

## Dentition and the Estimation of Sex in Children

Forensic identification plays a crucial role in the success of an investigation and the recovery of a deceased individual in the medico-legal context. The process of identification relies on many different factors such as age and ancestry along with other physical characteristics such as stature and osteological pathology. Arguably one of the most important factors in identification is the estimation of the sex of an individual and it remains to be “one of the most important questions” (Mokrane 851) forensic investigators research. Many of the markings characteristic of sex on bone are prominent on adult skeletal remains making it possible to identify these remains in the forensic context. However, not all remains discovered are full grown adults who have fully developed skeletons with sexually dimorphic characteristics. As a result, children’s remains are largely difficult to classify because the estimation of sex in sub-adults is an extremely difficult characteristic to ascertain.

Sexual dimorphism plays a crucial role in the identification process of remains, but as Mokrane writes, “while dimorphism may exist from an early age, it does not reach a sufficiently high level to permit discrimination of the sex until... puberty has arisen” (851). While the focus of sex estimation is usually on the physical characteristics of the pelvis and skull, these methods have not proven to be as useful to the identification of children as they are in adults. This is because the pelvis and skulls of young children have not yet gone through puberty and as a result, the pelvises of young girls look strikingly similar to boys. This is largely because the pelvis of a female child has not yet gone through puberty, thereby not receiving the needed levels of estrogen to widen the pelvis in anticipation of birth. Her narrow pelvis will look strikingly similar to her male counterpart. Likewise, the skulls of young boys will present themselves as female because the robust, characteristically male features of the skull have not yet had the chance to develop.

Sexual dimorphism is key to the identification process in the forensic context. This is how forensic investigators narrow down the identification of the individual because it removes half of the population of possible individuals. This is exactly why it is extremely important for scientists to develop ways in which the sex of young, pre-pubescent children can be estimated. Scientists have been exploring and testing many different methods that could help to properly estimate the sex in these young children. Many of these methods surround ideas that are already in place to estimate the sex in adult remains. Not surprisingly, many of these methods have ended inconclusively or proven to not be effective on the remains of young adults. The focus of sex estimation in prepubescent children should move from methods similar to those used on adults of studying the features of the pelvis, skull, and mandible to that of dentition in order to improve the estimation process for accurate identification in the medico-legal context.

Dentition tells forensic scientists a good deal of information about the remains of the individual and can typically accurately estimate the age of the individual. Based on certain tooth styles, it can also estimate ancestral affinity. It is not an uncommon practice of forensic investigators to procure dental records of the deceased individual in order to help identify individuals if they have received recent dental care in their adult lives. Though this practice is only useful in cases where the individual has recent records of dental care or history. Forensic investigators are able to use teeth as evidence because of the fact that teeth are composed of hard, durable tissue that can endure extreme external environmental hazards and still have the ability to give the forensic investigator important information regarding the deceased individual that can be extremely helpful in the identification process.

Teeth are incredibly durable because of the coating on the external surface, called enamel. Enamel is what helps keep teeth intact which later aids the forensic investigator in the identification process because of its ability to survive harsh external conditions. Enamel is also what protects the important and fragile vessels and nerves that lie below the crown of the tooth in the pulp cavity. Joan Viciano, author of *Sex Estimation Based on Deciduous and Permanent Dentition in a Contemporary Spanish Population*, describes teeth to be “one of the most long-lasting categories of physical evidence of an individual after death due to their hardness, durability, and resistance to postmortem insults” (Viciano 31). This emphasizes the fact that teeth should be utilized in forensic investigations and sex estimation because of this durability and their ability to preserve information about the deceased.

Much like adult teeth, deciduous dentition, also commonly referred to as “baby teeth”, is no exception. This type of dentition, much like adult dentition, has the potential to give forensic investigators helpful information on prepubescent individuals to aid in the identification process. There is evidence of sexual dimorphism found within the physical aspects of dentition itself and the timing of eruption in young children. Before exploring the method of using teeth to aid in the estimation of children’s remains, discussing the different methods of sex estimation currently being researched by scientists on the features of bone suggestive of sexual dimorphism will add to the discussion within the discourse on why teeth are such an important tool in the forensic context.

