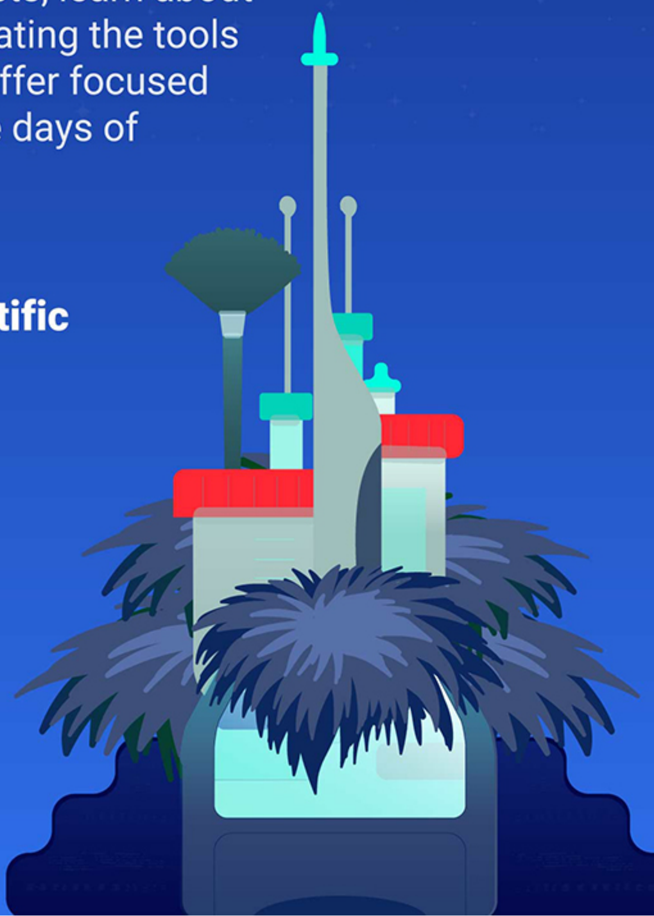

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PAPER

Odontology; Anthropology

# Specific oral and maxillofacial identifiers in panoramic radiographs used for human identification

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## Abstract

Radiographically assisted dental identification is an important means for individual identification. Specific identifiers help to quickly filter some of the possible corresponding AM and PM images at the beginning. The study seeks specific oral and maxillofacial identifiers in panoramic radiographs. A total of 920 panoramic radiographs from 460 live patients were used. The most recent radiograph served as the surrogate post-mortem (PM) record of an unidentified person, and the earliest radiograph served as the ante-mortem (AM) record of the same person. We evaluated the following four groups of identifiers of the images: (1) dental morphology, tooth number, and position; (2) dental treatment and pathology; (3) morphological identifiers of the jaw; and (4) pathological identifiers of the jaw. The ratio of each identifier being identified simultaneously in the AM and PM databases was determined. Specific identifiers were defined as those that appeared at low frequency (ratio: 0%–0.250%). A total of 18 specific oral and maxillofacial identifiers were determined. The specific identifiers were a retained deciduous tooth (0.011%), S-shaped deflection of a tooth root (0.012%), distal deflection of tooth root (0.017%), inverted impaction (0.018%), malposition (0.038%), supernumerary teeth (0.061%), mesial deflection of tooth root (0.092%), microdontia (0.136%), buccal/lingual impaction (0.188%), cementoma (0.002%), hypercementosis (0.002%), continuous crown (0.004%), pulp calcification (0.023%), attrition (0.030%), residual root (0.106%), root resorption (0.137%), implant (0.156%), and osteomyelitis (0.002%). Identifiers of the teeth and jaw can be used for human identification, and dental identifiers are more specific than identifiers of jaw.

KEYWORDS
forensic anthropology, forensic odontology, forensic radiology, human identification, identifiers, morphology

## 1 | INTRODUCTION

Teeth are the most durable parts of the vertebrate body. Due to the formation conditions and the protection of the skull, teeth and their surrounding structures are extremely resistant to destruction in major tragedies. Dental identification is known to be a rapid and sensitive means for individual identification [1]. This technique is widely applied to human identification in cases of mass disasters, as occurred in the east Japan earthquake and tsunami in 2011[2]. It is recognized that medical and dental radiographs can provide objective records of the anatomical and pathologic conditions and of the treatment conditions. These records are more reliable than written records, which are susceptible to error [3]. Of the many kinds of dental radiography, panoramic radiography is the most useful method in dentistry, providing a clear view of the teeth and jaws in one image [4].

