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# Morphological and morphometric changes in the faces of female-to-male (FtM) transsexual people

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## Abstract

Facial changes associated with administration of exogenous testosterone and oophorectomy in female-to-male (FTM) transsexual people (trans men; trans males) has not been previously documented. This study aimed to describe the qualitative and quantitative transformation from a female to a male facial appearance and to identify predictable patterns of change.

Twenty-five trans men were studied using morphological and morphometrical analysis of pre-transition 2-D images and post-transition 3-D scan models. The mean subject age was 39 years and all subjects had been taking testosterone for at least 3 years, with a mean duration of therapy of 8.6 years.

While 32% of subjects were classified by a majority of observers as male appearing in pre-transition photographs this rose to 95.5% in post-transition images. Eighty-six percent of subjects demonstrated an increase in male classification after transition. Morphometrically, 44% of subjects became wider in the face overall and 100% of subjects measured demonstrated a narrower nose after transition.

Testosterone virilises adult female faces and will cause widening of the face. The most consistent facial change was the production of a narrower nasal width at the alae, which may be a result of fat re-deposition not related to ageing effects or body mass index (BMI).


Key words: Exogenous testosterone; FtM transsexual people; masculinisation; sex-appearance reassignment surgery (SARS).

## Background

One of the most dramatic human transformations is the change in facial appearance from that of a female to a male in trans men. It is a revolutionary transformation, certainly for the trans man, if not for the society he inhabits (Bornstein, 1998). This radical revision of form and psyche raises questions about human identification systems, gendered identities, and a future understanding of sex, gender, and human development.

Transsexual individuals offer a rare and dynamic testimony in scientific exploration (Gooren & Giltay, 2014). They are, quite literally, walking, talking, biological and sociological experiments. As conspicuous partners in discovery, they engage with, and share a new perspective in human diversity and potential. This research is original: to date, no known studies of face masculinisation in trans men exist.

### *Effecting changes in sex appearance*

In response to a subjective and persistent experience of one's own self (an internal gender identity) as incongruous with birth sex (Gooren, 2006), transsexual people seek the application of exogenous cross-sex hormones and/or sex-appearance reassignment surgery (SARS).

The aim of hormone therapy is to reduce secondary characteristics of the sex assigned at birth and induce development of characteristics appropriate to the target sex appearance (Wierckx et al., 2012).

In trans men exogenous testosterone initiates virilisation: male facial- and body-hair growth pattern, re-deposition of body fat to a male profile, and the development of a male range voice. The application of testosterone continues for life; the aim being to mimic hormone values in the normal physiological range for a non- transsexual male individual (Gooren & Giltay, 2008).

Androgens increase muscle mass and strength. In combination with resultant changes to mechanical factors (mechanical loading, exercise and gravity), they therefore also increase bone mass and strength and are associated with larger cortical thickness. In trans males, greater muscle mass, as a result of testosterone, increases the mechanical loading on bones, and bone mass, bone geometry, and body composition is changed following long term exogenous androgen use (Elbers, Asscheman, Seidell, Megens and Gooren, 1997).

Studies of trans men who had undergone oophorectomy and been treated with testosterone compared bone scan data with age matched control females (Mueller et al., 2010; Turner et al., 2004; Van Caenegem et al., 2012) and found larger radial cortical bone area and bone size, increased trabecular volume bone mineral density (BMD), lower cortical volumetric BMD, higher lean body mass, greater muscle mass and greater grip strength in trans males. They also had a lower body and subcutaneous fat mass, with larger waists and small hips (including a larger waist-hip ratio), and body fat mass was 30% lower and lean body mass was 9% higher over that of the female comparison groups.

*Face sex and gender perception*

The biological importance of the facial complex is underwritten by the significance of its facilitation of communication (Bruce, 1990). Each human face is unique (Schimmler, Helmer & Rieger, 1993), their individual appearance transmitting character and identity as they transform throughout a lifetime (Berry & Mcarthur, 1986; Zimbler, Kokoska and Thomas, 2001); the face is the most important feature in identity determination (Bruce & Green, 1990). Perception of facial sex is a complex discriminatory function that is quick, automated and viscerally experienced (Ellis, 1986; Haxby, Hoffman & Gobbini, 2000; Sinha, Balsa, Ostrovsky & Russell, 2006); it is a vital “prerequisite for social behavior and communication” (Armann & Bulthoff, 2012, p. 70).

