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The Impact of Hormone Replacement Therapy on the Clavicle

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ABSTRACT

One of the many medical procedures of gender transition that are available for transgender individuals involve the use of cross-sex hormones to align one's physical characteristics with one's gender identity. During this process, transgender male-to-female patients may see the feminization of their bodies, while transgender female-to-male patients may see the masculinization of their bodies. Currently, little research has been done to show the full range of the effects that hormone replacement therapy induces, specifically regarding its impact on skeletal morphology. This lack of analysis is not only to the detriment of transgender patients themselves but also to the field of forensic anthropology. Methods of sex estimation on deceased individuals do not presently take gender identity or medical transition into consideration, potentially leading to misidentifications and unsolved cases. This literature review explores the potential influence of hormone replacement therapy in the development of the clavicle in transgender individuals under the age of 30, the average age at which the clavicle halts medial epiphyseal fusion and overall growth. The clavicle was chosen to study due to its ability to continue growing in length even after puberty has been surpassed, emphasizing that the introduction of cross-sex hormones at any point before medial epiphyseal fusion could influence its growth in length. This literature review also serves as a foundation for a future quantitative research study that measures the clavicle lengths of 17 transgender and non-transgender descendants to determine if there is a correlation between hormone replacement therapy and the clavicle's length at death.

INTRODUCTION

A significant gap exists in the research on the growth and development of transgender individuals within the field of forensic anthropol-

ogy. While it is important to highlight the value of transgender research, it is also essential to make the immediate distinction that the purpose of that research is not to understand transgender people, their choices, or lifestyles, or to treat them as a separate category. Rather, the purpose of transgender-focused research is to widen the scope of forensic anthropology's understanding of human variation. One out of the many topics that are under-researched in transgender medicine includes the effects of hormone therapy on individuals who are still physically developing. It is understood that the sex hormones estrogen and testosterone contribute greatly to the development of all individuals. Due to the importance that estrogen and testosterone have on bone health, research into the impact of hormone therapy on the development of the skeleton in transgender individuals is crucial to the forensic anthropologist to further expand the data pertaining to human variation that is applied to the identification of unknown descendants. Presently, there are no studies published that discuss bone growth and fusion rates of individuals undergoing hormone replacement therapy before fusion has occurred or growth has halted.

Forensic anthropology research demonstrates that biological sex can be accurately estimated by looking at specific features on the skeleton due to sexual dimorphism (Buikstra & Ubelaker, 1994; Spradley & Jantz, 2011). A significant amount of evidence supports this claim. According to a study performed by Inskip et al. (2018), looking at the macroscopic traits of both the os coxae and the skull combined produces a 97.7% accuracy rate in sex estimation. The clavicle is another bone that exhibits significant sexual dimorphism.

The clavicle has many different uses when creating a biological profile from the skeleton. It has been used for age, stature, and sex estimation in exploratory research in the field of forensic anthropology. It is the first bone to ossify in utero, and the last bone to fuse in adulthood. Fusion of the medial epiphyses begins around the ages of 16–18 years, but full closure can occur at any point between the ages of 18–30 years (Houpert et al., 2016; Langley, 2016). A research study conducted by Králík et al. (2014) discovered that using the clavicle alone to determine sex was 91.62–92.55% accurate (Králik et al., 2014). Due to the clavicle not fusing for such a long period of time, there is the potential for significant bone remodeling and growth far past the typical age of puberty (Hughes et al. 2020). There is also the potential for outside factors to disrupt or change the natural growth pattern of the clavicle at any point in time before fusion. With both of these factors in mind, it can be hypothesized that the introduction of cross-sex hormones before the age of

medial epiphyseal clavicular fusion may potentially influence the growth patterns of the clavicle to align more closely with the gender to which one is transitioning. This literature review will serve as a preview to a study performed on 17 transgender and cisgender deceased individuals whose clavicle length was measured using CT scans shortly after the time of death to test this hypothesis.

