Age Determination in the Juvenile

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Introduction

Age determination is a principal element in both anthropological and archaeological investigations (Cattaneo 2009a). It is generally assessed through the analysis of maturational milestones that manifest in the skeleton and dentition. Indicators of skeletal maturity can be used in both clinical and forensic examinations to assess developmental status; from this, chronological age may be inferred (Lewis and Rutty 2003). In a forensic context, the estimated age at death of the deceased constitutes a fundamental component of the biological profile, which is used by anthropologists to narrow the range of potential matches during the process of identification (Scheuer and Black 2007). Indeed, when presented with juvenile remains, the age at death is often the only biological parameter that can be determined with any degree of accuracy (Scheuer and Black 2000). However, age determination is not limited to situations involving individuals who are deceased and can also be utilized to assess age in the living (Cattaneo 2009b). This can be important in certain judicial circumstances, when authorities require age to be established to determine an appropriate course of action (Lewis and Rutty 2003). Such circumstances can be civil or criminal and can include cases involving pedopornography; sex with a minor; lack of legitimate identification; and criminal culpability (Lewis and Rutty 2003; Cunha et al. 2009). Age determination can also be important in clinical cases for the diagnosis of pathological versus normal growth and development (Scheuer and Black 2000). This chapter provides a review of the literature that has addressed age determination in the juvenile skeleton for the purposes of the objectives mentioned. This includes a discussion of the increasingly sophisticated investigative methods employed in juvenile age assessment combined with an evaluation of the accuracy and limitations inherent in the utility of these techniques.

Prior to discussion of the recent juvenile age assessment literature, it is appropriate to define the developmental boundaries addressed. The term *juvenile* refers to a minor and, for the purposes of this chapter, encompasses all subadult stages of maturation. In the literature, the juvenile life span is commonly divided into the following developmental phases: prenatal (prior to birth); infancy (birth to 1 year); childhood (1 year to adolescence or puberty); and adolescence (Ritz-Timme et al. 2000; Scheuer and Black 2004). In the United Kingdom, the age of 18 years is the threshold that legally defines adult status; therefore, this chapter only considers the age assessment literature dealing with individuals below this age. Details regarding postadolescent events are described in Chapter 2.

Trends in the Literature

The common methods available for juvenile age assessment are perfunctorily discussed in textbooks on the general subject of forensic anthropology (Scheuer and Black 2007; Lewis 2007; Cattaneo 2009a) and in numerous reviews (Ritz-Timme et al. 2000; Schmeling, Olze, et al. 2004; Schmeling, Reisinger, et al. 2006; Schmeling et al. 2007; Konigsberg et al. 2008; Cunha et al. 2009; Franklin 2010). Such texts, particularly the concise contributions by Saunders (2000), Scheuer and Black (2007), Cattaneo (2009a; 2009b), Cunha et al. (2009), and Franklin (2010), provide general overviews of the area and are useful as summaries for both students and practicing anthropologists. However, the remaining majority are repetitive and simply reiterate information previously available. For example, certain articles combine the discussion of techniques available for adult and juvenile material without providing an adequate coverage of the range of techniques specific to juveniles (Ritz-Timme et al. 2000; Schmeling, Reisinger, et al. 2006; Schmeling et al. 2007). Fortunately, core texts have been produced that go some way to alleviate this inadequacy in the anthropological literature (Scheuer and Black 2000, 2004; Baker et al. 2005; Schaefer et al. 2009).

The majority of work that has been performed in relation to the chronology of skeletal development is outwith the present text's 10-year scope. Therefore, for a comprehensive overview of the work before 2000, readers are directed to the seminal text by Scheuer and Black (2000), which provides a detailed account of skeletal development and includes an extensive compilation of the juvenile ageing literature encompassing work carried out over the 300 years preceding its publication.

