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Assessment of Influence of Age, Sex and BMI on Facial Soft Tissue Thickness Measurements Among Kanpur Population

Anuradha Katiyar*, Gayathri Ramesh

Department of Oral and Maxillofacial Pathology, Rama Dental College Hospital and Research Centre, Kanpur, 208024, Uttar Pradesh, India

Address of Correspondence: Anuradha K, Department of Oral and Maxillofacial Pathology, Rama Dental College Hospital and Research Centre, Kanpur, Uttar Pradesh, India; E-mail: dranuradha920@gmail.com

1. **ABSTRACT**

Background: Forensic facial reconstruction (FFR) is a mixture of science and art, as it attempts to re-establish the contours of the soft tissues over the skull. From a forensic point of view, identification of an unknown body relies heavily on this visual aspect of recognition. Accurate facial soft tissue thickness data are essential for acceptable results.

Facial reconstruction (FR) relies on the relationships between the facial features, subcutaneous soft tissues and underlying bony structure of the skull. If impossible to compare questioned remains with possible familiar material, in such cases one of the last chances is to recreate ante mortem appearance is by FR.

Within forensic anthropology facial reconstruction is employed when all other alternatives are unsuccessful, thus it is a last resort employed in the anticipation that someone, somewhere, will be able

to identify the deceased and offer clues to law enforcement investigators which ultimately lead to an arrest.

Aims & objectives:

Material & Method: The study was conducted among patients of Kanpur district reporting to the dental OPD of Rama Dental College Hospital and Research Center, Kanpur, Uttar Pradesh. In this study, lateral cephalometric radiographs of 100 healthy individuals were taken for 50 North Indian males and 50 North Indian females. All of them were aged between 15 and 40 years. Ethical approval was obtained from the ethical committee of Rama Dental College Hospital and Research Center, Kanpur, Uttar Pradesh.

Results: Student's t-test was applied to assess association between facial parameters and gender. The p-value of <0.05 was considered to be statistically significant. Of all the parameters, facial angle, upper lip curvature, Nose tip to H-line, and Upper lip sulcus did not show any statistical association between male and female groups. Skeletal convexity Pta, H-angle, and Lower lip to H-line was found to be greater in females than males and the difference was statistically significant. Upper lip strain, upper lip thickness, lower sulcus depth, and soft tissue chin thickness were parameters that had greater values in males as compared to females and this difference was also found to be statistically significant.

ANOVA test was applied to assess the facial parameters between the age categories. The facial angle was reported highest in the 31-35 years age group and lowest in 21-25 years age group. However the difference in facial angle values was not statistically significant between the age groups. The remaining parameters showed a statistically significant difference between age groups and so a post hoc test was applied to present the association between each age groupin the individual parameters. The post hoc test is presented and explained below.

Difference in Upper lip curvature was statistically significant between 15- 20 age group with 26-30 and 31-35 age groups, 21-25 with 36-40 age groups. H-angle was found to be statistically different between 15-20 and 31-35 years age group, 21-25 and 31-35 age group and 26-30 and 31-35 age groups. The upper lip thickness was found to be statistically different between 15-20 and 26-30 age group, 15-20 and 36-40 age group, 21-25 and 36-40 age groups. The upper lip strain was markedly significant when age groups 15-20 and 26-30, 21-25 and 26-30, 26-30 and 36-40 age groups were compared. The difference between lower lip to H-line was statistically significant between 15- 20 age groups versus all other groups, 21-25 versus 31-35 and 36-40 age groups, and 26-30 and 31-35 age groups. Also, in soft tissue chin thickness, statistically significant differences were found between age groups 15-20 and 26-30, 31-35 and 21-25 with 26-30, 31-35, 26-40 and between 26-30 and 36-40 age groups

ANOVA test was applied to assess the facial parameters and their association among the different groups as categorized by BMI categories. Of all the parameters, Facial angle, Upper lip strain and lower sulcus depth did not present any statistical variation as per BMI. The remaining parameters where BMI

categories showed statistically significant difference between each other were further analysed by using post hoc test and is presented below.

Post hoc analysis for Upper lip curvature showed significant difference in <18.5 BMI and 25-29.9, 35-39.9 and30-34.9 with 18.5–24.9, 25-29.9 and 35-39.9. Skeletal convexity Pta differed significantly in <18.5 with25-29.9 and 35-39.9with 18.5–24.9 and 30-34.9. BMI categories showed statistical difference between all categories except between 18.5–24.9 and 25-29.9, 30-34.9 BMI and 30-34.9 with 35-39.9 in case of H-angle. Nose tip to H line was statistically different for 35-39.9 with all other categories. Upper lip sulcus was found to be different in 35-39.9 BMI to all other categories and additionally <18.5 BMI was also different from 18.5–24.9 and 25-29.9. Upper lip thickness was measured to be statistically different for 25-29.9 BMI with <18 and 30-34.9, while 35-39.9 BMI differed with <18, 18.5–24.9and 30-34.9. Lower lip thickness was statistically variable only between<18.5 and 35-39.9. Lastly, soft tissue thickness showed a significant difference in BMI for<18 and 18.5–24.9 with 25-29.9 and 35-39.9 BMI respectively.