Our ability to determine sex from visual assessment of adult faces has been tested in numerous studies (Armann & Bulthoff, 2012; Burton, Bruce and Dench, 1993; Bruce, Burton, Hanna, Healey and Mason, 1993; Bruce, Ellis, Gibling & Young, 1987; Ganel & Goshen-Gottstein, 2002), and observers can correctly identify sex with 96% accuracy in less than a second from facial photographs without traditional sex and gender clues (hairstyle, clothing/accessories, and facial hair).

A number of studies using 2-D and 3-D images have examined the facial features important to sex determination, their order of importance and degree of influence. Often it is the configuration of features in relation to each other rather than a particular feature itself that is primary in denoting sex (Brown & Perrett, 1993). According to one study (Bruce et al., 1993), features that indicate sex (in Caucasians) are mouth width, eyebrow thickness, base width of the nose, distance between eyes and eyebrows, height of the forehead, the distances between the inner corners of the eyebrows, as well as between the point of the nose and the lowest corner of the nose. Features indicative of face sex may differ according to the subject set; in one study of Japanese faces, the jawline and mouth were more important, with the eyes and nose less so (Inoue, Ichikawa, Nagashima, & Kodama, 1995).

When features from a male prototype face were grafted onto a female face the most significant features contributing to a female face, the most significant features contributing to a female face being assigned male was the jaw, brows/eyes and then brows alone. Where female features were grafted onto the male prototype face, the features contributing most to a female assignment were again, jaws first, brows/eyes second and brows third (Brown & Perrett, 1993).

*Facial analysis*

Craniofacial dimorphism is well documented by Krogman and Iscan (1986) and White and Folkens (2000). Male skulls are larger and more robust than female skulls with stronger muscle attachments and larger mastoid processes (White & Folkens, 2000). Male skulls exhibit brow ridges, larger glabellar regions, a more sloping forehead, thicker supraorbital margins, more rectangular orbits, heavier zygomatic bones, a wider palate, squarer jaw, wider chin, squarer gonial angles, larger mandible, stronger supramastoid crests and gonial flaring (Wilkinson, 2004). These differences from female skulls are entirely related to endogenous testosterone and develop during puberty in males (Enlow & Hans, 1996). Sexual dimorphism in the face is directly related to these skull differences in addition to soft tissue differences, like male facial hair and balding patterns, rougher skin texture, leaner cheeks, higher vascularity, thicker lower eyebrows and larger ears (Neave & Shields, 2008; Sveikata, Balciuniene, and Tutkuviene, 2011).

Morphological comparisons assess discrete categories of features classified by standardised descriptions of shape, size and detail (Allanson et al., 2009; Dunn & Harrison, 1997; Iscan, 1993; Vanezis et al., 1996). Facial features are subject to radical changes due to ageing, surgery, injury and disease (De Sousa, 2008; Stuzin, 2007; Zimbler, et al., 2001) with additional effects relating to the environment, including sun exposure, drugs, alcohol and diet (Rexbye et al., 2006), and in the case of transsexual people, exogenous cross-sex hormones (Gooren & Giltay, 2014).

Morphometric comparisons may use photo-anthropometrical techniques including linear distances and angles between soft tissue landmarks (Davis, Valentine & Davis, 2010). Multiple photo-anthropometry studies using standardised facial images exist (Bishara, Jorgensen and Jakobsen, 1995; Farkas, 1994; Farkas & Deutsch, 1996; Katsikitis, 2003), one focusing specifically on sexual dimorphism (Fernandez-Rivieiro, Suarez-Quintanilla, Smyth-Chamosa and Suarez-Cunqueiro, 2002). Facial comparison using photo-anthropometry is optimal when facial images are standardized (Taylor & Brown, 1998), but this is not always possible where donated images are utilised.

Craniofacial superimposition is the placing of one image over another for comparison, often in a skull to ante-mortem facial photograph (Sekharan, 1993), or, as in this case, the faces of the living, in a face-to-face superimposition (Oxlee, 2007). Comparative superimposition of the living has increased with the development of non-invasive surface scanning, which produces 3-D facial models (Gwilliam Cunningham and Hutton, 2006). Morphological profiles within and between populations and sexes (Kau et al., 2010), visualising soft tissue changes following orthognathic surgery (Miller, Morris and Berry, 2007), syndrome diagnosis (Shaweesh, Clement, Thomas and Bankier, 2006), facial growth (Nute & Moss, 2000) and facial aging (Atsuchi, Tsuji, Usumoto, Yoshino and Ikeda, 2013) have been studied.