LITERATURE REVIEW

Clavicle Anatomy and Uses for Creating a Biological Profile

The clavicle, commonly referred to as the collarbone, is an S-shaped long bone that sits horizontally above the rib cage. The end that is closest to the midline of the body, known as the medial or sternal end of the clavicle, attaches to the manubrium of the sternum to form the sternoclavicular joint. The opposite end of the clavicle is known as the lateral or acromial end, connecting to the acromion process of the scapula to form the acromioclavicular joint (Miniato et al., 2022). The clavicle is part of the shoulder girdle, which includes both the scapula and the clavicle and articulates with the head of the humerus. The two curves of the clavicle are the convex curve, which makes up two-thirds of the clavicle, and the concave curve, which makes up the other third. There are a few non-metric characteristics that can be observed on the surface: the subclavian groove (or subclavian sulcus), the conoid tubercle, the trapezoid line, and the costal tuberosity (Hyland et al., 2022). These features can be useful in estimating the biological profile, which has significant impacts on forensic anthropological methods.

As mentioned previously, the clavicle completes its full growth and development cycle closer to the age of 30 years. The medial epiphysis is one of the last epiphyses in the body to fuse, and this lack of fusion allows the clavicle to continue growing in length until full closure is achieved. In a study performed by Hughes and colleagues (2020), researchers looked at the growth of the clavicle over time to determine how much growth is possible past the age of 12 years until the ages of 23–25 years. They found that in some of the cases they observed, patients continued to grow in clavicle length throughout the twenties, with one male patient gaining over 6mm in length from the ages of 21 to 25 years. Previous studies originally claimed that there is limited growth and remodeling past the age of 12 years in males and 9 years in females (McGraw et al., 2009). Hughes et al. (2020) went on to state that while due to the limitations of the study

they only included patients from the ages of 10 to 25 years and therefore could not determine a definitive age of terminal growth, they noted that based on their growth rate trajectories, growth can potentially continue beyond 25 years old.

Age-Related Changes in the Clavicle. Because the clavicle fuses at a fairly consistent rate, it is a useful bone for age estimation (Langley-Shirley & Jantz, 2010). There are multiple methods that have been used for measuring age in the clavicle. While the more commonly used system has been the 5-stage system designed by Schmeling et al. (2004), which used thick-slice Computed Tomography (CT) scans, one of the most accurate methods is Kellinghaus's substage system, in which specific age ranges are associated with a more narrowly defined stage by using thin–slice CT scans (Gürses et al., 2017). In total, there are five main stages based on Schmeling, with stages 2 and 3 each including substages A, B, and C which were added later by Kellinghaus. The five stages as designed by Schmeling et al. (2004) include:

- Stage 1: Epiphysis non-ossified.
- Stage 2: Ossified epiphysis with the growth plate not yet being ossified.
- Stage 3: Partially fused growth plate.
- Stage 4: Complete union between the epiphysis and the metaphysis, with the epiphyseal scar still visible.
- Stage 5: Describes a complete union between the epiphysis and the metaphysis with no visible scar (Kellinghaus et al., 2010).

The definition of these stages is especially important when looking into forensic cases involving young adults because it allows investigators to estimate the age range that the deceased individual lies within. In turn, this can narrow down a list of potential identities that could be associated with an individual. In a study performed on living subjects from an Egyptian population, researchers found that the five stages correlated with these age ranges:

- Stage 1: Most closely associated with ages below 17 years old.
- Stage 2: Age is greater than 15 years but less than 18 years old.
- Stage 3: Age is greater than 15 years but less than 23 years old.
- Stage 4: Age is greater than 19 years old.
- Stage 5: Age is greater than 21 years (El Morsi et al., 2015).

While researchers in this study conceded that more testing needs to be done in order to ensure that these measurements can be applied in every case and not just in population-specific cases, the data they gathered provides a solid foundation for future studies that further develop this method of age estimation. Other studies such as Langley-Shirley and Jantz (2010) and Langley (2016) emphasized the importance of using modern standards such as those used in El Morsi et al. (2015), and through the use of CT scans, the studies have produced accurate and consistent estimates of age.

