment the dependability of exams to decide sex, age estimative, parenthood and human personality. Consequently it got to be distinctly required that criminological specialists in a few zones of criminal examination, scientific restorative and dentistry would relate established examination systems to atomic science investigation and DNA exams so as to accomplish more dependable, goal and particular outcomes confronting complex cases.

Expertise exam must demonstrate a multi-train trademark and approach, in this way the present paper introduces a scientific literature review expecting to indicate the significance of forensic genetics qualities utilized alongside conventional examination techniques in human recognizable proof, chiefly with forensic dentistry. It additionally expects to demonstrate the tooth scientific pertinence as a wellspring of material to molecular genetics reviews.

Molecular Genetics Studies

These days, forensic human identification has evolved with advanced molecular genetics techniques as a capable association, for the species, family foundation, sex and age examination. Since that, assurance of species utilizing bone, tooth, hair or natural liquid specimens was done by looking with selective human molecular indicators (9). Those markers are polymorphic and effortlessly discernible in the populace. They can allude to a gene, a restricted site or some other DNA arrangement which presents diverse allelic form to that locus. The instruments that clarify polymorphism can be single changes in nucleotides (substitution, for example, SNP (Single Nucleotide Polymorphism), VNTR (variable number of couple rehashes) and STR (short pair rehashes) and the addition or avoidance of DNA successions (Indels, for example, Alu insertions (10). Add that a few pointers are particular to a decided populace, this happens in light of the fact that the distinction recurrence between two major populaces is over half, (for example, Europeans and Africans). Those markers are called PSAs, all the more as of ancestor indicators (AIMs) (11).

So as to decide sex it is conceivable to relate subjective and quantitative anthropological investigation of skull, pelvis and different bones with cytogenesis exams (Barr corpuscle nearness in female populace), atom exams (pointers in Y chromosomes) and for the most part dissecting the capable quality for amelogenin which is the most discovered protein in the dental lacquer. The amelogenin quality is found in chromosome X and Y and the diverse size and example of both qualities are utilized as dependable markers to decide sex, notwithstanding when there is little DNA (12-13) amount. Meyer *et al.*(14) utilizing old bones maturing 4000 and 7000 years evaluated the morphologic sex and

amelogenin investigation obtained from bone and tooth materials, they found an amplification index of this gene noteworthy than 90%. In another examination, Faerman *et al.* (15) decided sex utilizing amelogenin investigation separated from bones and teeth in 18 from 22 bodies. Those bodies had matured from 200 to 8000 years.

For determination of age, traditional strategies are performed utilizing sequential emission, tooth mineralization and bone configuration focuses investigation. Those strategies demonstrate attractive accuracy in youngsters (16-17). However, when the subject is an adult to have the age evaluated the fusion of sutures with Gustafson method of tooth changes procedure (18), though the scope of results may depart in a considerable measure. Keeping in mind the end goal to expand age estimative accuracy of deteriorated bodies, for example, bones a few investigators have been created attempting to for the most part the racemic blend of aspartic acid (D/L) from tooth tissues alongside one sequential age. It is outstanding that aspartic acid, especially in its destrogen shape (D), directly increments along aging (19-22). Others biochemical pointers, for example, gelatinase A and glutamic acid from dentine, are likewise being explored to be use in age estimative cases (23-24).

DNA Based Human Identification

Genetic material is sourced from numerous natural biological sources, for example, body liquids (blood and salivation), delicate tissues (muscles and viscera) and mineralized tissues (bones and teeth). There are points of interest and weaknesses for every source, those viewpoints are identified with how the source is accessible, how it decomposed and extraction methods, among others.

When managing living suspects in paternity test (father, mother, and child), genetic material is ideally acquired from either blood (leukocyte) or buccal mucosa. Trevilatto *et al.* (25) gathered buccal mucosa epithelium samples from 83 people, they composed that this specific technique demonstrates the preferred standpoint to be more plausible to be done uniquely when the suspect declines to cooperate with blood or managing with children for the same. The sum of DNA acquired to confirm the sexual orientation in amelogenin locus of X chromosome was acceptable in considerable cases.