Three dimensional scan models produced using surface scanners are accurate representations of skulls or faces (Kau, Richmond, Savio and Mallorie, 2006). Negations and distortions that occur with photography are avoided and the 3-D images are life size (1:1), making it possible to scale a comparison photograph to a 3-D model or vice versa (Yoshino, 2012). Three-dimensional imaging has been shown to be reliable when examining changes in soft-tissue facial morphology over time (Kau et al., 2005). Two-dimensional facial photographs were compared to 3-D face models using superimposition in a blind trial (Lynnerup, Clausen, Kristoffersen and Steglich-

Arnholm, 2009) establishing that laser surface scans were a good method for circumventing the (often unknown) “many different settings and differences in the equipment” (p. 170), used to photograph a face and make their duplication in a second photograph so difficult.

## Method

The researcher is an adult FtM trans man who provided embedded access to the subject cohort. Adult trans males were recruited through web-based peer fora, community groups, conferences, and health practitioners in gender identity clinics. All participants provided informed consent and the research was approved by the University of Dundee Research Ethics Committee (UREC 9040) in the United Kingdom.

Participants were required to have started taking testosterone after the age of 18 years, for a minimum of 3 years and to be able to provide pre-transition adult facial photographs. As the accepted age range for the maturation of facial skeletal growth in females is 10-13 years (Enlow & Hans, 1996; Farcas, Posnick & Hreczko, 1992; Iscan & Helmer, 1993; Scheuer & Black, 2000), limiting the study to subjects at least 18 years of age provided generous allowance for some females not reaching full maturity until later than the documented range

The pre-transition facial photographs could not be standardised, but guidelines included good quality, frontal images, and, where they existed, lateral/oblique angled images with an unobscured face and without extreme facial expression. Each subject agreed to the collection of photographic facial records and a 3-D laser facial scan (Figure 1).

The photographs were taken using a Canon digital camera with a 55-80 mm lens and the laser scans performed using a Polhemus FASTSCAN Scorpion laser surface scanner (Polhemus, 2007) with a 0.5 mm per 200-mm range resolution and 1 mm per 200-mm range accuracy. Subjects were asked to present without facial hair to facilitate the scan process.