Traditional methods of sex estimation in adults are extremely difficult to apply to the skeletal remains of children because the characteristics differentiating between male and female have not fully developed before children go through puberty. Scientists have researched these methods on young children and though some of the studies have shown promising results in correctly estimating the sex, these promising results tend to be rare, with the majority of the results being inconclusive or unable to apply to children. These methods typically look at the anatomical features on the cranium, the mandible, and the pelvis. By exploring these different methods and why the results conclude the way that they do, it will help explain why teeth have the potential to play an important role in the identification process of skeletal remains in children.

A good deal of research has been conducted on the characteristics of the cranium and the mandible on the remains of pre-pubescent children. Typically, this is an extremely useful method of sex estimation in adults because sexual dimorphism is so apparent in these specific bones. Males are generally more robust in their markings than females which makes it possible to identify the sex of the set of remains in question based on the features of the cranium and mandible. Pre-pubescent children are a different story because males and females tend to look more similar to one another before they go through puberty. Holger Schutkowski, a German anthropologist at the Institute of Anthropology at Gottigen University, worked to develop a method that would prove that similar aspects of the cranium and mandible examined in adults could be applied to the remains of children and produce accurate results of sex. Schutkowski concluded that male and female mandibles have a specific shape that alludes to their sex. Apparently, females displayed a parabolic-shaped dental arch while males typically displayed a U-shaped dental arch (Schutkowski 200). Schutkowski argued that female canines typically did not protrude from the dental arch towards the premolars like males (201). These characteristics were seen to be an indication of sex linked traits that could aid in the identification of pre-pubescent remains.

Schutkowski also looked at the gonial angle on the mandible. He believed that sex characteristics were displayed on this 90 degree angle of the mandible on children. Schutkowski argued that males typically displayed eversion in their gonial angle, meaning that it would flare out. Females lack this eversion in the angle giving them more of a rounded, smaller appearance (Schutkowski 200). This method is only reliable a small percentage of the time when estimating the sex in adult remains. Therefore, applying this method to children and producing accurate results would be highly unlikely. As was mentioned previously, males and females do not start displaying sex linked characteristics until they have gone through puberty (Broughton 2014). Applying these methods to pre-pubescent children and

expecting accurate results of the sex based on the angle of the mandible is unrealistic because those sex linked characteristics will not be apparent.

Schutzowski expanded his research on sex estimation of children to the pelvis as well. He studied characteristics of the iliac crest and suggested that the crest had a specific shape based on the sex of the individual. Schutzowski believed that male iliac crests display a severe S-shape superiorly while the same characteristic in females was less pronounced (Schutzowski 201). While this might be an indication of sex, using this method would be less than helpful because it is not a characteristic that is pronounced enough to display a difference between the two sexes and ultimately could not provide a proper estimation of sex.

The iliac crest is not the only aspect of the pelvis that he suggests displays sex linked characteristics in children. Schutzowski also looks at other regions of the pelvis that are commonly used in methods of estimating the sex of adult individuals- the sciatic notch. Typically, this characteristic of the pelvic bone suggests female if it is a wide, rounded notch or male if it is narrow and sharp (Schutzowski 201). This method of estimation is highly variable at best in adult skeletal remains. Schutzowski even explains this himself by saying, "Within each sex however there was considerable variation in each of the sex correlated traits, leading to a certain overlap of sex typical appearances" (202). Though it does suggest sex in some individuals, it is highly dependent on the individual and their anatomical make-up and also used in conjunction with other methods. This is not a universal sex determining characteristic that clearly defines male and female every time. That being said, this trait would not be applicable to pre-pubescent children because, before puberty, male and female pelvises are relatively similar. Females have not begun producing the amount of estrogen needed to allow the pelvis to widen in anticipation of birth. This means that prepubescent female pelvises are as narrow as males' and the sciatic notch would look virtually the same making this method unreliable in children.

