


# The Role of Oral And Maxillofacial Radiology in Identification: Review

## Kimlik Belirlemede Ağız Diş ve Çene Radyolojisinin Rolü

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### ABSTRACT

Forensic odontology is the branch of dentistry that deals with legal issues. With the development of technology, radiographs have become an indispensable part of forensic odontology. Today, comparative identification is based on the comparison of antemortem and post-mortem images of the deceased. The uniqueness of the structures in the oral and paraoral region and their resistance to environmental influences allow for comparative identification. These structures are so durable that they can maintain their structural integrity for a long time against various external factors. Comparative identification is done in 3 stages. Each stage has a special importance for the accuracy of the result of the comparative identity analysis. These stages are antemortem data collection, postmortem data collection and comparison of these data. Among the antemortem data, the most valuable are the radiographic records closest to the time of death. For identification, digital radiographs are often preferred to analog radiographs because of their ease of use and archiving. Although most of the radiography techniques are important in definition, the most commonly used radiography techniques are periapical, bitewing, cephalometric, wrist radiographs, occlusal, panoramic, waters and three-dimensional imaging methods. In addition, the reconstruction of the facial profile by means of three-dimensional images has also begun to be used today. The aim of this study is to reevaluate the usage of oral and maxillofacial radiology in identification.

**Keywords:** Forensic odontology, Identification, Oral and maxillofacial radiology

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### ÖZ

Adli odontoloji, diş hekimliğinin yasal konularla ilgilenen birimidir. Teknolojinin gelişmesi ile radyografiler adli odontolojinin vazgeçilmez bir parçası olmuştur. Günümüzde karşılaştırmalı kimlik tespiti, ölen kişinin ölüm öncesi ve ölüm sonrası görüntülerinin karşılaştırılmasına dayanmaktadır. Oral ve paraoral bölgedeki yapıların benzersizliği ve çevresel etkilere karşı dirençleri, karşılaştırmalı tanımlamaya olanak tanır. Bu yapılar öyle dayanıklıdır ki çeşitli dış faktörlere karşı yapısal bütünlüğünü uzun süre koruyabilmektedir. Karşılaştırmalı tanımlama 3 aşamada yapılır. Her aşamanın karşılaştırmalı kimlik analizinin sonucunun doğruluğu için ayrı bir önemi bulunmaktadır. Bu aşamalar antemortem veri toplama, postmortem veri toplama ve bu verilerin karşılaştırılmasıdır. Antemortem veriler arasında en değerlileri ölüm saatine en yakın radyografik kayıtlardır. Tanımlama için dijital radyografiler, kullanım ve arşivleme kolaylığı nedeniyle genellikle analog radyografilere tercih edilir. Radyografi tekniklerinin çoğu tanımlamada önemli olmakla birlikte en sık kullanılan radyografi teknikleri periapikal, bitewing, sefalometrik, bilek grafileri, okluzal, panoramik, waters ve üç boyutlu görüntüleme yöntemleridir. Ayrıca günümüzde üç boyutlu görüntüler aracılığı ile yüz profilinin rekonstrüksiyonunun yapılması da kullanılmaya başlamıştır. Bu çalışmanın amacı ağız diş ve çene radyolojisinin kimlik belirlemede kullanım alanlarının yeniden değerlendirilmesidir.

**Anahtar Kelimeler:** Adli odontoloji, Kimlik tespiti, Oral ve maksillofasial radyoloji

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## INTRODUCTION

Forensic odontology is a unit of dentistry that deals with legal issues.<sup>1</sup> This unit evaluates the evidence obtained as a result of the examination of dental, oral and paraoral structures.<sup>2</sup> It is used for purposes such as identification, gender determination and age determination.<sup>3</sup> The first example of the use of odontology for identification purposes in history is the identification of Lollia Paulina, which is described in Dion Cassius book "Roman History" written in the Roman period.<sup>4</sup>

Forensic odontology was also used for identification purposes in the Vienna Opera House fire in 1878 and the Charite bazaar fire in Paris in 1897, in which 126 people died. People who died in the Charite bazaar fire were diagnosed by dentists with crowns, extraction spaces in the jaws, amalgam and gold restorations.<sup>5</sup> Identification is necessary for social, legal, religious and personal reasons.<sup>6</sup> Genetic analysis, fingerprint and dental examination are the three most important methods in the diagnosis of disaster victims.<sup>5</sup> However, fingerprint and DNA matching in cases where human soft tissue is damaged, such as burning and decay may not be possible.<sup>7</sup> The reason why dental examination is advantageous in identification is the uniqueness of the structures in the oral region. Even a single tooth gives information about the person's age, genetics, lifestyle and social life. Teeth protect their structures against physical, chemical or mechanical forces longer than other body tissues.<sup>5</sup> In addition, finding records of tooth and bone structures from previous times also allows identification.<sup>8</sup> For this reason, radiographs recording oral and perioral hard tissues can be useful in identification. Radiological methods can be used for reconstructive and comparative identity analysis.<sup>3</sup> The purpose of this article is to reconsider the importance of oral radiology in identification.