Sexual Dimorphism of the Clavicle. The clavicle is also sexually dimorphic. There are different features and characteristics of the clavicle, metric and non-metric, that can be used to identify the sex of the individual to which it belongs. For example, one major feature that is most commonly used in sexing clavicles is the length of the clavicle. Male clavicles, on average, are longer than female clavicles by roughly 10 cm (Hughes et al., 2020). Male clavicles are also more robust in the mid-shaft circumference, heavier, denser, and have more prominent features such as a deep subclavian groove, a rhomboid fossa, or a larger nutrient foramen (Hughes et al., 2020; Rogol et al., 2000). Male clavicles are typically more curved horizontally than female clavicles, as well as more asymmetrical when comparing left and right together. This sexual dimorphism between male and female clavicles does not appear until after puberty.

Due to its later age in complete development, factors such as occupation and overall work distribution have a greater effect on the morphology of the clavicle than many other bones (Sehrawat & Pathak, 2016). Males more typically hold occupations that require a greater amount of physical activity than females in Western society, and therefore a more significant impact on male clavicles can be seen. Specifically in manual workers, it has been found to be thicker and more curved. Heavier load bearing, which is involved in the development of muscles in the shoulder, also makes the centers for muscle attachments more distinguishable than in their female counterparts. Some studies have shown that heavier load bearing also contributes to the asymmetry and more extreme curvature of the clavicles when comparing them side to side (Sehrawat & Pathak, 2016). The uneven distribution of work between the two clavicles is theorized to be responsible for male clavicles being more asymmetrical and curved than straighter female clavicles.

Lastly, it is important to note that the methods of sexing clavicles should not be used across multiple populations. A consistent method that can be used in this way has not yet been found, and studies that have

attempted to use population-specific methods on differing populations have seen declines in correct sex assignment accuracy down to almost 50% (Králík et al., 2014). This is partially due to how different cultures have different lifestyle practices and social positions which can have drastically different effects on the skeleton. Socioeconomic status has a significant impact on the overall development of the skeleton. It is not unreasonable to suggest that both metric and non-metric variables of the clavicle can be affected at different rates, which also disrupts the potential to use the same sexing methods even in populations that have similar social and economic climates. Although the clavicle is more accurate in sex estimation using population-specific methods (85.6%–94.8% accuracy in one study, and up to 100% accurate in a separate study (Králík et al., 2014), it is highly recommended that the clavicle is measured along with other bones such as the pelvis or skull when available. Developing methods for classifying clavicles as male or female across multiple populations would allow for forensic anthropologists to accurately identify the sex of an individual in any case if these bones are not present.

The Transgender Identity and Hormone Replacement Therapy

As mentioned previously, hormones have a great deal of influence on bone growth and development. The introduction of endogenous testosterone or estrogen into the body is directly involved in the remodeling of the clavicle to transform into a final form that aligns more closely with either the male or female body shape. Because of the importance of natural hormone introduction, it is necessary to discuss the topic of exogenous hormone replacement therapy (HRT) to allow for a better understanding of how it changes the body. This also begins the discussion about how HRT could possibly influence the growth and development of the clavicle if it is prescribed before terminal growth and epiphyseal fusion have been reached.

The term "transgender" refers to an individual whose gender identity does not align with their sex assigned at birth (American Psychological Association, 2023). People who identify as transgender often claim that the feeling of discomfort in their bodies, known as dysphoria, can appear early in childhood and persist throughout their lives. Hormone replacement therapy, which is a treatment for gender dysphoria, is the process of administering either testosterone or estrogen to a person who identifies as the gender opposite of their biological sex. Female-to-male (FTM) patients would receive testosterone therapy to masculinize their bodies (Deutsch, 2020b), while male-to-female (MTF) individuals

would receive estrogen therapy to feminize their bodies (Deutsch, 2020a). Hormones can be administered in different ways depending on the needs of the patient. In most cases for FTM transgender men, a standardized dosage of testosterone is injected either subcutaneously into body fat or directly into the muscle. For MTF transgender women, estrogen is most often administered in pill form and taken in combination with a hormone blocking drug that prevents the continued production of testosterone (Deutscha, 2020a). While this is not the only form of treatment available for transgender individuals, it is one of the most common medical interventions that are used in treating dysphoria. To many transgender people, HRT has been considered as a life-saving intervention that provides significant relief to the distress caused by gender incongruence.