Radiographically assisted dental identification may be classified into reconstructive or comparative types [1]. The former generates a reconstructive profile of a person based on post-mortem (PM) radiographs to provide hypotheses about their identity. The comparative identification depends on the observation and comparison of ante-mortem (AM) and PM dental radiographs with common features. The dental features include the morphology [5], pathology [6], and treatment [7] of teeth or their combination(s) [8]. However, with the use of fluoride and improvement in oral health awareness, there has been a decrease in the prevalence of dental caries in children and adults [9,10]. This decrease has resulted in a decrease in the number of dental identifiers relating to dental treatments. If there is no evidence of dental intervention, then the comparative human identifications must rely on anatomical features. Such anatomical identifiers might be dental related, such as the shape of teeth and spatial relationship between the teeth, or nondental related, such as the shape of the frontal sinus and nasal septum. Similarly, the pathological identifiers may include periapical lesions and bone fractures.

Many methods of human identification have been attempted by researchers. The number of remaining teeth has increased with the improvement of oral health. This trend contributes to the desirability of using dental patterns as the matching feature for human identification. Lee et al. proposed using the diversity of dental patterns across individuals in panoramic radiographs (PRs) [11]. Another approach is to compare PM to AM dental radiographs by dental identifiers [7,12]. Several computer-aided matching systems have been presented that use tooth contours, dental restoration shape, and automatic identification [13–16]. The frontal sinus and nasal septum can also act as useful indicators for personal identification because of their uniqueness in individuals. Some researchers have evaluated the size of the frontal sinus and nasal septum patterns and their value in human identification [17–20].

Although the feasibility of dental identifiers has been recognized, identification with them has received little practical application for the slow speed of matching. Thus, the aims of the present study were to determine the specific oral and maxillofacial identifiers in PRs, which can quickly filter the possible corresponding AM images to improve the matching speed for human identification.

## 2 | MATERIALS AND METHODS

The current study was approved by the Institutional Review Board (PKUSSIRB-201949121), and the requirement for written informed consent was waived. The 460 patients (ultimately associated with 920 PRs) were randomly selected from the picture archiving and communication system (PACS, v.11.0; Carestream Health, Inc. 2008) of Peking University School and Hospital of Stomatology between 2014 and 2019. All PRs were taken for diagnosis or treatment purposes; thus, there was no unnecessary radiation exposure to the patients. All PRs matched the following: (1) good image quality, which had a clear jaw and dentition including both condyles and maxillary sinuses, the image contrast and sharpness were appropriate and no motion artifacts, no serious overlaps between teeth in molar and premolar region, and no scratch on the image plate; (2) patient older than 14 years of age; and (3) patient who underwent PR examinations more than twice, with a minimum interval of one month between the examinations. The exclusion criteria were as follows: (1) image indistinctness and (2) mixed dentition. The PRs were taken using the Orthopantomograph OP 200 (Instrumentarium Dental, Tuusula, Finland) with an exposure time of 17.6 s and a tube voltage of 66–77 kV and tube current of 2–16 mA according to the patient size.

The two PRs included the initial and recent images of the patients. The recent radiographic image served as a surrogate PM record of an unidentified person, and the initial image served as the AM record of the same person. We evaluated the following four groups of identifiers from the images: (1) dental morphology, tooth number, and position (Table 1); (2) dental treatment and pathology (Table 2); (3) morphological identifiers of the jaw (Table 3); and (4) pathological identifiers of the jaw (Table 4).

The impacted third molars were categorized according to the Winter classifications based on the relationship between the impacted third molar and the long axis of the second molar [21]. The nasal septum patterns were recorded according to the features of deviation as seen on radiograph as straight and deviated (Figure 1). The height of the maxillary sinus floor (MSF) was classified based on the relationship between the apices of the maxillary molars and the MSF into three types: type 1, the root apex protruded into the maxillary sinus; type 2, the root apex was located in contact with the MSF; and type 3, the root apex was below the MSF (Figure 2). The depth of the sigmoid notch was defined as the distance from the lowest point of the sigmoid notch to the midpoint of the line between the most superior points of the condyle and coronoid. If the depth of the sigmoid notch was greater than half of the length of the line between the condyle and coronoid, it was called deep; if the depth of the sigmoid notch was less than or equal to half of the line, it was called shallow (Figure 3).