In recent years, as a result of escalating trends in global mobility, immigration, and asylum, it has become increasingly pertinent to assess whether individuals have reached the threshold age that signifies legal adulthood (Schmeling et al. 2007). This can be important because some countries do not have central systems documenting dates of birth or individuals may attempt to falsify their age to receive beneficial treatment in criminal or civil cases. Consequently, radiological assessment directed toward the adolescent and young adult age range has become a prominent area of investigation (Schulze et al. 2006; Meijerman et al. 2007; Ríos et al. 2008; Schmidt, Baumann, et al. 2008; Baumann et al. 2009; Cardoso and Severino 2009; Ríos and Cardoso 2009). The majority of the literature in relation to this has been produced by the Arbeitsgruppe Forensische Altersdiagnostik (AGFAD), a multidisciplinary international research group founded in Germany in 2000 (Schmeling, Olze, et al. 2004; Schmeling, Schulz, et al. 2004; Schmeling et al. 2005, 2007; Schmeling, Baumann, et al. 2006; Schmeling, Reisinger, et al. 2006; Schulz et al. 2005; Muhler et al. 2006; Meijerman et al. 2007; Schmidt et al. 2007; Schmidt, Baumann, et al. 2008; Schmidt, Koch, et al. 2008; Schmidt, Nitz, et al. 2008; Baumann et al. 2009). The goal of AGFAD is to establish standard practices for applying forensic ageing techniques (Schmeling et al. 2007); however, this may be difficult to achieve considering that legal age thresholds vary between countries. Other prominent researchers working in the area of juvenile age assessment are involved in improving the current methods of age assessment by applying discriminant statistical treatments (Cameriere et al. 2006; Cameriere and Ferrante et al. 2008) or by investigating skeletal timings in specific populations (Schaefer and Black 2005, 2007; Rissech et al. 2008; Schaefer 2008; Cardoso 2008a, 2008b; Cardoso and Severino 2009; Coqueugniot and Weaver 2007).

Skeletal Maturation

Skeletal maturation is a relatively reliable indicator of growth and development that has resulted in well-documented patterns of skeletal development in relation to chronological age. Age assessment from the skeleton relies on specific changes that occur as an individual matures and progresses through a distinctive series of maturational milestones. These changes are relatively stable and predictable and involve the appearance of primary and secondary ossification centers, morphological changes in size and shape of these centers, and finally fusion of these centers, resulting in the attainment of adult form (Scheuer and Black 2000; 2004; Schaefer et al. 2009).

Skeletal Age Assessment in Fetal and Neonatal Specimens

Age evaluation of the fetus and neonate places heavy emphasis on the number of primary ossification centers present and their location (Degani 2001). The majority of primary centers of ossification appear during the embryonic and fetal periods (Scheuer and Black 2000); however, there are inherent difficulties associated with assessing age in the prenatal period because the timing of conception can be difficult to determine. Therefore, the date of the last menstrual period (LMP) is usually selected as the preferred indicator to predict the date of birth and therefore the potential *in utero* age of the fetus (Taipale and Hiilesmaa 2001). Knowledge of the sequence of appearance of ossification centers permits the investigator to assign a “most likely” age based on those centers present compared to those not yet developed (Scheuer and Black 2000, 2004; Schaefer et al. 2009).

A number of methods that can be utilized to determine the appearance of ossification centers in fetal remains and the accuracies and subsequent reported timings of appearance vary depending on the technique applied (Scheuer and Black 2000). The most precise method is reported to be histological sectioning, which although little reported in the modern literature, has provided fundamental knowledge regarding the appearance times of ossification centers. A contemporary study applying histomorphomentry evaluated the proximal femoral metaphysis and considered its implications on providing information regarding fetal bone development (Salle et al. 2002). Alizarin staining is a further technique that was heavily used in the seminal juvenile ageing literature and involved destroying the soft tissues with potassium hydroxide and then applying the stain to visualize the skeletal material (Scheuer and Black 2000). Use of this technique is not reported in the recent literature, most likely due to advances in nondestructive imaging modalities, which allow for a comprehensive assessment of skeletal development without the requirement to remove the soft tissues. Radiographic techniques have proved to be particularly useful for the purposes of ageing the juvenile skeleton and continue to be used along with other more modern nondestructive imaging techniques (Sherwood et al. 2000; Taipale and Hiilesmaa 2001; Salpou et al. 2008). The suite of imaging modalities available for the assessment of ossification status includes radiography, computed tomography (CT), magnetic resonance imaging, and ultrasonography (Bilgili et al. 2003; Laor and Jaramillo 2009). Radiographic imaging has often been used for age assessment in fetal and neonatal individuals; however, this modality has significant limitations as the appearance of ossification centers tends to precede radiographic visualization. This is due to the degree of mineralization of a particular bone being insufficient for appropriate visualization during the initial stages of ossification (Scheuer and Black 2000). For age estimation in the living, ultrasound is now the preferred mode of imaging to capture the developmental stage of individual bones as it does not risk exposing the fetus to harmful radiation (Taipale and Hiilesmaa 2001; Salpou et al. 2008).