HRT is also not exclusive to the transgender community. There are many cisgender people (people whose gender aligns with their sex assigned at birth (Merriam-Webster, n.d.) who experience low estrogen or low testosterone levels throughout the life cycle, and the procedure to treat these conditions is the same as it would be in the case of transgender patients (Mayo Clinic, 2022a; 2022b). There are also cases in which cisgender individuals are born with conditions that prevent them from naturally producing the correct levels of hormones for their particular sex, in which case this treatment would also be prescribed. It is important to note this concept here to highlight the necessity of hormone replacement therapies for a wide range of individuals, not just transgender people. This concept will be expanded upon later in this literature review when discussing the discrimination and hate crimes that have affected the community.

In the case of female-to-male transgender people who undergo hormone therapy, testosterone is taken in order to change their physical features to more closely match the male form. Many different changes can take place at varying rates. Some of the more obvious changes that take place are the deepening of the voice, facial masculinization, increased muscle mass, and the thickening and increasing of body hair (Deutsch, 2020). In male-to-female transgender people, estrogen therapy can have a much less obvious impact on the individual, especially if the treatment is started years after puberty when the dominant effects of testosterone have already taken effect. Estrogen therapy does however contribute to a significant reduction in muscle mass, the softening of facial features, and an increase in body fat (Deutsch, 2020a). For both FTM and MTF transgender people, body fat redistributes to follow a pattern more similar to the gender they are transitioning to as well. The current belief that

is transferred from doctor to patient is that hormone therapy does not change the size or shape of the bones. However, this belief is actively being challenged as new research is being produced. There are currently no studies that have been performed that look specifically at the clavicle in transgender patients, which continues to grow into the late twenties.

Hormone Replacement Therapy and Bone Remodeling. As stated previously, HRT has a tremendous influence on the growth and development of bones. While genetic factors play a part in the average lengths and robusticity of long bones, hormones are still one of the most important factors in how bones end up forming. The introduction of secondary sex hormones in males and females begins at different times, and they continue to grow at different rates. Females generally have their first growth spurt in their long bones around the ages of 9–10 years, while boys see a larger growth spurt between the ages of 11–12 years (Soliman et al., 2014). When puberty occurs, testosterone or estrogen levels increase significantly, which influences the growth of the bones in length and in density. The overall skeletal growth of females ends around the age of 15 years while in males it ends around the age of 17 years (Rogol et al., 2000). By the age of 18 in both males and females, about 95% of bone accrual is achieved (Stagi, 2013). Interestingly, the clavicle can continue to grow and does not fuse until the late twenties and into the early thirties for some males (Langley-Shirley & Jantz, 2010).

Testosterone specifically, is understood to increase bone growth and continue bone maintenance. In studies performed by Ren et al. (1989) and Phillip et al. (2001), the administration of testosterone into rats that had been hypophysectomized or castrated (independent of growth hormone) produced results that showed stimulated growth in the tibial epiphyseal growth plate, as well as an increase in insulin-like growth factor-1 (IGF-1) which is another important hormone in bone growth. These two studies show that testosterone by itself induces growth, independent from other growth hormones. Estrogen on the other hand has been shown to regulate bone turnover while also being needed for proper closure of epiphyseal growth plates. Higher levels of estrogen cause the closure of epiphyseal growth plates to occur sooner, thus leading to the stature and structure differences between males and females (Noirrit-Esclassan et al., 2021).

Hormone therapy disrupts the natural growth patterns as described previously that take place in adolescence. In cases of transgender patients who are in the pre-pubertal or early stages of puberty, HRT has been shown to cause the patient to develop in the same way a cisgender

individual would, bringing their final stature and structure to very closely match the predicted average size and shape that they would have taken if they had originally been born the opposite sex (Klaver et al., 2018). This is often also assisted by the introduction of hormone blockers to prevent their naturally produced hormones from influencing the development of the body. This shows the significance of hormone introduction, whether natural or synthetic, in the growth and development of the body. In cases where the individual has already passed the point of puberty and reached adult stature, other methods of artificial bone remodeling may take place. More commonly performed is facial feminization surgery which removes bone around the jawline, as well as the brow ridge, in order to achieve more feminine characteristics. This is important to note because the recognition of this type of surgery can lead to better identification of transgender individuals in forensic cases.