The images were separately viewed by two oral and maxillofacial radiologists. They completed this work in a quiet viewing room with appropriate ambient lighting at a same time in the morning. To avoid fatigue, only one hour was admitted for observation of radiographs each day. They were initially calibrated by examination of 10% of

**Highlights**

- Rapid and accurate identification of deceased individuals is essential.
- Specific identifiers determined with panoramic radiographs may help expedite the identification process.
- Dental identifiers may offer greater discriminatory value than identifiers obtaining from the jaws.

TABLE 1 Dental identifiers relating to the morphology, position, and number of teeth

| Dental identifiers | Description |
|---|---|
| Retained deciduous tooth | A deciduous tooth retained in the permanent dentition |
| Supernumerary teeth | Natural teeth in excess of the number normally present in the jaw |
| Rotation | Tooth rotated around the vertical axis |
| Horizontal impaction | Long axis of the third molar perpendicular to the second molar |
| Vertical impaction | Long axis of the third molar parallel to the second molar |
| Buccal/lingual impaction | Impacted tooth inclined to the cheek or tongue |
| Mesial impaction | Impacted tooth inclined to the second molar in the mesial direction |
| Distal Impaction | Impacted tooth inclined to the second molar in the distal direction |
| Inverted impaction | Impacted tooth is reversed and positioned upside down |
| Macrodontia | Increase in the size of the tooth |
| Microdontia | Abnormal smallness of the tooth |
| Fused tooth | Partial or complete fusion of two or more individual teeth |
| Gemination | A tooth with a single root and root canal, but with two completely or incompletely separated crowns |
| Dens Evaginatus | An anomalous tubercle protruding from the occlusal surface of tooth |
| Enamel pearl | A tubercle protruding from enamel in tooth neck |
| Taurodontism | Prism-shaped molars with large pulp spaces |
| Talon cusps | A cusp protruding from the lingual surface of tooth |
| Dens invaginatus | Invagination of the crown before it is calcified |
| Mesial deflection of tooth root | The root apex deviates from the long axis of the tooth in the mesial direction |
| Distal deflection of tooth root | The root apex deviates from the long axis of the tooth in the distal direction |
| Labial/lingual deflection of tooth root | The root apex deviates from the long axis of the tooth in the labial/lingual direction |
| S-shaped deflection of tooth root | The tooth root is S-shaped |
| Malposition | The tooth is out of its normal position |
| Transversion | The positions of two teeth are exchanged |

(Continues)

TABLE 1 (Continued)

the cases. Ten randomly selected radiographs were traced by the same investigator again. Intra- and inter-observer agreements were assessed using the weighted Cohen kappa parameter. The identifiers of all AM and PM records were stored in the AM and PM databases, respectively. For each of the identifiers, the PM records were selected in the PM database according to this identifier, and the possible corresponding AM records were tracked in the AM database for the same identifier. The AM records with this identifier were referred to as the potential database. Then, the percentage of potential matches in the AM database was calculated. The matching ratio of each identifier in both AM and PM databases was reported. Specific identifiers were defined as those that appeared at a low ratio (0%–0.250%).

## 3 | RESULTS

The age of the 460 patients ranged from 14 to 78 years, with a mean age of 30.3 ± 13.2 years. The mean interval between two PRs of a patient was ten months, with a minimum interval of one month and a maximum interval of 6 years. The kappa coefficients were greater than 0.77 in the inter-observer agreement and greater than 0.858 in the intra-observer agreement for all the variables. A total of 18 specific oral and maxillofacial identifiers were determined. The lower the ratio of the identifier, the more unique the identifier was for human identification. Based on dental morphology, tooth number, and position, the specific identifiers were a retained deciduous tooth (0.011%), S-shaped deflection of tooth root (0.012%), distal deflection of tooth root (0.017%), inverted impaction (0.018%), malposition (0.038%), supernumerary teeth (0.061%), mesial deflection of tooth root (0.092%), microdontia (0.136%), and buccal/lingual impaction (0.188%) (Table 5). The specific identifiers relating to dental treatment and pathology were cementoma (0.002%), hypercementosis (0.002%), continuous crown (0.004%), pulp calcification (0.023%), attrition (0.030%), residual root (0.106%), root resorption (0.137%), and implant (0.156%) (Table 6). The number and percentage of identifiers related to the jaw are shown in Tables 7 and 8, and the specific identifiers were osteomyelitis (0.002%).