In the other hand, in the event that it is important to check genetic connection including post-mortem material, time from death and cadaver condition are applicable components to pick which strategy for DNA extraction to be utilized. In a current demise cases blood, viscera and delicate tissue are the principal materials of the choice, however as time passes by those sources get to be distinctly unseemly, prompting to mineral tissues sources: bones and teeth.

Bones are an essential source to get genetic material since they are internally present in the body and in light

of the fact that their mineral condition, which cortical shields the medullar part from outer components and microorganism that may corrupt the DNA (26). In mass disaster circumstances, Andelinovic *et al.* (27) displayed that DNA examination from bone and tooth material permitted distinguished 109 casualties of 12-year war in the previous Yugoslavia. Traditional recognizable strategies would not give such great outcomes. DNA investigation from bones and teeth would likewise control anthropological studies to distinguish populace movement cause in antiquated circumstances (28-29).

In exhumation cases, there are a few systems that must be seen to gather sample keeping in mind the end goal to limit its contamination. Melki *et al.* (30) considered 10 exhumations for genetic association purposes. The authors introduced a convention method to give the starting point and the decision of the best bone material to be examined. Despite the fact that sample reliability is a crucial feature in DNA extraction, examination with decomposed organic material appeared to be conceivable to study genetic material when it is disintegrated (200 to 1200 sets bases) (31-33).

Genetic material source- Teeth

Teeth additionally are a noble source to acquire genetic material. This is genuine for the most part in light of the fact that their awesome tissue resistance (finish, dentin, cementum and mash) against peripheral injurers (34-35). Malaver *et al.* (36) isolated DNA got from dentin and cementum of 20 dead bodies that had been buried inside for not less than 5 years.

Pulp tissue is a less tightened connective tissue and it decomposes effortlessly in comparison to others dental tissues. Pfeiffer *et al.* (37) studied the impact of the external environment in teeth DNA decomposition that was kept underneath the soil. They watched that a tooth with opened pulp presented to external influences demonstrated a noteworthy decomposition in 18 weeks, yet 20 sound teeth that had been covered for one year indicated saved genetic material, permitting amplification of mtDNA in all analyzed examples.

Dental pulp is secured by tooth structures and along these lines can introduce preferable condition over others delicate tissue for DNA extraction. Lessing *et al.* (38) demonstrated that pulp can be the source of DNA in teeth that had been kept or gotten in various conditions, for example, teeth that had been removed when the individual was alive and after death and kept at room temperature for correspondingly 6 and 12 months. Amelogenin can be additionally examined from the dental material that had been through unfavourable circumstances. Murakami *et al.* (39) demonstrated that an individual's gender can be resolved utilizing dental pulp kept at room temperature for a long time, teeth kept in ocean water for one to four weeks and buried or covered teeth for one, four and two months. There are numerous methods to get dental material to isolate DNA,

for example, tooth pounding or squashing, even separated tooth, pulp extirpation by tooth dampening and segmenting and nitrogen fluid cryogenic pulverization (40-41).

Some lawful safety measures must be taken after when managing dental material as a source to acquire DNA since the procedure devastates the material utilized as a part of the exam. Those safety measures include legitimate teeth as recognizable proof, portraying all attributes and on the off chance that it is conceivable, taking pictures and X-beams in the first positions when they are expelled from dental curve. Those safeguards are done to protect dental attributes of confirmations with a specific end goal to demonstrate their bona fide esteem when questions are raised concerning their inception or the after effects of the individual character. After the dental recording and documenting stage and before the treatment of samples, it is important to purify dental surface, sodium hypochlorite is substance most utilized, yet it is important to have advancement among fixation, time and applying the strategy for this substance (42).