HRT also plays a significant role in bone mineral density (BMD). Of the potential risks that come along with this treatment, osteoporosis or low bone mineral density has been a major concern for both transgender men and transgender women using HRT. This is because estrogen, which is greatly affected by HRT in both trans men and women, is essential to suppressing bone reabsorption and maintaining bone mass. In a study performed on 105 postmenopausal cisgender women, osteopenia was found in 31.4% of subjects, and osteoporosis was found in 14.3% as a result of estrogen loss (Unni et al., 2010). Cisgender men with lower testosterone levels have also been shown to have accelerated bone loss (Finkelstein et al., 2016). It must also be noted here that cisgender males typically have a higher total BMD than cisgender females, which is related to bone size (Alswat, 2017).

Because of the known negative effects of low estrogen on bone health, it has been hypothesized that transgender men could have compromised bone morphology due to suppression of estrogen production as a result of HRT and that transgender women receiving estrogen would have maintained bone microarchitecture (Bretherton et al., 2022). However, the most recent studies by Bretherton et al. (2022) have shown that the microarchitecture and BMD of transgender men are not affected by HRT, but transgender women have overall lower total BMD than the cisgender male population. The result in transgender men is likely due to the aromatization of testosterone into estradiol, while it is unclear the exact reason for lower BMD in transgender women in this study. Previous studies such as Wiepjes et al. (2017) showed that total BMD increased in both transgender men and women after one year of HRT. One of the lon-

gest-running studies in transgender medicine was performed by Wiepjes et al. (2019) that followed subjects over the course of ten years with 1,254 participants. It showed that BMD in both transgender men and transgender women is not negatively affected by HRT. Though there are somewhat conflicting results regarding the bone mineral density change in trans women, the overall results more consistently show that hormone replacement therapy does not have a medically significant impact on BMD or bone health overall.

Historical Forensic Investigative Techniques: Sex Estimation & Transgender

Forensic anthropologists frequently encounter cases of missing or unidentified gender-ambiguous remains. Due to the nature of hormone replacement therapy and gender-affirming surgery remodeling bone architecture, there is no "typical" transgender body, nor standards or guidelines to follow when handling these cases. According to a survey on perspectives held by forensic anthropologists, 75.0% of the respondents were unfamiliar with forms and evidence of gender-affirming procedures (Kincer, 2020). Along with this, 42.4% of respondents believe that sex is binary (Tallman et al., 2021). Forensic anthropologists and medical examiners alike have a responsibility to learn about the complexities of gender, sex, and atypical gender expression that can lead to the potential misidentification of transgender people. While there are many new techniques being developed to combat the current inflexible categorization of sex as being two options, male or female, there are still techniques being used and developed that reinforce this binary system. Rather than regarding sexual dimorphism, sexual polymorphisms may more accurately reflect biocultural variations in modern human populations (Mace, 2019).

In most cases presented to forensic anthropologists, the pelvis is the main bone used in identifying the birth sex of the deceased individual. The overall size of the pelvis is larger in females and more narrow and smaller in males. Females also have a larger pelvic inlet than males, which evolved to allow for infants to pass through during birth. This feature is one of the most useful characteristics used to estimate sex of an individual. The greater sciatic notch is typically wider in female pelves than in their narrower male counterparts (Walker, 2005). Analysts will also look at the subpubic region, which in females is concaved while in males it is straighter or convexed (Phenice, 1969). One of the features that is also of great importance is the subpubic angle. This is the anterior upside-down

v-shape that is produced when articulating the two halves of the pelvis together (White & Folkens, 2005). If the angle is greater than 90 degrees, the pelvis is designated as female, and if it is less than 90 degrees it is designated as male (Buikstra & Ubelaker, 1994).