Conclusion: In our study of all the parameters, facial angle, upper lip curvature, Nose tip to H-line, and Upper lip sulcus did not show any statistical association between male and female groups. Skeletal convexity Pt A, H-angle, and Lower lip to H-line was found to be greater in females than males and the difference was statistically significant. Upper lip strain, upper lip thickness, lower sulcus depth, and soft tissue chin thickness were parameters that had greater values in males as compared to females and this difference was also found to be statistically significant.

This study focused on evaluating soft tissue profile of Kanpur individuals according to Holdaway analysis. The results revealed that some measurements were different from those proposed by Holdaway including; facial angle, H angle, upper lip curvature, nose tip to H line and upper lip sulcus. These differences disclose the importance of using normative data established for Kanpur population in forensic reconstruction.

After analysing the effect of BMI on facial soft tissue thicknesses, this study states that the nutritional status of the individuals is an important factor to consider during facial reconstruction from skulls, as well as in studies on soft tissue thicknesses.

2. Keywords: BMI, Holdaway analysis, Forensic facial reconstruction (FFR)

3. INTRODUCTION

Forensic facial reconstruction (FFR) is a mixture of science and art, as it attempts to re-establish the contours of the soft tissues over the skull. From a forensic point of view, identification of an unknown body relies heavily on this visual aspect of recognition. Accurate facial soft tissue thickness data are essential for acceptable results [1].

Facial reconstruction (FR) relies on the relationships between the facial features, subcutaneous soft tissues and underlying bony structure of the skull. If impossible to compare questioned remains with possible familiar material, in such cases one of the last chances is to recreate ante mortem appearance is by FR [2].

Within forensic anthropology facial reconstruction is employed when all other alternatives are unsuccessful, thus it is a last resort employed in the anticipation that someone, somewhere, will be able to identify the deceased and offer clues to law enforcement investigators which ultimately lead to an arrest.

Anatomists were the first people to become interested in facial reconstruction as an ‘‘academic exercise’’. The German anatomist took facial tissue depth measurements from a small number of cadavers and used those measurements to model a face onto a plaster cast of the skull of the composer Johann Sebastian Bach in 1895, demonstrating favorable results when compared to Bach’s portraits. In 1898, Dante’s face was reconstructed by Kollman using a similar methodology. His and Kollman both used sculptors to produce their three-dimensional reconstructions. In 1899, Kollman went on to reconstruct the face of a stone-age woman from Auvenier, France, which is considered the ‘‘first real scientific reconstruction,’’ because Kollman used soft tissue thickness measurements from local women and used a technical plan to carry out the reconstruction [3].

In 1926, McGregor of Columbia University was the first person to carry out facial reconstruction in the United States and one of the first to employ a half-face reconstruction technique on prehistoric human skulls in which half of the face was sculpted onto the skull, while the other half of the skull was left bare, to give the viewer a better idea of the relationship between the finished face and the underlying bony structure of the skull. Soon after, these methods began to be applied in forensic cases, although this method of identification would not become popular until after 1960. The Russian anthropologist Gerasimov is credited with pioneering the Russian or anatomical method of three-dimensional facial reconstruction in which the face is re-built muscle by muscle, without the use of tissue depth measurements [3].

Facial reconstruction cannot be used as a primary identification method. It is a useful auxiliary technique for the identification of human remains when the skeletal remains cannot be identified by DNA analysis, fingerprint comparison, or radiographic and dental records examination. It may be conducted as a last resort. During procedures of manual and computer-assisted two-dimensional and three dimensional facial reconstruction techniques, FSTT becomes important as most facial characteristics are lost or damaged when the skull is found. FSTT can be measured by many methods including puncture, X-ray, computed tomography (CT), magnetic resonance imaging (MRI) and ultrasonography [4].

Cephalometric norms for various ethnic and racial groups have been established in many studies. Most investigators have emphasized about significant differences between ethnic and racial groups, and many cephalometric standards have been developed for various ethnic groups. These racial groups must be treated according to their own characteristics [5].

In reference to such practical need of soft tissue evaluation, many assessment methods of soft tissue profile were introduced including, Holdaways, Ricketts, esthetic plane and Burstone's [1959] soft tissue analysis. Amongst which Holdaways (1983) has attempted not only to quantify soft tissue features contributing to better treatment planning, but also has addressed the main profile characteristics of the lower and middle third structures and also relates its finding to the facial upper third [6].