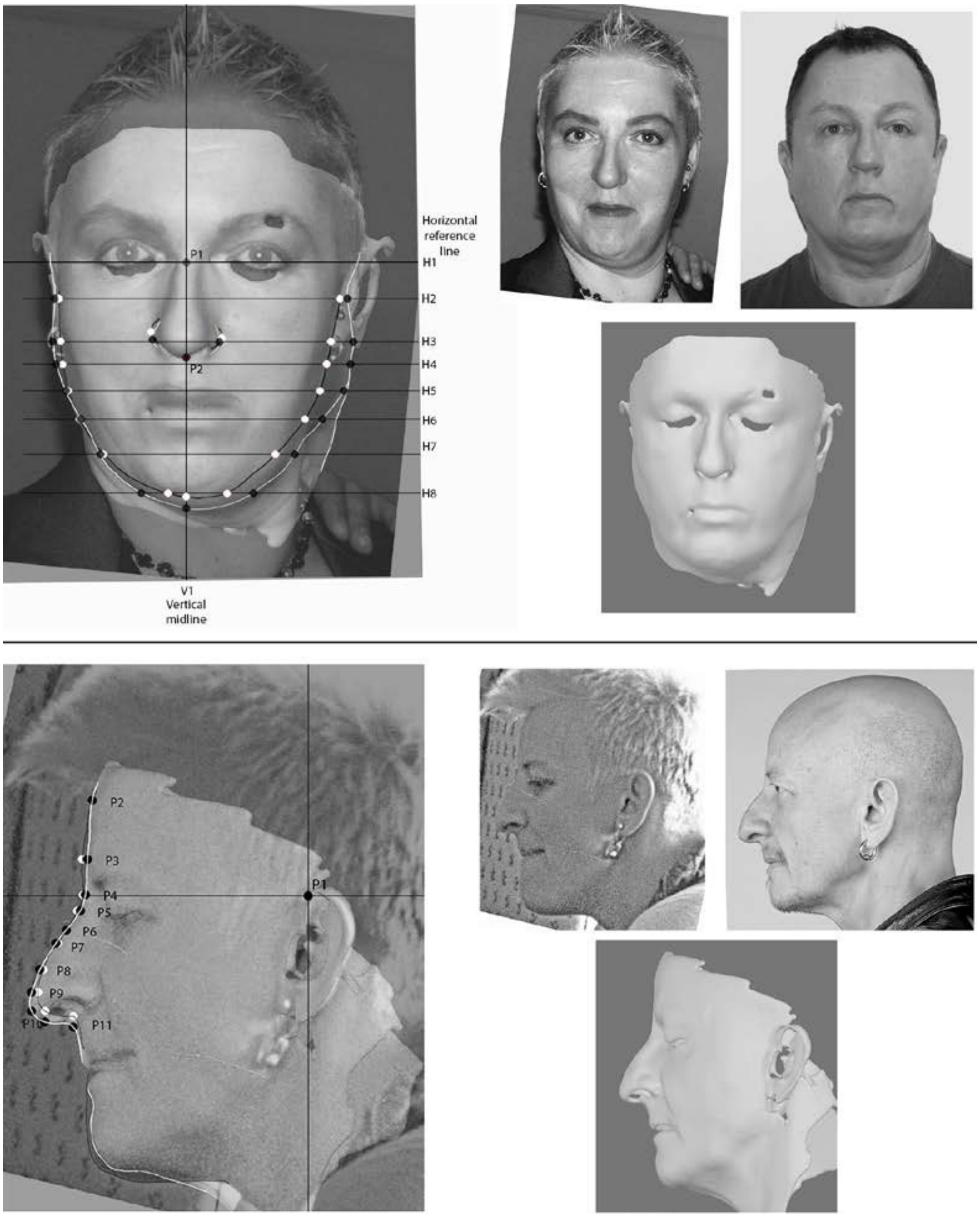


Figure 1: Top left: Subject no. 27 facial-measurement comparison with post-transition 3-D face model superimposed on 2-D pre-transition face. Top right: Pre- and post-transition photographs and 3-D post-transition scan of the same subject. Bottom left and right: The researcher as subject.

The 2-D image processing was carried out using Adobe Photoshop CS5 to scale, standardise and analyse the images. All frontal facial images (pre- and post-transition) were scaled to the same interpupillary distance (63mm). Three-dimensional scan processing was carried out using FASTSCAN software to create a 3-D model of the face. Geomagic Freeform Modelling Plus software (Geomagic, 2013) with a Phantom desktop haptic device was used to manipulate the 3-D model in six different directions and 360° of virtual space in relation to the 2-D images.

The post-transition 2-D facial image was scaled through superimposition with the post-transition 3-D facial model and then the pre-transition 2-D facial image was superimposed with the post-transition 3-D facial scan. Screen shots of the superimposition of the 2-D pre-transition facial image and 3-D face model view were recorded and imported into Adobe Photoshop CS5 where sex and gender appearance assessment and morphometrical comparisons were carried out.

The morphometric comparison of the facial images included the addition of facial landmarks (Table 1) and the measurement of proportional distances. Facial zones were defined as upper face (above *nasion*), mid face (*nasion* to *subnasale*) and lower face (*subnasale* to *gnathion*). Horizontal and vertical lines were added between points so that lines crossed the outline of the face or features annotated (Figure 1). In this way any differences in facial proportions and feature shape could be determined and quantified. Statistical analysis of the morphometric analysis was carried out using Excel and R software (R core development team, 2014).

| Landmark | Abbrev | Description |
|---|---|---|
| *alar crest* | *ac* | Most lateral point in the curved base line of each ala |
| *alare* | *al* | Most lateral point on each alar contour |
| *cheilion* | *ch* | Point at each labial commissure/corner |
| *endocanthion (soft)* | *s.en* | Point at the medial commissure/corner of the eye fissure |
| *exocanthion (soft)* | *s.ex* | Point at the lateral commissure/corner of the eye fissure |
| *glabella* | *g* | Most prominent midline point between the supraorbital ridges in the midsaggital plane |
| *gnathion* (*soft*) | *s.gn* | The most inferior median point of the soft tissue contour of the chin |
| *intertragal notch* | *it* | Notch inferior to the tragus and anterior to the antitragus |
| *nasion* (*soft*) | *s.n* | The midline and deepest part of the nasal root |
| *orbitale* | *or* | Most inferior point on inferior margin of each orbit; identified by palpation or visually by change in skin colour/depression beneath eye |
| *otobasion inferious* | *obs* | Point of attachment of the ear lobe to cheek; defining the inferior border of the ear insertion |
| *otobasion superious* | *obs* | Point of attachment of the helix superiorly where it meets the skin of temporal region (upper border of ear insertion) |
| *pogonian* | *pg* | Most anterior midpoint on the surface of chin |
| *porian* (*soft*) | *s.po* | Highest point on superior margin of cutaneous auditory meatus |
| *pronasale* | *prn* | Most protruded point on the tip of the nose |
| *subalare* | *sbal* | Point at inferior limit of each alar base; where the alar base disappears into the skin of upper lip |
| *superaurale* | *sa* | Most superior point of the helix of the ear |
| *stomion* | *sto* | Midpoint of horizontal labial fissure (between gently closed lips with teeth occluded in natural position), which intersects with the vertical facial midline |
| *subnasale* (*soft*) | *s.sn* | Midpoint of the angle at columella base where lower border of nasal septum and surface of upper lip meet |
| *tragion* | *t* | Notch on upper margin of the tragus |
| *tragus* | --- | Lateral and posterior projection of the vertical anterior border of the external auditory meatus |