### Comparative Identification

In comparative identification, oral and perioral structures are compared before and after death. Premortem status is determined by dental records, models, intraoral and extraoral radiographs. While dental records present relatively subjective data, more objective data are obtained when radiographs and dental records are used together.<sup>3</sup> Although dental

records alone constitute a valuable record by stating the condition of missing and filled teeth, radiographs were found to be more reliable due to inaccuracy and fraud in these records.<sup>9</sup> Individuals who have received more dental treatment can be easily diagnosed from individuals who have received less dental treatment.<sup>10</sup>

### Antemortem Data Collection

The first thing to do is to reveal the missing persons list.<sup>11</sup> Written records, models, photographs and radiographic records can be used as antemortem data. The most useful are radiographic records. Radiographic records carry many identification factors. Some of these factors are number anomalies of teeth, crown-root morphologies, crown-root pathologies, existing tooth type (primary teeth-permanent) and positions, periodontium structures and pathologies, anatomical formations and pathologies of the jaws, dental restorations. While collecting antemortem data, the most valuable records are radiographic records close to the date of death.<sup>2,12</sup> It is very important to record all these records properly. Because the accuracy of antemortem records is crucial in the success of identification.<sup>4</sup> It is useful to access antemortem image before taking postmortem radiography, because in this way, postmortem image can be taken under similar conditions by taking the antemortem image as a guide.<sup>1</sup>

### Postmortem Data Collection And Comparison With Antemortem Images

The purpose of postmortem radiography is to document the teeth and jaws after death. It should pattern after the radiography technique and irradiation angle of the antemortem image as much as possible. These radiographs should have appropriate contrast, detail and resolution.<sup>6</sup> Small changes in the angulation during radiography can lead to serious misinterpretations.<sup>3</sup> While the study conducted by Goldstein et al.<sup>13</sup> showed that five degrees of horizontal angulation differences would cause serious interpretation errors; it also revealed that the vertical angulation errors would be less misleading.

When comparing antemortem and postmortem images, it is possible to overlay and remove similarities between them.<sup>1</sup> Wood<sup>14</sup> used a modification of the superimposition method, but this method was

limited to situations such as mixed dentition and orthodontic treatments. In comparison of antemortem and postmortem images, Interpol's advantage Computer-based comparison programs such as Plass Data®, used in North America, and DAVID® used in Australia are utilised.<sup>11</sup> Recently, human-induced errors have been prevented by the use of artificial intelligence. In the researches, identity diagnosis made by artificial intelligence using panoramic films was observed with an accuracy rate of 97.7%.<sup>15</sup>

In general, maxilla dissection is not recommended when taking postmortem images, but in some cases, such as burn cases in which rigor mortis occurs, there are problems with the placement of X-ray sensors. For this reason, it can be used rarely.<sup>1</sup>

Tooth age estimation is an important part of identification. Tooth age estimation can be made in different ways.<sup>11</sup> It has been suggested that age estimation can be made by examining features such as root translucency, secondary dentin, cementum position, root resorption, periodontitis, attrition and abrasion of teeth. In children, age estimation can be made up to the age of 15 with the dental development atlas. If the age is between 15-22, age estimation can be made according to the developmental status of the third molars.<sup>5</sup> If the tooth development is completed, the KVAAL technique is used, in which two-dimensional images of the teeth are taken.<sup>16</sup> With Cone Beam Computed Tomography (CBCT), the volumetric pulp-tooth ratio can be calculated and thus age can be estimated with this method.<sup>17</sup> However, it should be noted that nutritional disorders may affect the development of teeth and may mislead the examiners who evaluate the radiograph about the examined person's age.<sup>7</sup> In comparative identification, diagnosis is difficult with six months intervals in the mixed dentition period of the same person.<sup>8</sup>