Pre-puberty is not the only reason why these researched methods are not possible in the accurate estimation of sex in children. It is also important to realize that these traits suggested as methods are highly variable to the individual among full-fledged adults and with children it is even more so. Experienced forensic investigators can only accurately estimate the sex of individuals about 85% of the time based on strong, clearly visible sex-linked characteristics (Broughton 2014) and with children that percentage of accuracy decreases considerably. This is exactly why methods of accurate and successful estimations of the sex of children is an issue that the forensic community has been working to solve for many years.

As a result, Schutzowski is not the first nor the only forensic scientist to argue for the method of studying the pelvis of the remains of pre-pubescent children. Fatima-Zohra Mokrane researched the pelvic ilium of infants using advanced methods of 3-D imagining. Like Schutzowski, Mokrane also looked at aspects of the pelvis like the iliac crest and the sciatic notch to determine if there was evidence of sexual dimorphism present in infancy. Mokrane produced many images with results ending similarly to previous studies on this method. Mokrane concluded that "this method proves the absence of difference between male and female groups" and even went as far to say that, "These findings question the existence of fetal sexual dimorphism [in the fetal pelvis]" (859). These findings suggest that using the pelvis of a deceased child to estimate sex is relatively unhelpful because there is little to no visible sexual dimorphism found on the features of the pelvis alluding to male or female remains. There are plenty of other studies focusing on the features of the pelvis that have concluded in this manner. This is precisely why forensic scientists should shift their focus from highly variable methods involving the pelvis and skull currently used on adult remains, to methods that yield more accurate results such as dentition.

As discussed previously, dentition is an extremely useful tool to forensic investigators in the medico-legal context. Not only does it aid in the estimation of age based on tooth eruption but it has proven to be a reliable method in estimating the sex in adult skeletal remains. Tooth anatomy is pretty

similar across the board between individuals and that is why it is widely used by forensic investigators when studying the remains of an individual where teeth are present. A great deal of research has been conducted on tooth anatomy, tooth placement within the mandible and maxilla and the alveoli or tooth sockets, and how the different aspects of dentition has the ability to correctly estimate the sex of adult individuals.

Studying teeth alone as a method of estimating sex can begin the process of identifying the sex in the remains of an individual. Scientists have conducted many studies on tooth size and how it indicates or differentiates between male and female remains. It is no surprise that when studying tooth size, males typically have larger teeth than females. Viciano thoroughly measured and researched the canines and molars of deceased individuals in a population where the gender was known. She concluded that when measuring the dimensions of teeth based on their crown size, evidence of sexual dimorphism within crown size is present. While the canine and the molars tend to be larger in physical size and present “the greatest level of sexual dimorphism” (Viciano 37), measuring the width of the crown is where other evidence of dimorphism can be studied by the forensic investigator.

Realizing that Viciano’s research was done on adult individuals is important to keep in mind. However, she states “... the existence of sexual dimorphism in particular dimensions of certain permanent teeth [canines and molars] suggests that there may be sexual dimorphism in deciduous dentition...” (38). Viciano goes on to explain that forensic scientists should apply this method more often in their attempts to estimate the sex of prepubescent remains because “it would be of considerable... forensic value to be able to utilize deciduous dentition in sex estimation” (41). This statement could not be more accurate. It would be of immense value for forensic investigators to develop a method that will narrow down the population by 50% when working to identify a set of prepubescent remains. Like Viciano and her team, other scientists have conducted considerable amounts of research on dentition of adults and how useful of a method it has proven to be in the process of estimating the sex of an individual. The question that remains to be unanswered in the research is why scientists are not applying these methods to deciduous dentition.