## 4 | DISCUSSION

Human identification based on a uniquely individual characteristic, such as fingerprints, retina, and DNA typing, has been a time-tested technique. However, when the body is burnt or destroyed and the

TABLE 2 Dental identifiers relating to dental treatment and dental pathology

| Dental identifiers | Description |
|---|---|
| Caries | Decay cavities in the crown |
| Attrition | Mechanical or chemical factors induce loss of dental tissue on the occlusal or incisal surface |
| Hypercementosis | Excessive development of secondary cementum on the tooth surface |
| Cementoma | A benign odontogenic tumor arising from the cementum |
| Residual root | Root remaining due to severe dental caries |
| Root resorption | Resorption in the root of a tooth |
| Hemisection | Removal of a root and part of the crown of a multiply rooted tooth |
| Pulp calcification | Calcification in the pulp cavity |
| Apical periodontitis | Inflammation of the tissues surrounding the tooth root |
| Periapical condensing osteitis | A focal inflammation of the periapical bone with formation of radiopaque sclerotic lesions |
| Enamel hypoplasia | Incomplete formation of the dental enamel |
| Dentinogenesis imperfecta | A disorder of dentin formation |
| Filling | Materials filled into the tooth cavity |
| Root canal treatment | Root canal filled by endodontic treatment |
| Full crown | A dental restoration that completely reproduces the clinical crown of a natural tooth |
| Post-and-core crown | A crown with post and core |
| Continuous crown | A restoration with multiple crowns attached |
| Implant | A prosthetic device implanted into the jaw bone |
| Fixed bridge | A prosthesis held in position by attachments to adjacent prepared natural teeth |
| Removable partial dentures | A partial denture that can be removed from the mouth |
| Single complete denture | A prosthesis replacing mandibular or maxillary natural teeth and associated structures |
| Complete denture | A dental prosthesis replacing all natural teeth and associated structures |

body remains degraded, these approaches were not fully effective. Hard tissues are normally resistant to putrefaction for years, and they may serve as good identifiers for human identification. In forensic odontology, the morphological, pathological, and therapeutic features of teeth provide the basis of dental identification [22]. One way to improve the matching accuracy is to increase the number of grades in the classification system, such as by grading impacted third molars. Another is to incorporate additional features such as jaw bone pathology. Currently, unique information from the teeth is obtained from morphological identifiers instead of treatment identifiers because the increased awareness of oral health has reduced the need for dental treatment [9,10]. Permanent dentition is convenient for the observation of identifiers in PRs. Most people complete tooth replacement by the age of 14.

There have been relatively mature international coding systems, such as Interpol coding, and the codes can be used for software compatibility. However, some Interpol codes that are used to register clinically detectable identifiers cannot be used for registration in radiographic images because of the differences between living humans and images, and some specific identifiers of teeth and jawbones are not involved. The identifiers we used are well suited for the radiographic observation, and the selected specific identifiers can be used to quickly filter the possible corresponding AM and PM images in computer-aided identification. In this study, it is assumed that the lower the ratio of the identifier is in both AM and PM databases, the lower its frequency in the population, and thus, the lower the probability that two people share this identifier. This leads to high uniqueness. Therefore, when there is a specific identifier in the PM image and the candidate AM image has the same specific

TABLE 3 Morphological identifiers of the jaw

| Identifiers | Description |
|---|---|
| Nasal septum patterns | The features of deviation |
| Symmetry of maxillary sinus | Symmetry of the shape of bilateral maxillary sinus |
| Maxillary sinus floor | The height of the maxillary sinus floor |
| Symmetry of condylar process | Symmetry of the shape of bilateral condylar process |
| Sigmoid notch | The depth of the sigmoid notch |