Table 1: Facial landmarks.

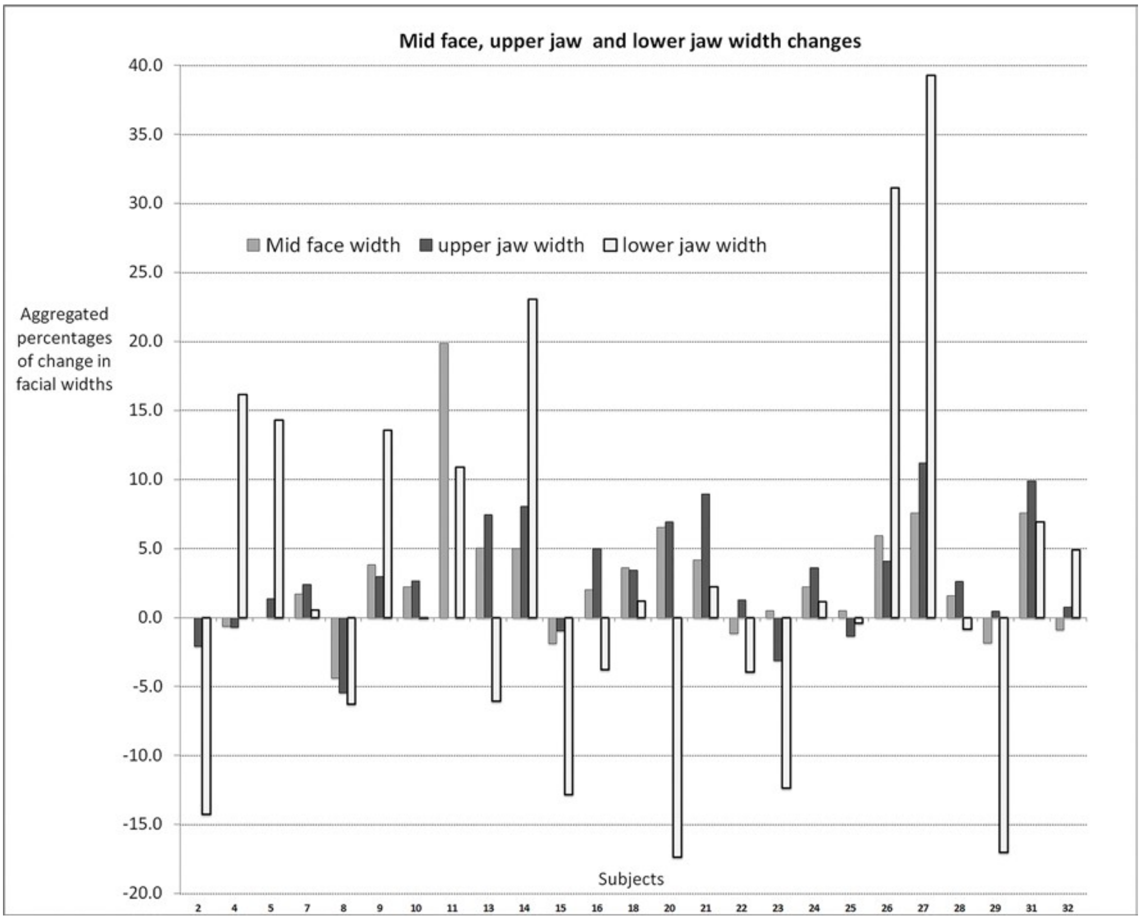


Figure 2. Morphometric comparison of 25 trans male pre- and post-transition face widths.

Interobserver (three observers) and intraobserver (repeated once) tests were carried out for the morphometric landmarks and measurements. Statistical analysis was carried out using GIMP plugin (Schofield, 2011) written for capturing and recording in a comma delimited text file the X Y coordinates of a set of points (the middle of circle landmarks) selected in images. Inter- and intraobserver variation in proportional distance estimations were expressed similarly, as degrees of difference and illustrated graphically using R (R Core Development Team).