Viciano was not the first scientist to suggest that sex estimation using deciduous dentition could be possible using similar methods used on adults. In fact, Howard Bailit and Edward Hunt also understood the importance of developing a sound method to estimate the sex of children to aid in forensic investigations. Both scientists worked to identify aspects of deciduous dentition that would suggest sexual dimorphism and could help forensic investigators decipher if the remains were male or female. Based on previous research conducted by Hunt, both scientists gathered that males tend to mature far more slowly than females and this evidence is present in dentition (Hunt 485). The canines of male dentition tend to erupt later than females because the crown length exceeds that of females. Based on Viciano’s findings, the canine is typically the tooth that shows the most evidence of sexual dimorphism among adults so Hunt and Bailit’s finding that male canine’s erupt later than females sounds reasonable (Bailit and Hunt 173). The bigger the tooth, the longer it takes to erupt. To put it into perspective, molars erupt much later than incisors because of how large they are (Broughton 2014). Bailit and Hunt focused on the correlation between deciduous tooth eruption and the sex of an individual and they found that in order to successfully estimate the sex of the remains, the age needed to be known in order to utilize the eruption method (473).

Again, the forensic community displays an interest in researching the utilization of deciduous dentition in the process of sex estimation but the research goes no further once scientist runs into negative results. We see this again in D. Williams research on another method of using teeth to estimate the sex of a set of remains. Williams suggests that the extraction of DNA from the pulp cavity of teeth should be considered in the forensic process of identification. Williams extracted DNA from incinerated teeth in order to determine if sex could be estimated from badly damaged remains (93). Williams focuses on deciduous dentition specifically in this study and mentions in the article that a

comparison with other studies is not possible because “there are no equivalent reports with deciduous teeth” (94). The possibility of using DNA extracted from the pulp cavity of teeth furthers sex estimation research because this will give scientists even more information on the sex of the remains at the genetic level. This goes beyond simply observing remains to estimate sex and takes it to an extremely specific identification.

This lack of deciduous dentition research in relation to the estimation of sex in the forensic context is becoming a common occurrence within the forensic anthropological community. The ultimate question is, if so much research has been conducted on the positive outcomes of tooth analysis and its ability to estimate the sex of adult individuals, why is it not being applied to the remains of pre-pubescent children? Rather, why does the research come to an abrupt stop when scientists run into various obstacles of identification? It is extremely disconcerting to see that the research being conducted on deciduous tooth analysis is not continuing when scientists encounter these issues. Obstacles such as inconclusive information on specific populations and opposing measurements of crown size result in a halted study while methods of pelvis, skull and mandible identification continue to be pursued by scientists when those methods clearly cannot be applied to children. Scientists need to utilize their negative results and use them to further their research because the forensic community is relying on them to provide methods that will further their ability to estimate the sex of prepubescent children.

The forensic community needs to shift the focus of sex estimation from modeling methods for children after those used on adult remains. Developing methods that are specific to children need to be the central focus of the research in order to help solve this long lasting issue of inaccurate sex estimation. In order to do that, scientists need to avoid discouraging themselves from pursuing research simply because they run into obstacles when studying different aspects of the body that display characteristics of a certain sex. From the many different studies recorded of sex estimation methods for pre-pubescent children, scientists have shown that they become hesitant to continue researching their method because they become discouraged from the results.

The identification process of skeletal remains continues to be one of the most important aspects of a forensic investigation. Without the identity of the victim, there is virtually no case to close and ultimately no way to provide justice to the individual that died. When children are the victims, the importance of identification increases considerably. The forensic community needs to develop and establish methods that will successfully and accurately aid in the estimation of the sex of the child and ultimately help identify the child to bring the family peace of mind. Many aspects of the medico-legal context rely on the identification process and without the ability to determine sex, identifying an individual proves to be virtually impossible. For these reasons, applying methods of identification using deciduous dentition would allow for more accurate results of sex estimation in pre-pubescent children. Forensic investigators and scientists should continue to explore teeth and their ability to provide information through their long lasting nature that other bones simply cannot provide. Teeth have the ability to display signs of sexual dimorphism based on the measurements of crowns and canine size. If this information were present with the discovered skeletal remains, the forensic investigator would be at a great advantage and could possibly use this information to further the investigation and accurately provide an identification of the pre-pubescent remains in the medico-legal context.

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