Holdaway (1983) emphasized the importance of quantitating soft tissue features in orthodontic treatment. He noted that "Usually as we correct malocclusion, we bring about changes in appearance that are pleasing to all concerned [5].

Holdaways measurements which were obtained from his patients have been applied to American movie stars, beauty queens and contestants [7].

Using the Holdaway soft‑tissue analysis [8]. reported that most Turkish adult measurements were similar to white norms. Mafi *et al* [9] studied the soft‑tissue facial profiles of Iranian women and found some significant differences compared with white women. Because the norms for one ethnic group might not fit for others, in the present study, we aimed to develop soft‑tissue cephalometric norms [10].

Previous studies have suggested that there is significant variation in facial tissue thickness between different populations. Databases of facial soft tissue thickness are available for the Turks, Indians, and Slovak. Some studies suggest that different body type (overweight, normal, underweight) plays an important role in facial reconstruction [11].

Facial soft tissue depth charts are used in the majority of FR methods. In the past a number of hypotheses were advanced concerning the impact of body mass index (BMI) and age on the depth of tissues. Although the use of different tissue depths with regard to body composition has minimal effect on the overall pattern of facial form, it significantly affects the subjective assessment, which suggests that variation in weight (BMI) may be an important contributor to the ability to achieve correct recognition of a reconstructed face. Apart from the wrinkling and texturing in the final stage of the process of facial reconstruction, alterations of the properties such as corpulence, age and sex, further referred to as attributes, are based on facial soft tissue depth tables. Hence this study will be undertaken to assess the influence of age, sex and BMI on facial soft tissue thickness measurements among Kanpur population [12].

4. Aim of the study:

Assessment of influence of age, sex and BMI on facial soft tissue thickness measurements among Kanpur population.

Objectives of the study:

1. To evaluate the soft tissue thickness parameters using Holdaway Analysis, for Kanpur Population.

2. To compare the soft tissue thickness parameter values in relation to gender

3. To compare the soft tissue thickness parameter values in relation to age

4. To compare the soft tissue thickness parameter values in relation to BMI

5. To establish the relationship of soft tissue thickness values with sex, age and BMI among Kanpur population.

5. MATERIAL AND METHOD

5.1 PATIENT SELECTION: The study was conducted among patients of Kanpur district reporting to the dental OPD of Rama Dental College Hospital and Research Center, Kanpur, Uttar Pradesh. In this study, lateral cephalometric radiographs of 100 healthy individuals were taken for 50 North Indian males and 50 North Indian females. All of them were aged between 15 and 40 years. Ethical approval was obtained from the ethical committee of Rama Dental College Hospital and Research Center, Kanpur, Uttar Pradesh (File No./02/IEC/RDCHRC/2014-15/001).

Residents of Kanpur district without any mixed population for last three generations were included in the study. Inflammatory or infected lesions, soft tissue and bone masses, cystic lesions and congenital anomalies were excluded from the study.

5.2 ARMAMENTARIUM:

- Kodak X-ray films (8″ × 10″)
- Acetate tracing sheets of 0.003 inch
- Pencil
- Millimeter scale
- Sharpener
- Eraser
- Protector

5.3 Methodology/Collection of data:

The cephalograms were obtained over a universal counter balancing type of cephalostat with the Frankfort horizontal plane parallel to the floor and the teeth in centric occlusion with relaxed lips. Kodak X‑ray films (8″ × 10″) were exposed at 70 kVp, 40 mA for 1.8 s from a fixed distance of 60 inches [Figure 4 and Figure 5]. The lateral head cephalograms were traced on acetate tracing sheets of 0.003 inch in thickness using a sharp 4H pencil over a view box using transilluminated light in a dark room and any stray light radiations were eliminated. Cranial registration marks were traced on the acetate tracing sheets after marking them on the cephalogram [Figure 3]. Only good qualities of lateral cephalograms were taken for the study. The following soft‑tissue cephalometric measurements were taken for establishing soft‑tissue norms of North Indian ethnic population using Holdaway analysis: Soft‑tissue facial angle, nose prominence, superior sulcus depth, soft‑tissue subnasale to H line, skeletal profile convexity (A to N‑pog), upper lip thickness, upper lip strain measurement, H‑angle, lower lip to H line, inferior sulcus to the H line, and soft‑tissue chin thickness.

The lateral cephalometric radiographs of 100 healthy individuals (50 males and 50 females) in the age group of 15-40 years were taken in the Dept of Oral Medicine and Radiology, Rama dental college, hospital and research centre, Kanpur.