**TABLE 4** Pathological identifiers of the jaw

| Identifiers | Description |
|---|---|
| Osteomyelitis | Inflammation of the jaw caused by infection |
| Jaw fracture | A break or rupture in the jaw bone |
| Space-occupying lesion | Space-occupying lesion of the jaw |
| Jaw defect | An imperfection or absence in the jaw |
| Cleft palate | Congenital fissure of the palate |
| Orthodontics | The supervision, guidance, and correction of dentofacial structures |
| Orthognathic surgery | The treatment of malposition of the jaw bone |
| Jaw surgery | Jaw surgery (except for orthognathic surgery) |
| Idiopathic osteosclerosis | A hardening or abnormal density of bone |

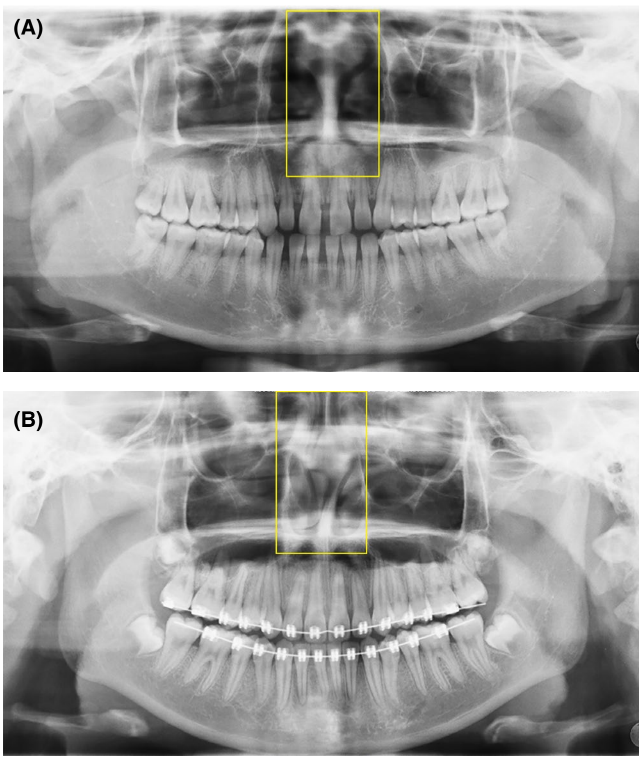


**FIGURE 1** The nasal septum patterns were classified into (a) straight and (b) deviated [Color figure can be viewed at wileyonlinelibrary.com]

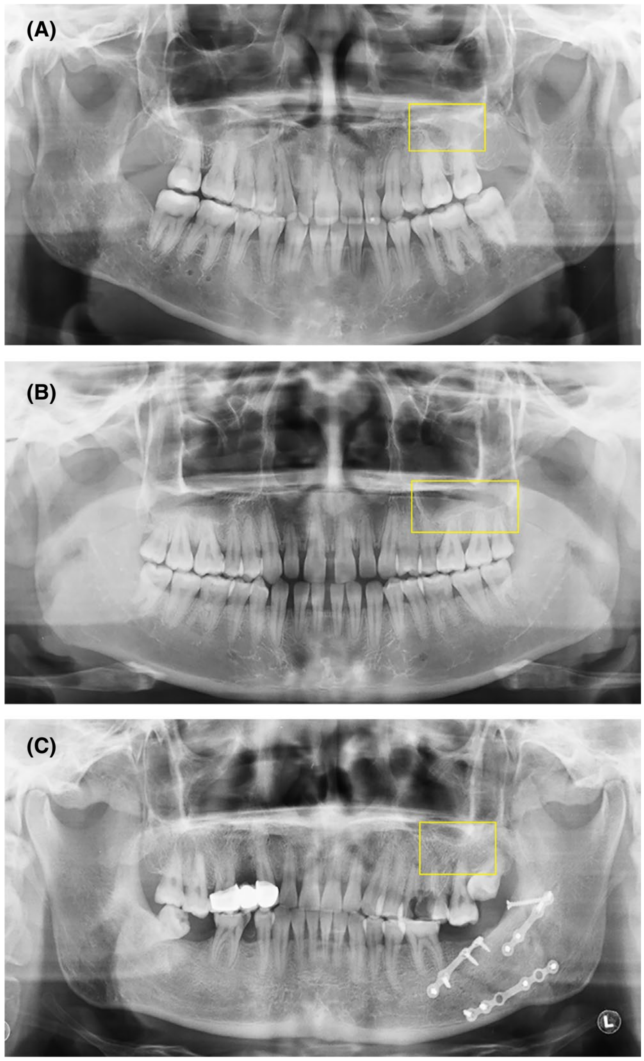


**FIGURE 2** The height of the maxillary sinus floor (MSF): (A) type 1, the root apex protruded into the maxillary sinus; (B) type 2, the root apex was located in contact with the MSF; and (C) type 3, the root apex was below the MSF [Color figure can be viewed at wileyonlinelibrary.com]