### **Analogue Films**

The main advantage of analog films is that they are easy to use with portable X-ray equipment where computer imaging would not be possible. The disadvantages are the main difficulties in film processing and storage. Since there is no risk of radiation exposure for the victim while taking the postmortem image, low-speed films give a clearer image, but it is recommended to use high-speed films since these films

will expose the people in that environment to more radiation. It is known that the radiation dose received can be reduced by using large receiver dimensions while taking the radiograph and by holding the receiver with hemostats if it is necessary to hold the receiver. If the maxilla are resected, they are placed in a polyethylene bag in which the maxilla can move freely. Thus, both radiographs are taken more easily and a relatively sterile environment is obtained.<sup>6</sup>

In order to create a physical record of the images obtained, previous research has suggested photographing or scanning digital images and sending them via e-mail. However, tabing was observed in the images due to the use of fluorescent lamps and fluctuations in alternating current in the use of scanners in the South Asian tsunami. Instead, it is recommended to photograph the images from the appropriate angle and distance. Position disorders during photographing may cause errors in the image.<sup>1</sup> In addition, a typical herringbone image occurs due to the placement of the wrong side of the film in analogue films.<sup>9</sup> As a result, digital radiographs are recommended in mass disaster events and routinely if there is no serious problem in energy sources.<sup>1</sup>

### **Digital Radiography**

The introduction of computerized and digital radiographs in dentistry has led to a great deal of progress in diagnostic imaging.<sup>18</sup> The biggest advantages are that they do not require developing procedures, fast image acquisition, easy export of images with additional software, and allowing enlargements and optical improvements on the resulting images. Hardwired image receivers, however, must allow appropriate distance from the operator of both the X-ray generator and the laptop. The soft tissues of the people to be examined may be damaged. Therefore, clearer images can be obtained by reducing the X-ray exposure factors. If mAs is reduced, images may not be of the desired quality. Instead of all these, it can be applied in additional filtration. Situations where the tissues are more swollen will cause the opposite, and tissue excision and double irradiation are recommended for the solution of this situation.<sup>6</sup>

### **Methods Used In Comparative Identification**

If periapical radiograph is to be used, CCD, phosphorplate, analog films can be selected. The most

important difference of Phosphor plate (PSPs) from CCD is that there is no cable in the sensor. This makes PSP more useful.<sup>9</sup> Valenzuela et al.<sup>19</sup>, were able to identify 6 of 28 burned bodies by periapical radiography. In the Asian tsunami in 2004, 79% of the cases were diagnosed only with intraoral radiographs.<sup>20</sup>

Comparative identity analysis can also be performed with bitewing radiographs.<sup>1,8,21</sup> In the studies conducted by Wenzel et al.<sup>22</sup>, and Fridell and Ahlqvist<sup>23</sup>, who conducted research on adults on this subject, it was stated that identification would be made with bitewing radiographs. However, it was suggested that it would be more difficult to diagnose pediatric patients in these studies. In another study, they found this method successful in their study on children.<sup>3</sup> In the studies carried out, they made an automatic dental identification system using bitewing radiographs and molar and premolar teeth.<sup>4</sup> Gender discrimination can be found out with panoramic, occlusal and cephalometric images.<sup>7</sup> The same regions are displayed with less exposure on occlusal radiographs, thus extending the battery life and the operator is exposed to less radiation.<sup>6</sup> It saves time and resources.<sup>3</sup>

Postero-anterior radiography and Waters radiography are good ways of imaging the frontal sinuses.<sup>3</sup> The fact that the frontal sinuses are different and have a solid structure even in identical twins gives the frontal sinuses an important place in the diagnosis of identity.<sup>8,24</sup> Although there is disagreement about the age at which the development of the frontal sinuses is complete, it is considered stable after it has completed its development. However, pathologies, surgical operations and traumas that may affect the frontal sinuses should be considered. In addition, frontal sinus aplasia is rarely observed in the community. Due to this low frequency, frontal sinus aplasia can also be used for identification purposes.<sup>25</sup> The frontal sinus has a different structure in each individual, its stable structure in adulthood, and the fact that it is covered by the frontal bone behind the glabella, which is resistant to external factors, allows this structure to be used in identification. Overlapping method can be used for identification with the frontal sinus.<sup>24</sup> Wrist radiographs and examination of cervical vertebra development with cephalometric radiographs can help in estimating age.<sup>3</sup> Lateral cephalometric radiographs

have also been used in the examination of the frontal sinus.<sup>25</sup>

Panoramic radiographs are one of the imaging methods used for identification.<sup>1,21</sup> Panoramic radiographs are very useful in identification because they include a large area in a single image. It is used for age estimation. If it is taken in conditions close to the pre-mortem image, the diagnosis is made with an accuracy rate close to 100%. As a disadvantage, the regions outside the image layer are blurred and are not used in the evaluation. In addition, superpositions degrade image quality.<sup>3</sup>