Traditionally, skeletal age estimation has been concerned with dry bone analyses of human remains, and it would be remiss to review juvenile age assessment without including the significant early contributions to the area by Stevenson (1924), Todd (1937), and Stewart (1934). However, the forensic utility of juvenile age estimation from dry bone is variable, depending on the age of the individual and the particular skeletal element examined (Scheuer and Black 2007). Because ossification centers initially develop as small, nonspecific nodules, these are unlikely to be recovered or be of particular significance until they have reached a distinguishable morphology (Lewis and Rutty 2003).

The most significant study of fetal dry bone material was performed by Fazekas and Kosa (1978), who studied 136 fetuses and correlated gestational age to ossification stage using metric measurements. There are problematic issues with the sample utilized in this study because a number of the specimens were naturally aborted and may therefore have had developmental defects (Scheuer and Black 2000). Specimens were also of undocumented gestational age, which was estimated based on crown-rump length. Despite these issues, the data collected regarding osseous development are still of significant value in modern forensic practice (Scheuer and Black 2000). Recent methods applying CT and plain plate radiography have been initiated in an attempt to validate the seminal metric data produced by Fazekas and Kosa (Nemzek et al. 2000; Adaline et al. 2001; Piercecchi-Marti et al. 2002). Additional, dry bone studies have also assessed the dimensions of certain skeletal elements, such as the atlas and axis for the determination of age with encouraging results (Castellana and Kosa 2001).

Skeletal Age Estimation of Infants, Children, and Adolescents

Prior to discussion of the age assessment literature for infants, children, and adolescents, it must be acknowledged that different skeletal maturation rates are exhibited between the sexes, with females having an accelerated maturation rate over males throughout the entire juvenile period (Molinari et al. 2004).

A major focus of recent research has been directed toward the assessment of age from radiographic atlases. This work has built on the longitudinal radiographic studies of the mid-20th century, which documented growth in living individuals by assessing the developmental status of the bones in the hand and wrist (Greulich and Pyle 1959; Tanner et al. 1962, 1975). These can be broadly divided into two categories: those that require direct visual matching of an x-ray to a representative standard (Greulich and Pyle 1959) and those that involve the use of a cumulative scoring system (Tanner et al. 2001). Direct comparison methods are relatively straightforward to use and rely on skeletal atlases illustrating the most representative radiograph for a particular age. Radiographic scoring methods involve assigning each skeletal element a numeric score based on the assessment of size and morphology. The sum of these is then used to calculate a total maturity score, which further corresponds to a particular age. Radiological techniques have inherent methodological issues, such as noted by Scheuer and Black (2000) that atlases inherently include the order of fusion, which can be variable, and an examiner may incorrectly categorize an age as a result of this. Scoring methods eliminate this problem but are more onerous to use (Scheuer and Black 2000) and have limitations due to the degree of subjectivity involved in assigning a categorical value to the continuous process of growth. The most recent revision to the Tanner and Whitehouse method, termed "TW3," was published by Tanner et al. in 2001. This version used more recent information from European children to allow secular changes that occurred in the time that had passed since the first editions to be addressed. It is argued that TW3 is more reliable than the previous Tanner Whitehouse versions for use in forensic identification as it is based on a more contemporary population (Bertaina et al. 2007).

The development of these radiographic atlases was originally intended for the clinical purpose of establishing normal skeletal development in relation to age for detecting growth disturbances. However, they have also proved to be invaluable within the forensic field (Cattaneo 2009b). Recent research has shown that the Greulich and Pyle atlas approach is poor at recognizing racial differences in growth patterns (Zhang et al. 2009), thus suggesting that alternative data should be developed for different populations. Indeed, this has been acknowledged, and in the past decade numerous studies have produced population-specific data (Koc et al. 2001; Mora et al. 2001; Van Rijn et al. 2001; Krailassiri et al. 2002; Lewis et al. 2002; Garamendi et al. 2005; Lynnerup et al. 2008). An ultrasonographic version of the Greulich and Pyle atlas has also been produced that has been shown to be highly correlated and a valid alternative to plain radiography for bone age estimation (Bilgili et al. 2003).