The skull is also used in identifying the sex of a skeleton. As referred to previously, forensic anthropologists Buikstra and Ubelaker (1994) and Walker (2008) designed a method of observing five non-metric traits of the skull that can be assigned to either males or females. The nuchal crest, mastoid process, supraorbital margin, glabella, and mental eminence are rated on a scale from 1–5, 1 being more feminine or minimal expression, 5 being more masculine or maximal expression, which scores are then added together to produce a final number that determines the sex. This method has been praised for its ease of use due to procedures not requiring measuring equipment, as well as the ability of those with little experience in skeletal examination to be able to use the system with a high degree of accuracy (Walker, 2008).

Body size and stature are other components of the biological profile that can be related to sexual dimorphism and sex estimation, as human males are about 15% larger on average than females (Larsen, 2003). There are different formulas that have been created to estimate sex-specific stature through the measurements of the long bones (Trotter, 1970), which have in turn been used to predict sex through measuring different features such as overall length, width, and diameter of the epiphyses. Metric sex estimation can have very high rates of accuracy, exceeding 90% accuracy for sex estimation using multivariate analyses (Spradley & Jantz, 2011). For example, the humeral head diameter measurement alone has been shown to be 90.41% accurate grouping bones into sex categories (Mall et al., 2001). However other elements when measured together such as the maximum radial length, radial head diameter, and distal radial width produced results that were 94.93% accurate. The measurements of the humerus and ulna follow closely behind, which produced 93.15% and 90.58% accurate results, respectively.

While the results of measuring the different features of these bones mentioned above may be extremely effective in measuring the biological sex of a young to middle-aged individual, this system still makes estimations based on strictly male and female dichotomous categories and does not account for the overlap in metric and non-metric values measured between the male and female categories. Issues can arise when using these measurements in the cases of intersex, transgender, and gender non-conforming individuals especially when considering the effects

of exogenous HRT on growth and development of the skeleton. The current binary system of identification assigns individuals with sex-ambiguous measurements as "indeterminate" in the sex category. This method, which is utilized in every formula for sex estimation, not only reinforces the concept of only two sexes but also perpetuates the inflexible and sometimes harmful language used to describe these categories (Watson, 2022) which may lead to inaccurate estimations and unidentified human remains.

Discrimination, Homicide Rates, and Hate Crimes. To provide more context to the necessity of this research, it is imperative to discuss the various forms of oppression and discrimination that the transgender community faces today. The LGBTQ+ community in the United States faces discrimination and harassment in many different ways, which not only comes interpersonally from those who reject their lifestyles and identities, but also includes legalized discrimination. Increasingly in recent years, the transgender community in particular has faced some of the highest rates of violent acts committed against them and the most legal discrimination out of any other identity in the LGBTQ+ community. In 2023 and only halfway through the year, 558 anti-trans bills have been introduced across 49 states (Trans Legislation Tracker, n.d.), and the numbers have continued to rise. This is in comparison to 2022, where only 174 bills were proposed throughout the entire year. These bills range in content, from bathroom bills that disallow transgender individuals from using the bathroom that matches their gender identity, to outright bans on gender-affirming hormone therapy. Many of the proposed bills target transgender minors, banning the use of puberty blockers, hormone therapy, and gender-affirming surgeries. In the state of Florida, Senate Bill 254 was proposed and signed into law by Governor Ron DeSantis, becoming one of the harshest anti-trans bills to pass in the country (HRC, 2023a). The bill bans age-appropriate gender-affirming care for transgender youth, imposes severe legal consequences for practitioners providing these services, prevents private and public entities from insuring trans healthcare, prevents transgender individuals from changing their gender marker on government identification, and even allows for the state of Florida to remove children from the custody of their parents if they receive gender-affirming care.

It is important to make clear that the gender-affirming therapies available for minors are very limited. Doctors rarely, if ever, prescribe secondary sex hormones or perform any surgeries on minors under the age of 14 years (Nos et al., 2022). Most often, puberty blockers, which

are shown to cause no long-term harmful effects to adolescents and the effects of which are reversible (Guss & Gordon, 2022), are given in order to provide more time for the individual to make a decision to transition before their irreversible natural puberty takes place. This care typically is only provided once several therapy sessions and evaluations have been completed (Nos et al., 2022) to ensure that cross-sex hormone introduction would be the correct path to take. The legal discrimination that is targeted towards transgender youth, their parents, and their doctors, is based on misinformation and the overall lack of understanding of transgender medicine.