Human Identification using Multidisciplinary approach

Individual distinguishing proof is essential in a few law circumstances and the most fitting recognizable proof system is identified with collected samples, for example, an individual is living or dead; immediate or past death; the dead body is complete, in pieces or disintegrated. In the wake of being legitimately gathered, suspected examples are contrasted with materials whose identity is beforehand known or demonstrated, as such, standard material that can have organic nature or records (therapeutic, dental or photo graphical). These days, some recognizable proof cases ask for a multi-disciplinary approach, this happens either as a result of need or nonattendance of standard material to be looked at or due to the nearness of more than one kind of evidence to be analyzed.

For example, in criminal examinations, the individual's personality can be accomplished by advanced impressions left at the crime scene (3). If the gathered material does not indicate quality or amount of enough attributes to be looked at, DNA profiling examination can be performed attempting to get biological material from suspect computerized material (43). Forensic examinations built up a great deal from the minute that they had hereditary exams related to conventional strategies. In the relatively recent past, sexual assault cases were for the most part limited to spermatozoid examinations in the gathered example, blood classification or other blood tests which results were not up to the mark. At the point when hereditary material got to be distinctly conceivable to be separated from spermatozoid, hair globule, foetal material the ability to incorporate or prohibit an assault or sexual fierce endeavour suspect was a genuine probability. This did not rely on upon the nearness of genetic material in the samples under examination (44-45).

DNA investigation acquired from oral mucosa cells has awesome significance in dental impressions, also called bite marks. Ordinarily, the essential examination approach of this kind of evidence is identified with the investigation of dental attributes left on the deceased or on the objects at the crime scene (47-48). On the other hand, when those imprints don't give a convincing outcome, biological material gathering from where bite mark was used to discover the individuality that was liable for the mark. Among the methods to acquire DNA from human skin there is the twofold swab procedure which comprises of applying a swab with cleaned distilled water took after by another dry swab on the bite mark. This method indicated great outcomes to get biological material to be explored (49-50). In the Borgula *et al.* (51) trial research was exhibited that is conceivable to investigate the genotype of particular microbes found in the oral cavity (*Streptococcus*) of people as an option when it is impractical to get the DNA of the person who brought about the bite mark.

In more complex cases, for example, displayed by Bilge *et al.* (52) a multi-disciplined methodologies was important to recognize a body whose head was discovered roughly 6 months after the body was found. Anthropological methods, forensic dentistry, computerized based superimpositions and DNA examination were utilized. Sex was dictated by skull features and too by amelogenin investigation. Age was evaluated utilizing longitudinally partitioned crown estimations and computer based superimposition demonstrated a positive distinguishing proof between deceased facial features and the head discovered. DNA was removed from dental pulp, bones, muscle tissues and match up to with DNA profile of the deceased's assumed, spouse and girl child. Parenthood sign was confirmed in 11 considered loci. For another situation, Sweet *et al.* (53) introduced a recognizable proof of a lady who was vanished for a long time with the help of human parts gathered. Examinations demonstrated that the assumed deceased had 3 smear cell laminas in the lab records. DNA was isolated and matched with DNA profile acquired from the dental specimen of the discovered remains. The outcome was convinced, demonstrating correspondence in 8 of the 8 analyzed loci, including amelogenin.

For charred bodies to be identified, the considerable resistance of mineralized tissues permits the deceased to be recognized not just by DNA isolated from bone material (54,) additionally from the dental material. Sweet *et al.* (55) demonstrated recognition of a homicidal deceased that had been scorched with flammable liquid. DNA was isolated from dental pulp separated from the intra-bony third molar. Yamada *et al.* (56) exhibited another recognizable proof instance of a burned body whose head was discovered 4 months after the body. The connection amongst head and body was emphatically demonstrated by DNA obtained from dentin and muscle tissue sources. Confronting a mind-boggling result displayed in the legal writings and from the much more

consistent approaches, DNA identification and Molecular genetics techniques turned into a fundamental device to help or comprehend analyzing matters that had been viewed as the potential scientific solution in medico-legal cases. Consequently, it is compulsory that those in forensic examinations procure information about forensic genetic facts to apply with conventional examination procedures. This affiliation would bring about a more noteworthy increment of criminal justice system (57).