Especially antemortem panoramic recordings are easier to access than 3D imaging methods. Fujimoto et al.<sup>26</sup> computed tomography images of patients with panoramic radiography were compared. In the panoramic view, the apex of the single-rooted teeth, the distal root of the multi-rooted teeth except the wisdom teeth, and the distal alveolar ridge were marked and compared. This study was found successful and it was suggested to use the method in disaster victim identification (DVI). However, there are limitations in the study such as not being able to be used in cases where there are few teeth, metal artifact in computed tomography and unreliability in cases such as severe periodontitis that changes the maxilla structure, orthodontic treatment. It has been stated that this method can be used by people who are not dentists if it is automated.

Lundberg et al.<sup>20</sup>, in another study, it was studied whether total edentulous patients could be diagnosed on panoramic films. Oral and maxillofacial radiologists and non-oral and maxillofacial radiologists participated in the study. Non-oral and maxillofacial radiologists were successful at a high rate of 96%. Oral and maxillofacial radiologists were 100% successful. Although there are no teeth, inferences were made using anatomical variations and pathologies in the maxillas. As a result, it has been understood that identification can be made with panoramic radiographs in edentulous patients.

The use of computed tomography is a useful method for identification.<sup>25</sup> It can be used instead of autopsy in some cases.<sup>27</sup> It is a fast and inexpensive method compared to methods such as DNA analysis.<sup>28</sup> It is also recommended for the examination of the

frontal sinus.<sup>25</sup> Tatlısumak et al.<sup>29</sup>, found a developed definition by performing 3D analysis. Metal artifacts can complicate the interpretation of the image, but lately it has been known that artifacts can be reduced by using different algorithms.<sup>1</sup> 2D manipulation and sizing is possible in computerized tomography. In a study conducted by Sakuma et al.<sup>30</sup>, which evaluated the comparison of dental radiographs and computed tomography images with fusion, tooth roots that were relatively less affected by metal artifact were based on. However, it is recommended to be used in cases where there is a large number of tooth roots during the fusion process.

CBCT has advantages such as lower cost and lower dose compared to computed tomography. It is a valid diagnostic tool in all specialties of dentistry.<sup>25</sup> Its low metal artifact provides an advantage over computed tomography.<sup>31</sup> With CBCT, pulp and tooth volumes can be calculated in 3D and age can be estimated.<sup>11</sup> Compared to periapical and panoramic radiographs, CBCT gives more accurate information about tooth and periphery tissues.<sup>32</sup> In some types of CBCT, the image is scanned in the supine position, so there is no problem when scanning loose body parts.<sup>20</sup>

### **Facial Reconstruction**

It is a method of obtaining facial appearance with human skeletal remains. In this case, the positions of the anterior teeth are important.<sup>8</sup> According to the study of Kirschhoff et al.<sup>33</sup>, although three-dimensional reconstruction procedures by means of computed tomography are found to be costly, it has been seen that it can be useful in identification.

### **The Use of Artificial Intelligence in Forensic Dentistry**

Technological developments have enabled artificial intelligence to be used in forensic odontology as in many other fields in recent years and have brought great conveniences. Artificial intelligence is known to be used with high accuracy in facial reconstruction, age and sex determination.<sup>15</sup> In the research conducted by Nicolás Vila-Blanco et al. programs called DANet and DASNet which were used for sex and age determination and the results were compared. According to the results of the research, DASNet was found to be more successful.<sup>35</sup> It is thought that the use of artificial intelligence will be beneficial in the

identification process and speed up the identification process.<sup>36</sup> In addition, artificial intelligence will help decision-making in cases where physicians decide.<sup>37</sup>

### **CONCLUSION**

In the past, identification was made by inspection of the oral and paraoral structures. Later, with the introduction of radiographs, radiographs of victims were compared and identification was made effortlessly. With the development of technology, 3D imaging systems have increased the accuracy rate. Today, the human factor has been removed with artificial intelligence and the error rate has been minimized. As a result, identity diagnosis in mass death events such as natural disasters and wars can be applied much more practically and accurately thanks to the developments in radiography and artificial intelligence.

### **ETHICS COMMITTEE APPROVAL**

Ethics committee approval was not obtained as human or animal sources were not used in this study.

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No financial support was received from any institution or organization for this study.

### **CONFLICT OF INTEREST**

There is no conflict of interest in this study.

### **AUTHOR CONTRIBUTIONS**

Design: MSK, Data collection and processing: MSK, Analysis and interpretation: MSK, Literature review: MSK, Writing: MSK.

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