The sample were put into five age groups (15-20, 21-25, 26-30, 31-35, 36-40) and each group consisted of 20 individuals.

After subjecting the study subjects to lateral cephalographs, demographic characteristics of the patients such as age, sex, weight and height was recorded. Height was calculated with the help of measuring tape and weight was measured with the help of weighing machine. Body mass index was calculated by placing the height and weight at the formula (kg/m^2) [Figure 6].

If the right and left structural outlines were lacking in superimposition on each other, then the average between the two was drawn by inspection and thereafter cephalometric points were located to the arbitrary line. The linear and angular measurements were made to the nearest 0.5 mm and 0.5°, respectively, with the help of scale and protractor.

The following measurements were analyzed using the definitions provided by Holdaway [Figure 1]:

1. **Soft tissue facial angle:** is the downward and inner angle formed between FH and a line drawn from soft tissue nasion, where S–N line crosses the soft tissue profile, to soft tissue chin.
2. **Nose prominence:** the distance between the tip of the nose and a perpendicular line drawn to the FH plane from the vermilion of upper lip.
3. **Upper lip sulcus depth (upper lip curl):** the distance measured between the upper lip sulcus and a perpendicular line drawn from the vermilion of upper lip to the FH plane.
4. **Soft tissue subnasale to H line:** the measurement from subnasal point to the H line.

5. **Skeletal profile convexity:** the distance between point A and the skeletal facial plane. The distance was denoted as positive when point A was ahead of the facial plane, and as negative when point A was behind the plane, and as zero when point A was on the plane.
6. **Upper lip thickness:** the distance between labrale superius and the labial surface of maxillary incisors.
7. **Upper lip strain:** the difference between the basic upper lip thickness and the upper lip thickness.
8. **H angle:** the angle formed between the soft tissue facial plane and the H line (the tangent drawn from the tip of the chin to the upper lip).
9. **Lower lip to H line:** the distance between labrale inferius and H line. The distance was denoted as positive when the vermilion point was ahead of the H line, as negative when it was behind the line, and as zero when it was located on the H line.
10. **Inferior sulcus to the H line (lower lip sulcus depth):** the distance measured at the point of greatest convexity between the vermilion border of the lower lip and soft tissue chin measured to the H line.
11. **Soft tissue chin thickness:** the distance between the skeletal and soft tissue facial planes at the level of Ricketts' supra-pogonion.

All collected data was analyzed using SPSS software and appropriate statistical tests were applied. Data was classified by differences between age, sex and BMI groups. The mean, standard deviation and range was calculated for all land marks.

DISCUSSION

Facial reconstruction is currently used in two principal contexts: forensic science and archaeology. In the forensic context it plays an important role in identification of the dead where post-mortem deterioration has made this problematical. In archaeology, it is used to create three-dimensional visual images of people from the past, from skeletal remains, mummified bodies, or bodies preserved in bogs [62].

When no link can be found between the post-mortem file of unidentified human remains and the available ante-mortem files of reported missing people, dissemination of information concerning the victim to the public can be considered in order to redirect the investigation toward a potential identity. Different forensic facial imaging techniques are available to attempt to depict the facial appearance of the individual. One of these techniques is cranio-facial approximation, which consists of (re-) creating the face of the individual based on its skull. Recently, this method gained popularity through the media, as well as scientific recognition as indicated by the number of peer-reviewed papers published in the scientific literature. Cranio-facial approximation is based on a correct application of rules of thumb in combination with facial soft tissue depth data, two components that allow quantification and thus repeatability. Rules of thumb define the correct position of eyes, nose, mouth and ears, and soft tissue depths determine the shape of the facial tissue envelope. The impact of the facial soft tissue depths has been repeatedly questioned for two main reasons. Firstly, only tissue depths averaged over a subcategory of the population are used for all the skulls. Secondly, anthropological assessment of age, sex or ethnic origin of the skull is imperfect, not to mention the difficulty of accurately determining the corpulence from skeletal remains. Studies on the use of inappropriate tissue depths are rather limited. Two studies were performed on the effect of using datasets of a non-matching ethnical group. Aulsebrook and Van Rensburg showed that strict adherence to the traditional tissue depths for White Europeans and Black Africans in the reconstruction of a skull of mixed racial origin compromised the accuracy of the facial approximation [12].

Wilkinson (2002) [24] et al. applied the Manchester method to produce six different approximations of the same skull based on data of different ethnic groups and used resemblance ratings and photographic superimposition to score them. The tissue depth data of the proper ethnic group of the skull gave the best results, but reasonable resemblance was also obtained even with the tissue depths of other ethnicities. They suggested that strict adherence to the exact tissue depths should be avoided and that the morphology of the skull and the anatomy should be followed with tissue depth measurements being used only as guides. A view on which apparently even pioneers such as Gerasimov, whose morphologic method was claimed to be based only on the anatomical structures, and Krogman, whose morphometric method rested only on tissue depths, could have agreed on according to Stephan [12].