References

- [1]. Ramos DIA, Daruge E, Daruge Júnior E, Antunes FCM, Melendez BVC, Francesquini Júnior L, *et al.* Transposición dental y sus implicaciones éticas y legales. *Rev ADM.* 2005; 62: 185-90
- [2]. Gonçalves ACS, Travassos DV, Silva M. Campo de atuação do odontologista. *RPG Rev Pos-Grad.* 1999; 6: 60-5.
- [3]. Figini ARL, Silva JRL, Jobim LF, Silva M. Tratado de perícias criminalísticas - identificação humana. 2.ed. Campinas: Millenium Editora; 2003.
- [4]. Silva RF, Cruz BVM, Daruge Júnior E, Daruge E, Francesquini Júnior L. La importancia de la documentación odontológica en la identificación humana. *Acta Odontol Venez.* 2005; 43: 67-74.
- [5]. Jeffreys AJ, Wilson V, Thein SL. Hypervariable minisatellite regions in human DNA. *Nature.* 1985; 314: 67-73.
- [6]. Alonzo LG, Genofre GC. Genética molecular e odontologia forense. *Rev Odontol Univ St Amaro.* 1999; 4: 30-3.
- [7]. Pena SDJ. Homo Brasilis - Aspectos genéticos, lingüísticos, históricos e sócio-antropológicos da formação do povo brasileiro. Ribeirão Preto: Editora Funpec; 2002.
- [8]. Smith BC. Introduction to DNA analysis. *Dent Clin North Am.* 2001; 45: 229-35.
- [9]. Jobim LF, Costa LRS, Silva M. Tratado de perícias criminalísticas - identificação humana. Campinas: Millenium Editora; 2006. volume II
- [10]. Edwards A, Civitello A, Hammond HA, Caskey CT. DNA Typing and Genetic Mapping with Trimeric and Tetrameric Tandem Repeats. *Am J Hum Genet.* 1991; 49: 746-56.
- [11]. Shriver MD, Mei R, Parra EJ, Sonpar V, Halder J, Tishkoff AS, *et al.* Large-scale SNP analysis reveals clustered and continuous patterns of human genetic variation. *Hum Genomics.* 2005; 2: 81-9.
- [12]. Slavkin HC. Sex, enamel and forensic dentistry: a search for identity. *J Am Dent Assoc.* 1997; 128: 1021-5.
- [13]. Santos MCLG, Line SRP. The epigenetics of enamel formation. *Braz J Oral Sci.* 2006; 17: 991-5.
- [14]. Meyer E, Wiese M, Bruchhaus H, Claussen M, Klein A. Extraction and amplification of authentic DNA from ancient human remains. *Forensic Sci Int.* 2000; 113: 87-90.
- [15]. Faerman M, Filon D, Kahila G, Greenblatt CL, Smith P, Oppenheim A. Sex identification of archaeological human remains based on amplification of the X and Y amelogenin alleles. *Gene.* 1995; 167: 327-32.
- [16]. Liversidge HM, Lyons F, Hector MP. The accuracy of three methods of age estimation using radiographic measurements of developing teeth. *Forensic Sci Int.* 2003; 131: 22-9.
- [17]. Mesotten K, Gunst K, Carbonez A, Willems G. *J Forensic Odontostomatol.* 2003; 21: 31-5.
- [18]. Gustafson G. Dental identification. In: *Forensic odontology.* London: Staples Press; 1966.