Population-specific studies have also been performed for the Tanner Whitehouse methods (Dvorak et al. 2007; Ortega et al. 2006; Nig et al. 2007; Ashizawa et al. 2005; Freitas et al. 2004; Ranjitkar et al. 2006). In addition, further atlases of hand-wrist skeletal development have been developed (Gilsanz and Ratib 2005; Cameriere et al. 2006); however, the suitability of some of these methods for forensic age estimation has been suggested to be limited

(Schmidt et al. 2009). There is continued research aimed at developing a more accurate and simplistic system that also reflects the growth and maturation parameters as evidenced on a modern population (Schmidt, Baumann, et al. 2008; Zhang et al. 2009). This has involved the attempted automation of the Tanner Whitehouse system (Bocchi et al. 2003; Aja-Fernandez et al. 2004).

Other skeletal areas have also been investigated recently in terms of their utility for age assessment from a radiographic scoring system or atlas; these include the foot (Whitaker et al. 2002) and knee (O'Connor et al. 2008). In addition, further studies have also attempted to compare methods of age assessment using different areas of the skeleton (Aicardi et al. 2000). Radiographic assessment has also been applied to investigate the correlation between chronological age and cervical vertebral maturation (CVM) by the CVM method, which assesses change in the shape of the cervical vertebral bodies with increasing age (Baccetti et al. 2005, 2006). Many of these studies have correlated CVM with hand-wrist skeletal maturity indicators. Such studies have demonstrated that CVM is a valid indicator of skeletal growth during the circumpubertal period and has a high correlation with hand-wrist maturity (Chang et al. 2001; Mito et al. 2002; Grave and Townsend 2003; Flores-Mir et al. 2006; Gandini et al. 2006; Kamal and Goyal 2006; Alkhal et al. 2008; Lai et al. 2008; Soegiharto et al. 2008; Stiehl et al. 2009; Wong et al. 2009).

Much work has also concentrated on the assessment of epiphyseal fusion times on dry bone populations. It has been acknowledged that different epiphyses have different fusion and formation rates, with those that develop and fuse within a short time frame being of higher forensic utility (Scheuer and Black 2007). Caution has been advised when ageing using epiphyseal fusion times as epiphyses may not survive inhumation, and taphonomic damage can mean that stages of epiphyseal fusion may not be distinguishable (Lewis and Rutty 2003). Patterns of epiphyseal fusion have been extensively studied for various populations, including a Bosnian male population (Schaefer and Black 2005, 2007; Schaefer 2007, 2008); Portuguese populations (Coqueugniot and Weaver 2007; Cardoso 2008a, 2008b; Cardoso and Severino 2009; Rios and Cardoso 2009); and European American, African American, and Mexican American populations (Crowder and Austin 2005).

Further studies have examined the closure times of the sutures, fontanelles, and other growth areas within the skull to determine their use in age estimation. Such studies are beginning to produce data that contradicts previous knowledge in the ageing literature. Examples include the finding that normal or physiologic closure of the metopic suture occurs much earlier than had been described previously (Vu et al. 2001). A further study has examined the closure times of the foramen of Huschke, concluding that the previously reported chronology of closure times in the literature are erroneous (Humphrey and Scheuer 2002). In addition, the state of fusion of the basilar synchondrosis as an indicator of age has demonstrated that the stage of fusion is not a good indicator of age in males, while in females the feature could be useful when estimating age of unknown human remains (Kahana et al. 2003).

A further developing area within the arena of juvenile age assessment involves the application of morphometrics and procrustes-based geometric morphometrics. Morphometric studies examining the growth of ilium, ischium, and pubis using simple metric measurements have demonstrated age-related patterns that can be applied to subadult age determination (Rissech et al. 2003; Rissech and Malgosa 2005, 2007). Additionally, morphometrics have been used to document the development of the femur and scapula from the neonatal period through to skeletal maturity, which proves useful in the prediction of age at death (Rissech et al. 2008; Rissech and Black 2007). Furthermore, diaphyseal lengths from long-bone measurements have been reviewed for the purposes of age assessment and build on the large pre-2000 literature base of long-bone metrics (Smith and Buschang 2004, 2005).