In addition to the researcher, eight observers trained in human anatomy assessed the face sex/gender appearance of 22 of the 25 pre- and post-transition subject images for the morphological appraisal and classified the images as either male appearing or female appearing. The number of observers classifying a face as male therefore gave a score of perceived maleness. Three of the original subject cohort did not consent to this part of the study.

## Results

Twenty-five trans males were recruited with a mean age of 39 years and a range of 23 to 59 years. All had taken testosterone for a minimum of 3 years at the time of the 3-D facial scan collection. The earliest age at which subjects started taking testosterone was 17 years and the oldest age was 48 years. The average subject age at start of testosterone was 30.5 years, with the majority (56%) having initiated testosterone usage between the ages of 20 and 40 years. The average time on testosterone was 8.6 years with 44% between five and 10 years. Half the subjects had received an oophorectomy as part of their sex-appearance reassignment surgery.

Among the pre-transition images, 32% were classified as male and 68%, as female in appearance by a majority of observers, while 95.5% of post-transition subject images were assessed as male appearing and 4.5% as female appearing. However, 86% of subjects had an increase in the number of observers classifying their post-transition faces as male compared to their pre-transition image. One subject was already classified as male by all observers in their pre-transition image, one subject demonstrated no change and another subject demonstrated a decrease in male appearance. This facial masculinization result is statistically significant (p=0.0004 significance test).

Among post-transition subjects, 96% had beard shadow/facial hair, 52% demonstrated some degree of hair thinning or male balding pattern and 48% displayed skin texture coarser than that of their pre-transition facial image; 24% had a combination of head hair loss and coarse skin texture, while another 24% had combined head hair loss, coarse skin texture and beard shadow/facial hair. Of post-transition subjects, 44% of post-testosterone subjects showed evidence of adipose tissue migrating from the zygomatic, maxillary and mandibular areas to the oblique/anterior jawline, chin and anterior/lateral neck.

One hundred percent of subjects demonstrated changes in proportional dimensions of the face:

- 72% exhibited a wider post-transition midface, and 28% exhibited a narrower midface.
- 76% of subjects showed a wider post-transition upper jaw and 24% were narrower.
- 52% showed a wider post-transition lower jaw and 48% narrower.

Not all the subjects could be assessed for nasal width due to image quality or view. Of all subjects measured (n = 18), 100% showed a narrower post-transition nasal width at the alae (mean -8.36%) (Figure 3). There is a large and positive correlation (r = 0.6) between the number of years spent on testosterone and a decrease in nasal width, and another large and positive correlation (r = 0.63) between the age of subjects at scan collection and the decrease in nasal width. A very large and positive correlation (r = 0.891) was seen between the change in proportional dimensions of the midface width and that of upper jaw width (Table 2).