identifier, then this AM image is more likely to be the corresponding image of the PM image. The advantage of using anatomical identifiers is their high level of uniqueness. In the present study, 18 specific identifiers were determined, 9 of which were related to the morphology, position, and number of teeth. This is similar to the results from the study conducted by Angelakopoulos et al., in which clinically detectable dental identifiers (CDDIs) relating to morphology would found to be more specific than treatment properties [23]. However, in their study, some morphological identifiers were not included, such as root morphology. Although some pathological identifiers in the present study are also specific, their stability is relatively poor and might change with the progression of disease. This should be considered when applying these identifiers, which are preferably applied in conjunction with others. Note that, in this study, some dental identifiers might be overvalued because the sample was collected mostly from orthodontic, orthognathic, and surgical patients, in which rotated and displaced teeth and root resorption were more common and residual root and attrition were relatively fewer. In addition, when we apply these identifiers, the tooth position should be considered as well.

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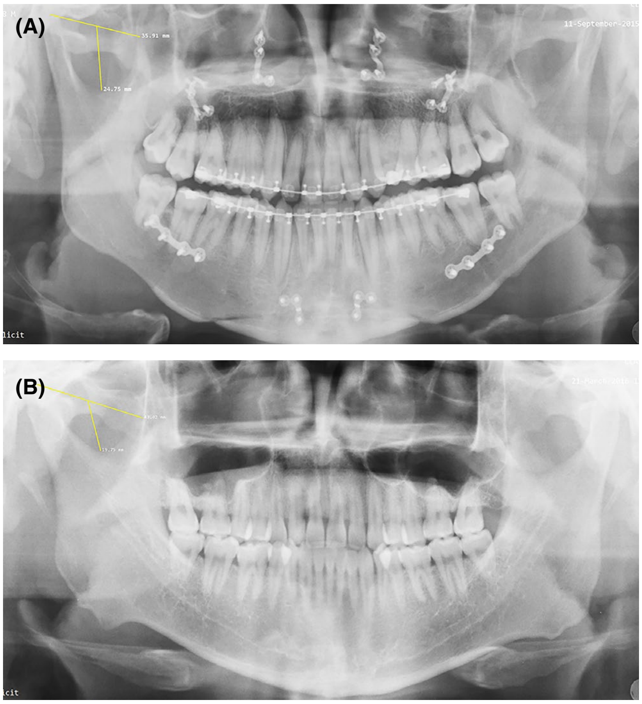


FIGURE 3 The depth of the sigmoid notch was recorded as (A) deep and (B) shallow. (A) The distance from the lowest point of the sigmoid notch to the midpoint of the line between the most superior points of the condyle and coronoid was greater than half of the line between the two most superior points. (B) The distance from the lowest point of the sigmoid notch to the midpoint of the line between the most superior points of the condyle and coronoid was less than or equal to half of the line [Color figure can be viewed at wileyonlinelibrary.com]

In the present study, we took morphological and pathological identifiers of the jaw bone into consideration. Nasal septum patterns have been proven in several studies to be useful for human identification. Verma K et al found a straight nasal septum pattern in almost 41.25% of individuals, followed by occurrences of left deviation, right deviation, sigmoid, and reverse sigmoid [19]. These findings were different from those of a study by Taniguchi M et al., which concluded that straight nasal septum not the most common pattern in individuals [24]. Although the nasal septum patterns are not defined as specific identifiers in this study, there is also a certain difference in the frequency of occurrence between the straight and deviated patterns. The straight nasal septum pattern was seen in almost 89.35% of individuals. For the height of the maxillary sinus floor, several researchers have proposed different classification methods according to the relationship of the molar root with the MSF, some of which were based on cone-beam computed tomography (CBCT). For instance, Choi et al categorized this configuration into four types and concluded that type 3 (with at least one root protruding to the sinus floor) is the most common relationship [25]. Zhang et al. categorized it into five types and reported that the most common arrangement was an MSF located above the connection between the buccal and palatal root apices [26]. These results may be impacted by criteria for patient selection, radiographs used for