Further sophisticated, procrustes-based geometric morphometric techniques are beginning to enable the quantification of size and shape variation within juvenile skeletal remains and have been useful for age estimation (Braga and Treil 2007; Franklin and Cardini 2007; Franklin et al. 2008). These studies have produced age-related data for three-dimensional cranial size changes (Braga and Treil 2007), mandibular morphology (Franklin and Cardini 2007; Franklin et al. 2007, 2008), and cervical vertebrae shape (Chatzigianni and Halazonetis 2009). As data produced using these modern methods are considered to be less subjective than those based on visual scoring systems, related studies investigating other areas of the developing skeleton are becoming increasingly popular for application to forensic anthropology (Franklin 2010).

Common Issues in Juvenile Skeletal Age Estimation

A major problem associated with both dry bone and radiographic methods of estimating juvenile age is the reference material utilized for comparative purposes (Usher 2002). There are only a limited number of collections of juvenile remains, and some of these are of undocumented age; many are of specific, noncontemporary populations (Usher 2002; Lewis and Rutty 2003). Only a limited number of population-specific studies have been performed (Schaefer 2008). Similarly, standard radiographic atlases have been created using data retrieved from growth studies on subjects from the middle of the 20th century (Greulich and Pyle 1959; Tanner et al. 1975). The applicability of such data to modern populations is arguable as secular changes in nutrition and health status can influence growth and development (Scheuer and Black 2007). Standard atlases rely on data gathered from predominantly white, middle-class individuals from a specific population, so again these will not be directly comparable with other populations. Radiographic and dry bone methods are also not directly comparable, with radiography of living individuals giving different timings for both appearance and fusion of centers than those reported on dry bone. As a result, there may be discrepancies between these times and the two modalities (Coqueugniot and Weaver 2007; Schaefer 2008). In addition, many of the radiographic and prenatal studies are nonreproducible in the modern era due to ethical considerations.

The difficulties with some modern approaches to ageing juvenile individuals can be demonstrated through the critical evaluation of such a study. Schmeling et al. (2003) described the age assessment of 247 immigrants who lacked valid identification to determine whether the individuals required legal treatment as an adult or as a minor. On the basis that 41 cases allowed verification to within ±12 months, the authors concluded that age estimation was sufficiently reliable for legal purposes. However, when dealing with a narrow legal time frame, this error margin is not sufficiently narrow to distinguish accurately between minors and adult individuals. This article has been criticized in other respects as it not only lacks detail other than a brief overview of the procedures utilized, but also, importantly, it was impossible to evaluate the accuracy of results for the majority of cases (Clarot et al. 2004). Therefore, the reliability of estimations performed can be contested. The authors acknowledged that, for many migrant subjects, there is a lack of population-specific standards available for comparative purposes but dismissed ethnicity as a factor that could lead to over- or underestimations of age (Schmeling et al. 2003; Schmeling, Olze, et al. 2004). Schmeling and colleagues (2003) recognized that differences in socioeconomic circumstances can influence the rates of skeletal maturation but justified that, because the individuals originated from less-developed populations, the estimated ages would be underestimated and therefore not disadvantageous. The fallacy in such an approach is that there are legal instances, such as criminal cases involving pedopornography or sex with a minor, in which underestimations of age could have potentially devastating effects.

Skeletal versus Dental Age Assessment

The relationship between skeletal and dental age assessment has been well recognized; in general, it is accepted that although the skeleton is more likely to display retardation as a result of disadvantageous circumstances, the dentition seems to be better protected and is less affected. This has resulted in greater emphasis being placed on the reliability of dental ageing compared to skeletal ageing, especially when the ethnographic profile of the individual is unknown. Age evaluation in the living has unquestionably dominated the ageing literature of the last decade, and the proposed method for an age assessment utilizes a combination of both dental and skeletal age. It has been accepted that if the socioeconomic gradient is sufficiently unbalanced, then dental development can also be impaired. This topic is discussed at some length and has been summarized in a recent text (Black et al. 2010; Cameriere and Ferrante 2008; Cardoso 2007; Flores-Mir et al. 2005; Franklin 2010; Kanbur et al. 2006; Kimmerle, Jantx, et al. 2008; Kimmerle, Prince, and Berg 2008; Krailassiri et al. 2002; Matrille et al. 2007; Sahin Saglam and Gazilerli 2002; Sciulli 2007; Uysal et al. 2004).