Several studies have been performed to set values and norms for harmonious facial soft tissue, and the results have stressed the importance of soft tissue in the diagnoses.[7,63,64,65,66,67,68] Holdaway (1983) [63] attempted to express quantitatively those soft-tissue relationships that are pleasing and harmonious, as well as those that are not.

Until the mid-1980s, most studies on soft tissue thicknesses employed the needle puncture method on cadaveric samples. However, in the last two decades, several imaging-based methods, including cephalometric radiography, ultrasonography, computed tomography (CT), and MRI have permitted measurements to be taken on living individuals. As the software performance/quality has advanced, so too has the display technology improved, which can now reconstruct three-dimensional (3D) images of the skull and face using spiral CT data on personal computers. Several studies have measured facial soft tissue thicknesses based on reconstructed CT images, and the similarities as well as differences between this method and the needle puncture method have been evaluated [1].

Many studies have established cephalometric norms for different ethnic and racial groups, with most investigators concluding that there are significant differences between diverse groups. All of these studies indicate that what is considered to be a ‘‘normal’’ measurement for one race or ethnic group may not be considered normal for other groups [7, 68-76].

The purpose of the present study was to add new data to the existing literature and propose average soft tissue thicknesses of the Kanpur population, taking individual age, sex and BMI into account. These results would be useful in forensic science as well as other research applications.

Age related observations

In our present study when association between Age and Facial parameters was assessed we observed that facial angle was highest in the 31-35 years age group and lowest in 21-25 years age group. However the difference in facial angle values was not statistically significant between the age groups. There was statistical difference between the upper lip thickness, soft tissue chin thickness and lower lip to H-line between different age groups.

In a study done by Brier's et al (2015) [55] on children below 13 years their results showed statistically significant differences between 9 and 10-year-old age groups at the supra-glabella, glabella and labiomentale. Unexpectedly, STT at all three landmarks were larger for the 9-year-old group compared to the 10-year-old group and ranged between 0.69 mm and 1.32 mm. Significant differences were also seen between the 10 and 13-year-old groups at the labiale inferius and labiomentale. STT at these landmarks was larger in the 13-year-old group compared to the 10-year-old group. In practical terms few significant differences were seen between age groups and the STT increased at only at two landmarks with age [55].

The correlation between facial soft tissue thickness and age was also observed in the study by Petra Panenková mostly at forehead region, nose region, eyes and cheek region. The negative correlation with increasing age was observed at mouth zone. According to the author these differences were probably more influenced by body constitution than age [77].

According to Tng Ching Hwa landmark located at the periorbital region, which supposedly has a sunken look on the aging face that one would normally associate with the atrophy of soft tissue. However, the result shows that the soft tissue thickness decrease from the young to middle age group, and then increase from the middle to old age group. The change in the dimensions of the orbital rim might be one of the factors that offset the effect of atrophy and migration of soft tissue [78].

Wilkinson (2004) [79] stated that the age-related changes in tissues at the mouth and lower cheek tend to decrease with age, and tissues at the chin and eyebrow may increase with age. Similar results were obtained in a study by Greef et al. (2009) [12]. But increase was observed in inferior malar and the mid mandibular angle and decrease in the occlusal line and mid masseter muscle. An explanation for these local differences attributed on the role of fat on the ageing face and they concluded that the ageing face can be analyzed as a change in volume and position of the different fat compartments, both superficial and deep [12 78-79].

In a study done by Chen et al (2011) [80] found both craniofacial soft tissue thickness (CFSTT) and nasal profile showing good correlation with age. The thickest CFSTT of male and female were found at the respective ages of 45–59 and 35–44, and the nasal profile becomes more constant after 24 years of age. CFSTT of the lower part of the face shows greater variation compared to the upper part, so special care needs to be applied when reconstructing the lower portion of the face. The author concluded that the data on CFSTT and nasal profile for the Chinese Xi'an Han population is important in understanding craniofacial characteristics of the Chinese population and might be potentially helpful in forensic identification [80].

In a review done by Ramesh et al (2015) [2] it has been mentioned that, as human age, the facial feature undergoes many changes that we recognize as aging. The significant changes occur around the midface region by the fourth decade. Some of the distinctive features of an aged face include sunken volume around the periorbital region, the increasing prominence of the nasolabial fold and the accumulated folds of skin along the jaw. As the change in volume of subcutaneous fats at various facial points is found to be inconsistent, it suggests that there might be a combination of atrophy and migration of fats [2].