TABLE 5 The number and percentage of potential databases and the number of selected PM records and the ratio of co-occurrences in the AM and PM databases of each identifier related to dental morphology, number, and position

| Dental identifiers | Potential database | Percentage[a] | Number (PM) | Ratio[b] (%) |
|---|---|---|---|---|
| Retained deciduous tooth | 6 | 1.304 | 4 | 0.011 |
| Supernumerary teeth | 13 | 2.826 | 10 | 0.061 |
| Rotation | 54 | 11.739 | 46 | 1.174 |
| Horizontal impaction | 23 | 5.000 | 23 | 0.250 |
| Vertical impaction | 49 | 10.652 | 47 | 1.088 |
| Buccal/lingual impaction | 21 | 4.565 | 19 | 0.188 |
| Mesial impaction | 120 | 26.087 | 111 | 6.295 |
| Distal impaction | 97 | 21.087 | 93 | 4.263 |
| Inverted impaction | 8 | 1.739 | 5 | 0.018 |
| Macrodontia | 0 | 0 | 0 | 0 |
| Microdontia | 18 | 3.913 | 16 | 0.136 |
| Fused tooth | 0 | 0 | 0 | 0 |
| Gemination | 0 | 0 | 0 | 0 |
| Dens evaginatus | 0 | 0 | 0 | 0 |
| Enamel pearl | 0 | 0 | 0 | 0 |
| Taurodontism | 0 | 0 | 0 | 0 |
| Talon cusps | 0 | 0 | 0 | 0 |
| Dens invaginatus | 0 | 0 | 0 | 0 |
| Mesial deflection of the tooth root | 14 | 3.043 | 14 | 0.092 |
| Distal deflection of the tooth root | 6 | 1.304 | 6 | 0.017 |
| Labial/lingual deflection of the tooth root | 0 | 0 | 0 | 0 |
| S-shaped deflection of the tooth root | 5 | 1.087 | 5 | 0.012 |
| Malposition | 9 | 1.957 | 9 | 0.038 |
| Transversion | 0 | 0 | 0 | 0 |

[a]Percentage = $\frac{\text{Potential database}}{\text{Total number of AM records}} \times 100$

[b]Ratio (%) = $\frac{\text{Potential database}}{\text{Total number of AM records}} \times \frac{\text{The number of selected PM records}}{\text{Total number of PM records}} \times 100$

**TABLE 6** The number and percentage of potential databases and the number of selected PM records and the ratio of co-occurrence in the AM and PM databases of each identifier related to dental treatment and pathology

| Dental identifiers | Potential database | Percentage | Number (PM) | Ratio (%) |
|---|---|---|---|---|
| Caries | 55 | 11.956 | 51 | 1.326 |
| Attrition | 8 | 1.739 | 8 | 0.030 |
| Hypercementosis | 2 | 0.435 | 2 | 0.002 |
| Cementoma | 2 | 0.435 | 2 | 0.002 |
| Residual root | 15 | 3.260 | 15 | 0.106 |
| Root resorption | 17 | 3.700 | 17 | 0.137 |
| Hemisection | 0 | 0 | 0 | 0 |
| Pulp calcification | 7 | 1.522 | 7 | 0.023 |
| Apical periodontitis | 34 | 7.391 | 35 | 0.562 |
| Periapical condensing osteitis | 0 | 0 | 1 | 0 |
| Enamel hypoplasia | 0 | 0 | 0 | 0 |
| Dentinogenesis imperfecta | 0 | 0 | 0 | 0 |
| Filling | 181 | 39.348 | 188 | 16.081 |
| Root canal treatment | 134 | 29.130 | 137 | 8.676 |
| Full crown | 40 | 8.700 | 39 | 0.737 |
| Post-and-core crown | 28 | 6.087 | 28 | 0.371 |
| Continuous crown | 3 | 0.652 | 3 | 0.004 |
| Implant | 15 | 3.261 | 22 | 0.156 |
| Fixed bridge | 24 | 5.217 | 27 | 0.306 |
| Removable partial dentures | 0 | 0 | 0 | 0 |
| Single complete denture | 0 | 0 | 0 | 0 |
| Complete denture | 0 | 0 | 0 | 0 |