Aside from the discrimination directed specifically towards minors, transgender adults also face discrimination and oppression based on their identities. While accurate data on the subject is extremely difficult to collect, many studies that measure the rate of discrimination experienced by transgender people are in agreement that there are significant trends of victimization among the transgender population (Stotzer, 2017). According to the Transgender Murder Monitoring Project, one murder of a transgender person occurs every 36 hours, with murder rates increasing over time (TGEU, 2023). This statistic does not account for the cases that go unreported or the cases in which the gender identity of the victim is not fully known. The Human Rights Campaign states that over 310 transgender and gender non-conforming individuals have lost their lives in hate crimes in the last 10 years within the United States (HRC, 2023b). The majority of these murders have been perpetrated against transgender women of color and transgender women who are sex workers.

Transgender adults have also faced legislative discrimination and attempts to remove access to gender-affirming care, as well as removing protections against discrimination based on gender identity. Gender-affirming care bans for anyone under the age of 26 are currently being considered in Oklahoma, Texas, and South Carolina (HRC, 2023a). Laws that ban drag, a term that refers to performances involving men dressing in exaggerated feminine attire or women in exaggerated masculine attire solely for entertainment purposes, have a potential impact on the transgender community, as well. Bills banning drag that have vague language such as "male or female impersonators" could be applied to transgender people, even though they are not considered to be "in drag" (Garnand, 2023). The effect would ultimately lead to transgender people being arrested in public spaces under the claim that they were illegally performing drag. Laws such as these have been proposed in states like Tennessee

and Arkansas (Chamlee, 2023).

The legal measures being taken by these state legislatures do not solely harm transgender individuals. As mentioned previously, hormone therapy is not just limited to transgender people. Due to the laws being put in place that deny gender-affirming care to the community being so broad, cisgender people could be affected as a result. For example, in cases where legislation has passed that bans the administration of hormone blockers for minors, non-transgender minors who experience pathological precocious puberty may be denied access to medications that would have a great impact on their physical health. With doctors in many states now being threatened with professional and legal punishment for administering gender-affirming therapy, many are being forced to end the practice of prescribing treatments such as these (Reardon, 2021). Even in cases where the doctor does not focus on transgender medicine, their authority to prescribe puberty-blocking treatments for non-transgender patients may be affected, as well.

Cold Cases and Missing Persons. There are thousands of forensic cases where analysts were unable to associate an identification with human remains, with 11,000 sets of unidentified remains kept in medical examiner and coroner offices in 2018 alone (NamUS, n.d.). Whether they did not match any markers of people reported missing, or their disappearance was not reported at all, there are many individuals who have yet to be identified. Another layer of difficulty is added when the individual presents as one gender externally but presents as another based on skeletal markers. In the case of transgender people, there are many instances in which forensic anthropologists could not give an appropriate assessment of the gender identity of the individual and therefore cases have sat cold for several years (Lenti, 2021). Attaching an accurate identification to a set of remains of transgender people may be difficult also because their families might have reported them as missing under their birth sex and birth name. The family may not even know about them living as the opposite gender, in which case they may reject a proposed identity assuming their family member was cisgender (2021). As of 2023, there are currently over 206 cases of missing persons that fall under the transgender or intersex categories (Trans Doe Task Force, n.d.); however, there may be many more due to the lack of reporting and other issues as stated above.

Police negligence may also contribute to the high number of unsolved cases. Historically, there have been numerous incidents in which the police have interacted with the LGBTQ+ community in extremely

violent ways. For example, when being gay or transgender was still illegal, police regularly checked ID's, patrolled gay neighborhoods, and harassed or beat patrons of gay bars (Eckhouse & Saxen, 2017). This ultimately led to revolts such as the 1966 Compton Cafeteria Riots in San Francisco and the 1969 Stonewall Rebellion in New York City. Research also shows that the LGBTQ+ community still faces higher rates of this style of oppression by law enforcement (Mallory et al., 2015). Due to the long history of police brutality against the LGBTQ+ community and continued discrimination and harassment, negligence when handling missing persons cases has become another negative outcome. Between the years of 2010 and 2017, a man named Bruce McArthur committed 8 murders of gay community members in Toronto, Canada. After a thorough investigation of the police's response to these cases, it was determined that there was "profound systemic failure" within the Toronto Police Service's handling of the crimes and many ignored warnings and tips provided by those living in the area (Woods & Ware, 2021).