- [19]. Yamamoto K. Molecular biological studies on teeth, and inquests. *Forensic Sci Int.* 1996; 80: 79-87.
- [20]. Othani S. Estimation of age from dentin by utilizing the racemization of aspartic acid: influence of pH. *Forensic Sci Int.* 1995; 75: 181-7
- [21]. Ohtani S, Yamada Y, Yamamoto I. Age estimation from racemization rate using heated teeth. *J Forensic Odontostomatol.* 1997; 15: 9-12.
- [22]. Arany S, Ohtani S, Yoshioka N, Gonmori K. Age estimation from aspartic acid racemization of root dentin by internal standard method. *Forensic Sci Int.* 2004;141: 127-30.
- [23]. Sajdok J, Pilin A, Pudil F, Zídková J, Kás J. A new method of age estimation based on the changes in human non-collagenous proteins from dentin. *Forensic Sci Int.* 2006; 156: 245-9.
- [24]. Martín-de las Heras S, Valenzuela A, Overall CM. Gelatinase A in human dentin as a new biochemical marker for age estimation. *J Forensic Sci.* 2000; 45: 807-11.
- [25]. Trevilatto PC, Line SRP. Use of buccal epithelial cells for PCR amplification of large DNA fragments. *J Forensic Odontostomatol.* 2000; 18: 6-9.
- [26]. Iwamura ESM, Soares-Vieira JA, Muñoz DR. Human identification and analysis of DNA in bones. *Rev Hosp Clin Fac Med Sao Paulo.* 2004; 59: 383-8.
- [27]. Andelinovic S, Sutlovic D, Ivkovic IE, Skaro V, Ivkovic A, Paic F, et al. Twelve-year experience in identification of skeletal remains from mass graves. *Croat Med J.* 2005; 46: 530-9.
- [28]. Leonart R, Riego E, Suárez RR, Ruiz RT, Fuente J. Analyses of DNA from ancient bones of a pre-columbian Cuban woman and a child. *Genet Mol Biol.* 1999; 22: 285-9.
- [29]. Vernesi C, Benedetto G, Caramelli D, Secchieri E, Simoni L, Katti E, et al. Genetic characterization of the body attributed to the evangelist Luke. *Proc Natl Acad Sci.* 2001; 98: 13460-3.
- [30]. Melki JAD, Martin CCS, Simões AL. Procedimentos em exumações para investigação de vínculo genético em ossos. *J Public Health.* 2001; 35: 368-74
- [31]. Ogata M, Mattern R, Schneider PM, Schacker U, Kaufmann T, Rittner C. Quantitative and qualitative analysis of DNA extracted from postmortem muscle tissues. *Z Rechtsmed.* 1990; 103: 397-406.
- [32]. Wurmb-Schwark N, Harbeck M, Wiesbrock U, Schroeder I, Ritz-Timme S, Oehmichen M. Extraction and amplification of nuclear and mitochondrial DNA from ancient and artificially aged bones. *Leg Med.* 2003; 5: S169-72.
- [33]. Bender K, Farfán MJ, Schneider PM. Preparation of degraded human DNA under controlled conditions. *Forensic Sci Int.* 2004.139: 135-40.
- [34]. Pretty IA, Sweet D. A look at forensic dentistry. Part 1: the role of teeth in the determination of human identity. *Br Dent J.* 2001; 190: 359-66.
- [35]. Gaytmenn R, Sweet D. Quantification of forensic DNA from various regions of human teeth. *J Forensic Sci.* 2003; 48: 622-5.
- [36]. Malaver PC, Yunis JJ. Different dental tissues as source of DNA for human identification in forensic cases. *Croat Med J.* 2003; 44: 306-9.
- [37]. Pfeiffer H, Hühne J, Seitz B, Brinkmann B. Influence of soil storage and exposure period on DNA recovery from teeth. *Int J Legal Med.* 1999; 112: 142-4.
- [38]. Lessig R, Edelmann J. Individualisation of dental tissue-An aid for odontological identification? *J Forensic Odontostomatol.* 1995; 13: 1-3.