**TABLE 7** The number and percentage of potential databases and the number of selected PM records and the ratio of co-occurrence in the AM and PM databases of each morphological identifier of the jaw

| Identifiers | Potential database | Percentage | Number (PM) | Ratio (%) |
|---|---|---|---|---|
| Nasal septum patterns | | | | |
| Straight | 411 | 89.348 | 411 | 79.830 |
| Deviation | 49 | 10.652 | 49 | 1.135 |
| Symmetry of the maxillary sinus | | | | |
| Symmetric | 311 | 67.609 | 311 | 45.709 |
| Asymmetric | 149 | 32.391 | 149 | 10.492 |
| Symmetry of the condylar process | | | | |
| Symmetric | 370 | 80.435 | 370 | 64.698 |
| Asymmetric | 89 | 19.348 | 89 | 3.743 |
| Maxillary sinus floor | | | | |
| Left | | | | |
| Type 3 | 56 | 12.174 | 56 | 1.482 |
| Type 2 | 60 | 13.043 | 60 | 1.701 |
| Type 1 | 343 | 74.565 | 343 | 55.600 |
| Right | | | | |
| Type 3 | 74 | 16.087 | 74 | 2.588 |
| Type 2 | 51 | 11.087 | 51 | 1.229 |
| Type 1 | 331 | 71.957 | 331 | 51.777 |
| Sigmoid notch | | | | |
| Left | | | | |
| Deep | 226 | 49.130 | 226 | 24.138 |
| Shallow | 228 | 49.565 | 227 | 24.459 |
| Right | | | | |
| Deep | 226 | 49.130 | 226 | 24.138 |
| Shallow | 227 | 49.348 | 227 | 24.352 |

identification, and the specific human race. In the present study, the MSF height was classified into three types, which could be observed in PRs, and the most common relationship was type 1.

Although two-dimensional images have some influence on the evaluation of some morphological identifiers, when the same position in exposure is adopted, these identifiers can be kept consistent. The PM radiographs should be taken in as close a recreation of the AM anatomic position as possible. To take a PR, the jaws were positioned in normal occlusion on a level surface. The position of the incomplete jaws was secured with adherent wax, tape, and soft paper as necessary [27].

In comparative human identification, PM evidence is often acquired from fragmented, burned, and decomposed human remains, which means that only partial PM identifying information is available. Therefore, further research is necessary to validate the availability of the presented outcomes in individual identification. Additionally, with the improvement in recent technology, many researchers have investigated the method of tooth recognition on radiographic images through deep learning of artificial intelligence [15,16]. Therefore, the applicability and usefulness of outcomes in coding and data matching systems should also be taken into consideration. The implementation of specific identifiers would contribute to improving the matching speed of unknown individuals in real casework.

## 5 | CONCLUSION

According to the present study, it can be concluded that identifiers of the teeth and jaw can be used for human identification and

**TABLE 8** The number and percentage of potential databases and the number of selected PM records and the ratio of co-occurrence in the AM and PM databases of each pathological identifier related to the jaw

| Identifiers | Potential database | Percentage | Number (PM) | Ratio (%) |
|---|---|---|---|---|
| Osteomyelitis | 2 | 0.435 | 2 | 0.002 |
| Jaw fracture | 42 | 9.130 | 41 | 0.814 |
| Space-occupying lesion | 58 | 12.609 | 58 | 1.590 |
| Jaw defect | 26 | 5.652 | 26 | 0.319 |
| Cleft palate | 0 | 0 | 0 | 0 |
| Orthodontics | 181 | 39.348 | 121 | 10.350 |
| Orthognathic surgery | 160 | 34.783 | 167 | 12.628 |
| Jaw surgery | 64 | 13.913 | 72 | 2.178 |
| Idiopathic osteosclerosis | 27 | 5.870 | 27 | 0.345 |

that identifiers relating to dental morphology and pathology offer greater discriminatory value than identifies of jaw.

## ETHICAL APPROVAL

This work was performed in compliance with ethical standards.

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