Gender- related observations

A number of facial soft tissue depth studies have been performed since the end of the 19th century, providing the forensic artists with many charts reporting classic statistics of means, medians, standard deviations or ranges for different ethnic groups, subdivided into different categories based on body build, age and sex. Maat and Stephan et al. questioned this sex separation because the variation within each sex was large while the variation between the sexes was small. Stephan and Simpson studied trends and differences across 55 adult studies published between 1883 and 2007 in a univariate way. They suggested that sub-categorization of the soft tissue depth data according to variables such as publication year, method of measurement, race and sex is of little practical benefit given the totality of data uncertainty that exists. Uncertainty caused not only by measurement errors but also by the choice of the measurement method as well as erroneous physical placement and representation of the soft tissue depths on skulls in caseworks. They proposed to pool all the soft tissue depth data available in the literature in order to provide a statistically more powerful and simplified data set involving 25 commonly measured landmarks [12].

Most studies on facial soft tissue thicknesses subdivide their subjects into male and female categories, and show sexual dimorphism in the skull and the facial soft tissues. Nevertheless, Stephan et al. investigated previously published data of sex differences, and found that while soft tissue thicknesses display some sexual dimorphism, it is not marked and is of little practical value for craniofacial identification [1].

In the present study, it was found that in the Kanpur population, males have thicker soft tissues than females at most of the landmarks, similar to other populations. However, based on the statistical analyses, only one third of the soft tissue thickness measurements at these anthropological landmarks were significantly different between males and females. Skeletal convexity Pt A, H-angle, and Lower lip to H-line was found to be greater in females than males and the difference was statistically significant. Upper lip strain, upper lip thickness, lower sulcus depth, and soft tissue chin thickness were parameters that had greater values in males as compared to females and this difference was also found to be statistically significant.

Sexual dimorphism also has been reported for several craniofacial structures in various studies [7, 72-74, 76].

Two studies done on Uttar Pradesh population was available who have used Holdaway's analysis is one by Sachan (2012) [10] et al on North Indian ethnic population which showed that men had greater soft tissue facial angle (92.10°) than women (89.92°). Also, they had more nose prominence (18.10 mm) than women (16.44 mm). Skeletal profile convexity (A to N pog) of men (0.40 mm) was less than women (1.76 mm). Basic upper lip thickness was higher in men (16.60 mm) compared to women (14.24 mm), while H angle was higher in women (16.68°) as compared to men (14.30°). In the lower face area, inferior sulcus to the H line distance was more in men (7.30 mm) than women (4.80 mm). Men had greater soft tissue chin thickness (14.10 mm) than women (12.84 mm). another is by Mehta (2010) [39] et al conducted a study on the population of Lucknow, India using Holdaway's soft tissue cephalometric norms and reported basic upper lip thickness, lip thickness at vermillion border, inferior sulcus to H line distance and soft tissue chin thickness was found to be significantly higher amongst males ($p<0.05$) while lower lip to H line distance was found to be significantly higher amongst females ($p<0.001$).

Perlaza Ruiz has reported no significant difference associated to gender for most anatomical landmarks in Colombian population. However, where differences were found, these were mainly located on the anatomical landmarks of the medial line and particularly with greater value among males [52].

A study done by Hashim (2003) et al [27] showed no statistical significant differences between the Saudi males and females except for the angle of total facial convexity, soft tissue facial plane angle, lower lip length, sagittal nasal tip to the most protrusive lip distance, and also sagittal chin to the most protrusive lip distance. The Saudi females had a greater angle of total facial convexity and soft tissue facial plane angle than the males. In addition, the females had a shorter lower lip. They also had a short distance between the nasal tip and chin to the most protrusive lip.

Saglam (2001) et al [21] reported that all measurements were significant at various levels except for upper lip sulcus depth, subnasal-H line distance, and lower lip H distance in girls, and upper lip sulcus depth, subnasal-H line distance, H angle and lower lip H line distance in boys.

In a study done by Bulut (2015) [4] et al among Turkish sub-adults reported that the boys showed a general increase in tissue thickness with an increase at all the midline and cheek points. The girls showed increased tissue thickness with age at all points except supraglabella, upper lip, frontal eminence, lateral nasal, sub-orbital and supraglenoid.

Study done by Qadir (2008) [5] et al among Iraqi adults revealed a significant sexual dimorphism for upper lip sulcus depth, upper lip thickness, basic upper lip thickness, and soft tissue chin thickness.

According to Yan dong (2012) [1] et al males have thicker soft tissues than females at most of the anthropological landmarks in the Chinese population, similar to other populations. However, only one-third of these differences were statistically significant between males and females.