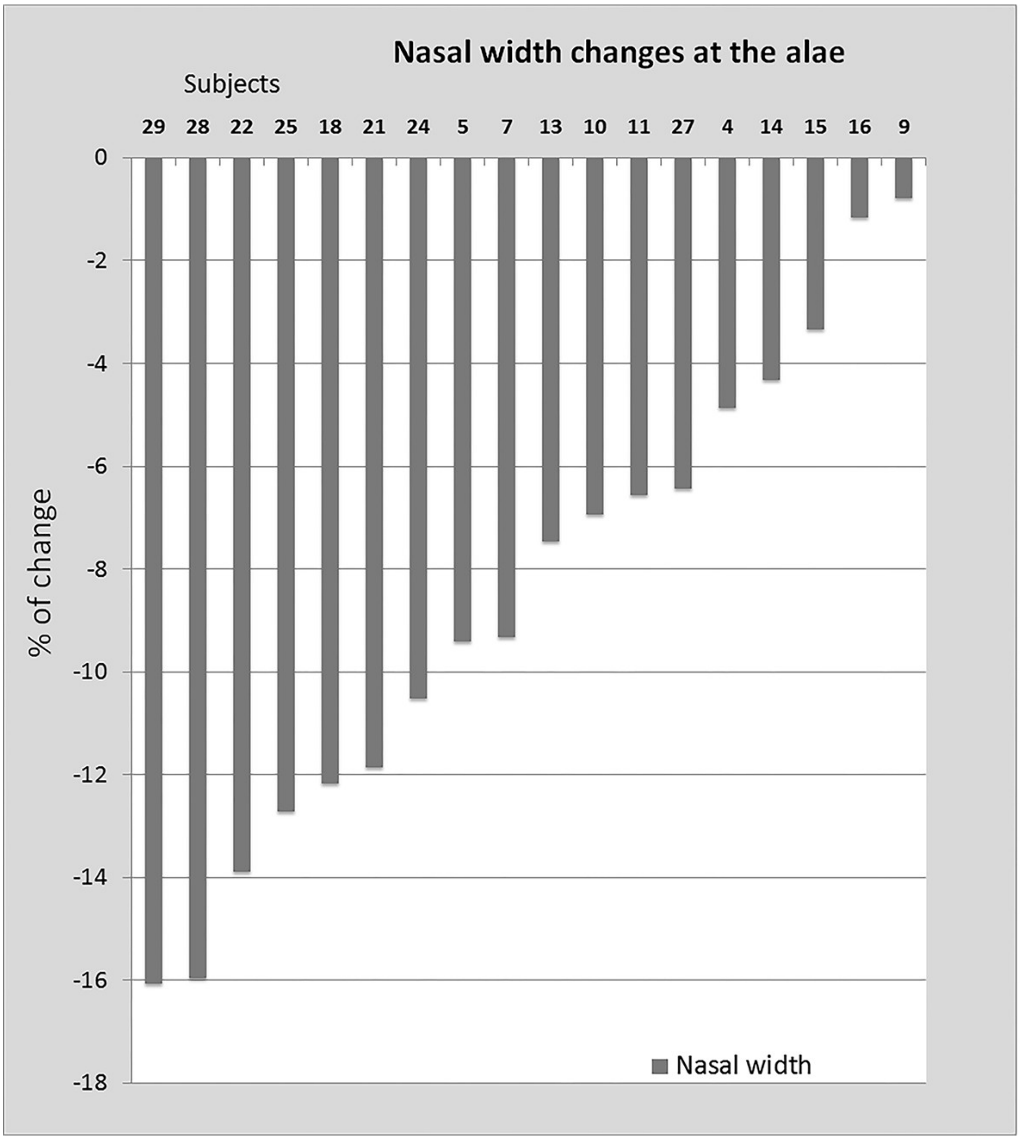


Figure 3: Morphometric comparison between pre- and post-transition trans male nasal widths.

| Value | Correlation | % facial change | R value |
|---|---|---|---|
| Age at start of testosterone | | upper jaw width | 0.46 |
| | | lower jaw width | 0.43 |
| | | mid face width | 0.06 |
| | | nasal width | 0.39 |
| Age at scan | versus | upper jaw width | 0.41 |
| | | lower jaw width | 0.37 |
| | | mid face width | 0.05 |
| | | nasal width (*alae*) | 0.63 |
| Years on testosterone | | upper jaw width | -0.08 |
| | | lower jaw width | -0.06 |
| | | mid face width | -0.10 |
| | | nasal width (*alae*) | 0.60 |

Table 2: Correlation statistics between facial change and age of subject or age at the start of testosterone application.

The intra-observer trial showed that 90% of landmark placements had 0.5 mm accuracy, and 100% of distance estimations had 0.5 mm accuracy. Cohen's (1968) weighted Kappa indicated high intraobserver agreement and low *P* values in both instances indicated high significance.

Interobserver trials showed a mean error of 0.4 mm (deviance from mean placement) where 58% of placements showed less than 0.5 mm and 95.9%, less than 1.0 mm of error. Interobserver distance estimations show that 78% were within a tolerance of 1.5 mm error (when half of two landmark circles measuring three mm in diameter overlap) from the mean.

# Discussion

The aim of this research was to document changes in the facial appearance of FtM transsexual individuals under the influence of exogenous testosterone during transition. Implicit was the assumption that in such a cohort a virilised appearance can be attributed to the effects of testosterone, an idea based upon the current general understanding of the function of androgen, the observations of endocrinologists and gender specialist clinicians who monitor hormonal transition in trans males (Gooren & Giltay, 2008; Van Caenegem et al., 2012; Wierckx et al., 2012), and the experiential testimony of trans males. This study documents for the first time facial changes in a unique population, producing the first such data about a transformation with far-reaching social ramifications and potential for further research.