The assessment of age in the living has been dominated by the aforementioned AGFAD research group (see all references related to Baumann, Schmeling, Schmidt, Schulz, and Olze), but there are an increasing number of studies that examine this specific area of legal age evaluation (Cameriere and Brcic et al. 2008; Cattaneo et al. 2009; Cunha et al. 2009; Nuzzolese and Di Vella 2008; Solheim and Vonen 2006; Stathopulu et al. 2003).

This subject is also discussed in some length in Chapter 2 as the important legal boundary between childhood and adulthood is 18 years of age, and this is a time of little demarcation in both skeletal and dental age.

Dental Age Assessment in the Juvenile

Age estimation from the juvenile dentition is based on a number of premises: (a) that all the teeth will erupt and grow, (b) that the teeth will erupt and grow in a prescribed sequence, and (c) that sequence can be correlated with the chronological age of the individual. Age techniques need not rely on imaging technology, for example, when counting the number of teeth present in the mouth. However, there is little doubt that the utilization of radiographic imaging (flat plate and CT) is particularly important in assessing the calcification of the tooth, its eruption process, and its maturation. That there are so many stages in the development of a tooth and that there are up to 20 deciduous and 32 adult teeth in the lifetime of the individual lends itself particularly well to rigorous statistical evaluation with regard to age estimation. With the additional benefit that dental growth seems to be protected from insults compared to skeletal development, there is no doubt that this is a viable and powerful tool for age estimation.

Much of the earlier work is well established, and a considerable proportion of the literature over the last 10 years has concentrated on two particular aspects: testing the reliability of the core techniques compared to other approaches and testing them on different ethnic populations. The consensus seems to be that the core techniques perform well on different populations, indicating their robusticity, but that the small variations may be sufficient to warrant ensuring that a wide age range is offered when age assessment is undertaken on individuals of unknown ethnic origin. The literature on this subject is extensive, so we have chosen to list it in a bibliography rather than intersperse the references in the text.

Identification of age in the early neonatal period has important implications for analysis of the survival period of the child after birth. The identification of a neonatal line in over 90% of all primary teeth and the first permanent molars has proved to be of significant value in assessing the age and time of postbirth survival of the baby. Recent work has concentrated on the morphological structure of the line and the relationship between time and the periodicity of dental microstructure deposition. Although a significant amount of research has been undertaken in the clinical environment, the importance of this topic to human evolution and primate comparative anatomy has also been examined in the current decade.

The Third Molars

Calcification, eruption, and growth of the third molars is one area of dental development that crosses the boundary between juvenile and adult ageing; as a result, it is considered only briefly in this chapter, and further discussion can be found in Chapter 2. A considerable amount of attention has been paid to the eruption and maturation of these molars in the past decade and again specifically to address the issue of age evaluation in the living. Within the dentition, the third molar is the only tooth that has not completed growth by the age of 18 years (an important legal milestone in most countries). There have been many warnings issued in relation to the unreliability or indeed unpredictability of the maturation of this tooth, but it remains one of the mainstays of age estimation in the living because it is one of the few areas readily available for inspection and analysis. Again, for ease in reading, a bibliographic list containing some of the references associated with this topic is included, but Chapter 2 contains further information.

Summary

The majority of research in relation to skeletal maturation was performed in the early and middle portions of the 20th century (Stevenson 1924; Stewart 1934; Todd 1937; Greulich and Pyle 1959; Tanner et al. 1975; Fazekas and Kosa 1978). However, the last decade has seen the production of core texts, including seminal work by Scheuer and Black (2000, 2004) and Schaefer et al. (2009), which provide a useful reference summary of skeletal development and the morphological determination of age. This has been supplemented by research aimed at establishing the growth and development of specific skeletal elements across a series of maturational milestones. It is also clear that a trend of research aimed toward distinguishing the skeletal maturity of legally relevant ages has begun to dominate the juvenile age assessment literature. Furthermore, age determination from the dentition in the past decade has concentrated heavily on evaluation from the living and testing of existing approaches on different populations. It is likely that the research in the area of juvenile age determination will expand markedly over the next decade as researchers strive to apply ever-advancing technologies to gain a better understanding of skeletal and dental development in different populations and relate this to the accurate determination of age in both the deceased and the living.

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