Fernandes (2013) [49] et al did a comparative study of the soft tissue of young Japanese-Brazilian, Caucasian and Mongoloid patients and found that the Japanese-Brazilian sample of females showed thinner soft tissues in the nasion region and smaller nose when compared to the Caucasians. The Mongoloid sample showed thinner tissues in the supramentonian and pogonion regions. In males, the Japanese-Brazilians had thinner tissues in the nasion region; thicker lower lip and supramentonian region in comparison to the Caucasian sample. For the Mongoloid, soft tissue was thicker in the glabella and ANS-Sn regions.

Taki (2009) [38] et al measured Facial Soft Tissue Values in Persian Adults by comparing men with women, the nose prominence, basic upper lip thickness, upper lip thickness , inferior sulcus to H line , and soft tissue chin thickness were significantly increased in Persian men compared with Persian women.

These studies show definitive differences in the STT values among different populations and between different genders.

BMI related observations

Forensic facial anthropology is the interpretation of human remains to attempt to depict the face of the individual. [79, 81-83] It is a powerful tool that significantly enhances the chances of identification of the deceased. Following major natural disasters, such as the Tsunami of 26 December 2004 and Hurricane Katrina of August 2005, human remains may be extremely difficult to recognize due to decomposition or environmental effects; clothing and personal items may be lost and dental records unavailable. [84] Skin colour is altered by early pallor or later rigor mortis, putrefaction and epidermal sloughing; eye colour quickly becomes indistinguishable as decomposition of the eyeballs begins immediately after death, and hair pattern may be uninformative due to hair loss at the roots or tissue shrinkage. [85] In addition, water movement, body movement, rigor mortis, environmental pressure and animal activity can cause feature distortion or surface marks. [86] The jaw of the cadaver may become slack due to the relaxation of the muscles of mastication, and the outer canthal angle of the eye may appear upturned due to a combination of the effects of gravity and rigor mortis of the lateral palpebral ligaments. [87] Gas production from putrefaction will bloat the body and the eyelids and lips become closed and swollen; the cheeks puff out, and the distended tongue may protrude between the lips.[88] Even where facial preservation is sufficient for recognition by a family member to be attempted, the emotional circumstances result in many examples of false recognition. [89] Ten percent of victims of the Tsunami and fifty percent of victims of the Bali bombing of 12 October 2002 were wrongly identified by facial recognition. [90] The social, legal and religious implications of misidentification are enormous. International investigative authorities advocate that it is vital to identify the deceased to allow remains to be returned to their families for proper recognition and religious observance, for grieving and acceptance of death and for judicial matters of estate.[90] With mass disasters such as these, the usual accepted methods of identification are often inappropriate and the importance of unusual and less definitive methods of identification has been recognized [27].

According to Panenková et al (2012) [76], the age does have influence on facial soft tissue thickness, and it is likely that weight would have bigger influence.

Tng Ching Hwa emphasized that, one of the limitations of his study was that weight of the subjects was not included in the scope, hence the readings from a few subjects were observed to have either much larger or smaller thickness reading than the rest of their age group [77].

In two different studies by Utsuno et al (2010) [40] and Dong et al (2012) [1], have reported that few soft tissue depth variations with body weight and body mass index (BMI), but the use of different tissue depths with regard to body composition has minimal effect on the overall pattern of facial form. They also state that it significantly affects the subjective assessment, which suggests that variation in weight may be an important contributor to the ability to achieve correct recognition of a reconstructed face [1, 40].

According to Greef et al. (2009) [12] the impact of the body composition, on facial STT depends on two important aspects: (a) all tissues are thinner for emaciated compared to well-nourished people with the exception of the nasal bridge, and (b) the landmarks differing most are the chin, mandible and cheek region. In his study the cheek and mandible zone were the most influenced by the BMI.

Starbuck and Ward chose to examine the facial variations associated with body weight within the same ethnic group as well as its effect on facial recognition. They manually created an emaciated, normal and obese face on three casts of the same skull by using the American method and applying different tissue depth data. Morphological variation was measured quantitatively, using the anthropometric craniofacial variability index, as well as qualitatively using survey data that assessed the subjective appearance of similarity among photographs of the three faces. The qualitative data appeared in opposition with the quantitative data. They concluded that, although the use of different tissue depths with regard to body composition has minimal effect on the overall pattern of facial form, it significantly affects the subjective assessment, which suggests that variation in weight may be an important contributor to the ability to achieve correct recognition of a reconstructed face. To cope with this issue the authors proposed to generate multiple versions of the face, bringing us back to the role of the soft tissue depth data in the approximation process. Indeed, apart from the wrinkling and texturing in the final stage of the process, alterations of the properties such as corpulence, age and sex, further referred to as attributes, are based on facial soft tissue depth tables [12].