The faces of trans men examined here demonstrate obvious effects of virilisation. In qualitative assessments, 86% registered an increase in the number of male classifications compared to their pre-transition images. This reflects a greater variability in the perception of face sex appearance for pre-transition subjects rather than post-transition subjects. Three ambiguously assessed pre-transition subjects (ratios of 5 male/4 female; 5 male/3 female/1 androgynous; and 6 male/3 female) all recorded an increase (scores of nine, nine, and eight respectively) in the number of male classifications post-transition. One post-transition subject demonstrated some ambiguity (ratio of 6 male/3 female) having previously been assessed as unambiguously female in the pre-transition image (8:1).

Quantitative analysis demonstrated regional alteration in widths, the most common being a widening of the upper jaw in 76% of subjects and of the lower jaw in 52%. Given that the jaws are an important feature in the perception of face sex, these increases in dimensions of facial widths may contribute significantly to the faces of post-transition trans men appearing male. The key quantitative finding was the mean reduction in nasal width of 8.4% at the level of the alae, which was unrelated to normal ageing or BMI variation, and may arise from fat re-deposition, an acknowledged effect of exogenous testosterone usage in females. The width changes to the mid- and lower face are likely due, in part, to an increase in muscle mass associated with the introduction of a testosterone based physiology.

The effects of facial virilisation included beard growth (96%), male pattern balding (52%), and coarse skin texture (48%). In trans men the addition of beards or beard shadow and male pattern balding are vital contributions to a definitive male appearance, irrespective of size or robusticity: "Even a very feminine-shaped face would presumably be categorized as male if there is any evidence of beard growth" (Burton at al., 1993, p. 174).

Twenty-four percent of subjects became heavier in the face, while 16% became thinner and 44% showed fat migration inferiorly toward the chin, jawline and neck; and this made it difficult to differentiate exogenous testosterone-induced facial changes from the effects of ageing. What can be said of ageing trans male faces in this study is that they appear as older men *not* as older women. The appearance of comparatively deeply set eyes (as accentuated by ageing skin and weight gain), coarse skin texture, increased skin floridity, increased neck width, larger appearing noses and ears, and bushier eyebrows, are effects of ageing that are documented as sexually dimorphic in human faces (Albert, Ricanek, and Patterson, 2007). As the result of a testosterone based physiology (Zimbler, et al., 2001), these effects contribute to making the faces of trans men appear male.

A component of facial gender appearance is a quality described as *intention*. Though sometimes difficult to qualify and impossible to quantify, it is integral to facial expression. Theoretically, gender is an internal positioning (Devor, 2004) of a personal life schema, which in transsexual individuals, is made external by transition. Perhaps the intention of the gendered self, as perceived by observers, whether consciously or unconsciously (Bruce & Young, 1998), complements the physical changes brought about by testosterone. If some of the habitual facial expressions of femaleness - such as the smile, a set of the jaw, head position - are retired during transition (Rachlin, 2002), what may emerge is a new repertoire of expressions that correlate with an affirmed (male) gender and sex appearance (Bruce & Young, 1998).

## Limitations and future research

Limitations of this study include the small cohort and the poor availability and quality of pre-transition images. The justification for using photogrammetry was based upon the practical reality that if pre-testosterone facial images were to be collected for this cohort, the only method available was to solicit images from personal photograph collections. Ideally, a complete set of standardized facial images suited to comparative analysis would be collected, including left and right 45- and 90-degree perspectives and a forward-facing view. The majority of images available from the personal photo collections of subjects were facing-forward images because this is how people most often pose for photographs. Some subjects who wished to participate in the study could not because all photographs from their pre-transition life had been destroyed. In some instances, parents of subjects were still in possession of relevant images that were inaccessible due to the breakdown of family communication.

Further research should include a longitudinal study using 3-D data for both pre- and posttestosterone images rather than relying on donated and unstandardized facial images. This, in conjunction with a larger cohort, would allow the production of a prediction algorithm to enable pre-transition trans men to visualize the potential changes to their face related to testosterone treatment.

It was not possible to determine if there was a link between the facial changes and alterations to the facial skeleton related to testosterone; this remains theoretical until further research can include the analysis of pre- and post-transition CT scan data. Nor is it possible, based on the data gathered here, to hypothesise whether gonadectomy in subjects increases the effect of exogenous testosterone – either in the body generally or upon facial change. The researcher is unaware of any comparative data that addresses this question.

Separating the collateral effects of facial ageing in trans males from testosterone induced masculinisation could be addressed by assessing subjects in age ranges where ageing effects over time are minimized. Subjects who begin using testosterone by the age of 18 to 20 years and are examined by the age of 23 to 25 years, would act as a form of control by reducing the grosser morphological deteriorations that ageing present.

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