Biases of forensic anthropologists may also be a factor in the misidentification of transgender individuals. As stated previously, one survey found that 75% of forensic anthropologists were unfamiliar with gender-affirming procedures and another 42.4% of respondents believed that sex was binary (Tallman et al., 2021). With the severe lack of understanding of the transgender community and the ways in which their bodies develop, it is clear that there is a large gap in the knowledge that would benefit forensic anthropologists in the identification of missing persons. This is the reason why the research as proposed in the present literature review is necessary.

Expansion of Gender-Affirming Care, Even in Death. Solutions to the lack of appropriate handling of missing persons cases involving transgender individuals starts with a reassessment of the current methodologies employed by forensic anthropologists today. The current perspective that is held by the greater portion of the forensic anthropology community is that there are two biological sexes, with some individuals falling into the intersex category. There have been recent articles published that challenge this binary system and propose that a broader approach be applied in identification procedures, considering sexual polymorphisms. While estimating biological sex for the most part is possible, it is important to take into consideration the lived experiences and cultural aspects of the person's life that had an impact on their skeletal system. As mentioned previously, the clavicle is a bone that is sexually dimorphic, and often takes on more extreme features (such as a more prominent

curve, deeper subclavian groove, etc.) depending on the amount of work applied to them. This implies that regardless of the biological sex one is assigned, they could have potentially made lifestyle choices (e.g., using HRT) that influenced the development of their skeletal structure to look more masculine or more feminine.

The appropriate way to approach cases where a transgender or gender-ambiguous person is involved may vary on a case-by-case basis. When referring to a deceased individual, for example, one solution to help alleviate biases would be to use gender-neutral language that does not assign a sex or gender to ambiguous remains. Understanding the importance of taking a broad perspective when discussing the gender of the person while still acknowledging the importance that sex estimation can have on identification are concepts that can coexist in the field of forensic anthropology.

CONCLUSION

There are multiple reasons why measuring the clavicle in transgender and gender non-conforming individuals on HRT is important to the field of forensic anthropology and the scientific community as a whole. With the high number of violent crimes perpetrated against transgender people and the comparatively high number of missing transgender people, research in this field is absolutely crucial to broadening the tools available to forensic anthropologists in assisting with the identification of human remains. While there are many different bones and skeletal features that can be used to identify the sex of an individual, the clavicle adds another vital piece of information that could be useful in identifying the remains of transgender individuals. Especially in the case of FTM transgender individuals, determining if the length of the clavicle relative to stature, for example, and whether it is affected by the administration of testosterone before the age of 25 could help to determine the lived gender of a set of remains, especially if the remains are gender ambiguous. The clavicle's high degree of sexually dimorphic characteristics, its ability to structurally change based on the type of lifestyle lived, and its relatively consistent rate of development and fusion by age makes the clavicle especially useful in creating a biological profile from skeletal human remains.

The discrimination against transgender individuals that has dramatically increased in the last year has a greater impact on their livelihoods than may be understood by the general population. With new laws and restrictions that reduce accessibility to gender-affirming care taking

effect all across North America, the number of violent hate crimes that result in deaths and missing persons cases is sure to rise. Some estimates have determined that as many as 375 or more transgender people have been killed across the world in the year 2021 alone (Wareham, 2021). While more research into transgender medicine has been produced that shows the essential role that gender-affirming care has in transgender people's lives, the number of discriminatory, oppressive laws and actions that directly harm the community continue to be proposed and passed. It is critically important that further research on the variation of transgender individuals continues to persevere through these challenges and for forensic anthropologists to focus more on the clavicle in missing persons cases involving transgender individuals.

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