Facial soft tissues fluctuate in accordance with the nutritional condition of the individual, and facial variations resulting from different body types may limit the effectiveness of facial reconstruction. Several studies incorporated three body type categories (slender, normal, and obese) into their assessments of soft tissue thicknesses and found that body mass index (BMI) was a major contributing factor in accurately determining differences in facial soft tissue thicknesses between individuals. Consequently, future studies in facial recognition now demand consideration of the different BMI categories when estimating soft tissues thicknesses [1].

In the present study of all the parameters, Facial angle, Upper lip strain and lower sulcus depth did not present any statistical variation as per BMI. The remaining parameters where BMI categories showed statistically significant differences.

Johari Masoume (2014) [11] et al conducted a study among Iranian population showed that in some landmarks, significant differences were found between underweight, normal and overweight patients. In the most cases, facial soft tissue thickness increased with increased BMI. Only inferior malar point thickness decreased by increasing BMI.

Study done by Yan Dong (2012) [1] et al among northern Chinese adult population showed that the soft tissue thickness measurements increased with increased BMI levels for both sexes at each landmark, and the statistically significant differences were depicted between the different BMI categories at most of the landmarks.

According to the review by Ramesh et al. (2015) [2] questioning as to is it enough if norms are set for STT, the authors conclude that there is also no way to tell which method provides the best resemblance of the true STT of humans, but refinement of the methods, additional data and larger samples, including regional variations, as well as practical and identification tests on this data, should further support the reliability of the soft tissue values used in reconstructions. They also emphasize that prior to application of STT in facial reconstruction STT norms set among any population different age groups including ageing changes, gender, different skeletal malocclusion classes, weight and body mass index, population selected should not be from mixed family at least for three generations and standard method for analysis should be considered [2].

Possibility to describe and predict all the huge amount of face variations may not be possible, Nevertheless, it is necessary to study relationships between cranial and facial features to obtain nearly acceptable resemblance to the victim.

CONCLUSION

In 1946, the anthropologist Wilton Krogman, aided by sculptors, began studies into the accuracy of facial reconstruction techniques. Using tissue depth data appropriate to the sex and racial origin of individual skulls, Krogman's sculptors were able to reproduce faces that resembled photographs of the individuals in life, thus Krogman concluded that three-dimensional facial reconstruction could be a useful tool in forensic identification. In 1946, Krogman published the FBI Law Enforcement Bulletin; an account, for the FBI, of how facial reconstruction ought to be carried out [3].

Data regarding age, sex and body build are generally limited.[42]The present study measured facial soft tissue thicknesses of Kanpur population, taking age, sex and BMI into account. These values should be useful for facial reconstructions as well as other research or forensics applications [1].

Simply finding linear dimensions that match is not in itself sufficient. There are many people who can wear a size 42 coat but each one fills it differently. We should be looking at the relationship between the smaller shapes. Much like Cinderella's glass slipper, that fitted one foot only, we should be looking for shapes that fit into other shapes. The zygomatic bone should fit into the overlying upper cheek as an anatomical pair rather than simply have enough room to be contained within its limits. In addition, it must not simply 'look' right. To convince the courts we must be able to give values to our opinions: numerical statistics of shapes that have been compared for fit [4].

In my study I made an attempt to understand the various soft tissue depth data pool for facial reconstructions. I collected facial tissue depth measurements with lateral cephalograms of individuals living in Kanpur city and standard tracing of soft tissue were made on the acetate matte tracing paper. Then eleven soft tissue traits were studied as described by Holdaway. My dataset of the facial tissue depths of Kanpur population yielded some expected and unexpected results.

The analysis of the eleven mentioned parameters led us to the following significant conclusions:

In our study of all the parameters, facial angle, upper lip curvature, Nose tip to H-line, and Upper lip sulcus did not show any statistical association between male and female groups. Skeletal convexity Pt A, H-angle, and Lower lip to H-line was found to be greater in females than males and the difference was statistically significant. Upper lip strain, upper lip thickness, lower sulcus depth, and soft tissue chin thickness were parameters that had greater values in males as compared to females and this difference was also found to be statistically significant.

This study focused on evaluating soft tissue profile of Kanpur individuals according to Holdaway analysis. The results revealed that some measurements were different from those proposed by Holdaway including; facial angle, H angle, upper lip curvature, nose tip to H line and upper lip sulcus. These differences disclose the importance of using normative data established for Kanpur population in forensic reconstruction.

After analysing the effect of BMI on facial soft tissue thicknesses, this study states that the nutritional status of the individuals is an important factor to consider during facial reconstruction from skulls, as well as in studies on soft tissue thicknesses.

The conclusion drawn from our study suggests the results of this study are useful for forensic artists and forensic anthropologists in facial reconstruction. This will be of benefit to forensic investigations.

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