- [39]. Murakami H, Yamamoto Y, Yoshitome K, Ono T, Okamoto O, Shigeta Y, et al. Forensic study of sex determination using PCR on teeth samples. *Acta Med Okayama.* 2000; 54: 21-32.
- [40]. Sweet D, Hildebrand D. Recovery of DNA from human teeth by cryogenic grinding. *J Forensic Sci.* 1998; 43: 1199-1202.
- [41]. Trivedi R, Chattopadhyay P, Kashyap K. A new improved method for extraction of DNA from teeth for the analysis of hypervariabel loci. *Am J Forensic Med Pathol.* 2002; 23: 191-6.
- [42]. Kemp BM, Smith DG. Use of bleach to eliminate contaminating DNA from the surface of bones and teeth. *Forensic Sci Int.* 2005; 154: 53-61.
- [43]. Schulz MM, Reichert W. Archived or directly swabbed latent fingerprints as a DNA source for STR typing. *Forensic Sci Int.* 2002; 127: 128-30.
- [44]. Goes ACS, Silva DA, Domingues CS, Sobrinho JM, Carvalho EF. Identification of a criminal by DNA typing in a rape case in Rio de Janeiro, Brazil. *Sao Paulo Med J.* 2002; 120: 77-80
- [45]. Silva DA, Goes ACS, Carvalho JJ, Carvalho EF. DNA typing from vaginal smear slides in suspected rape cases. *Sao Paulo Med J.* 2004; 122: 70-2.
- [46]. Silva RF, Pereira SDR, Daruge Júnior E, Daruge E, Francesquini Júnior L. A confiabilidade do exame odontolegal na identificação humana. *ROBRAC.* 2004; 35: 46-50.
- [47]. Atsü SS, Gökdemir K, Kedici PS, Ikyaz YY. Bitemarks in forensic odontology. *J Forensic Odontostomatol.* 1998.16: 30-4.
- [48]. McKenna CJ, Haron MI, Brown KA, Jones DAJ. Bitemarks in chocolate: a case report. *J Forensic Odontostomatol.* 2000; 18: 10-4.
- [49]. Sweet D, Lorente M, Lorente JA, Valenzuela A, Villanueva E. An improved method to recover saliva from human skin: the double swab technique. *J Forensic Sci.* 1997; 42: 320-2.
- [50]. Bowers CM. *Forensic dental evidence An investigator's handbook.* San Diego: Elsevier; 2004.
- [51]. Borgula LM, Robinson FG, Rahimi M, Chew KE, Birchmeier KR, Owens SG, et al. Isolation and genotypic comparison of oral streptococci from experimental bitemarks. *J Forensic Odontostomatol.* 2003; 21: 23-30.
- [52]. Bilge Y, Kedici PS, Alakoç YD, Ülker KÜ, Ilkyaz YY. The identification of a dismembered human body: a multidisciplinary approach. *Forensic Sci Int.* 2003.137: 141-6.
- [53]. Sweet D, Hildebrand D, Phillips D. Identification of a skeleton using DNA from teeth and PAP smear. *J Forensic Sci.* 1999; 44: 630-3.
- [54]. Soares-Vieira JA, Billerbeck AEC, Iwamura ESM, Cardoso LA, Muñoz DR. Post-mortem forensic identity testing: application of PCR to the identification of fire victim. *Sao Paulo Med J.* 2000; 118: 75-7.
- [55]. Sweet D, Sweet CHW. DNA analysis of dental pulp to link incinerated remains of homicide victim to crime scene. *J Forensic Sci.* 1995; 40: 310-4.
- [56]. Yamada Y, Ohira H, Iwase H, Takatori T, Nagao M, Ohtani S. Sequencing mitochondrial DNA from a tooth and application to forensic odontology. *J Forensic Odontostomatol.* 1997; 15: 13-6.
- [57]. Da Silva Rhonan Ferreira, da Rocha Pereira Sávio Domingos, Júnior Eduardo Daruge, Barcelos Rejane da Silva Sena, Godinho Neide Maria de Oliveira, Souto Rafael. Genetics and molecular biology: a literature review of forensic dentistry application. *Brazilian Journal of Oral Sciences.* 2007. Vol. 6 (20): 1254-1259.