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ORIGINAL ARTICLE

Analysis of facial soft tissue changes with aging and their effects on facial morphology: A forensic perspective

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Abstract While working on the concept of employing human faces as a biometric tool for personal identification, it is common to come across certain hindrances such as illumination, pose variation and facial hair. But, dealing with the aging process of an individual has been generally overlooked until recently. This relatively untouched aspect may enable us more insight while tackling identification problems. As the face matures, it changes some of its most enduring properties (e.g., shape of the cranium) and acquires new attributes (e.g., wrinkles). These changes are the basis of information about the aging of the face. The human brain can analyze the face and estimate the approximate age of an individual, though this estimation is not accurate. The perception of age in the human brain is still a subject of research. This article takes the phenomenon of "aging of face" into consideration and following the same, this study has been carried out to analyze the kind of changes occurring in the facial soft tissue thickness with progression of age and can be used along with other biological markers for personal identification or in developing automatic facial age estimation. The data can be used as an additional feature for corroboration or authentication in individualization. This preliminary study will help in forensic investigation although a database needs to be generated on other populations.

1. Introduction

The features of a human face, facial components, as well as the human face taken as a whole, act as a biometric tool for purposes of individual human identification. With the advancements in technology and with the introduction of biometric systems for the purpose of identification, automated face recognition (FR) systems have been created to match individual faces from print and digital photographs and video to the faces of an individual with the reference image in a computer database or with the photograph of the suspect. One of the main problems which is addressed with the facial recognition systems is the change occurring in the face with time or

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with aging. As the personal identity credentials such as passports, driving licenses and ration cards are valid for years. The primary problem that arise with automated facial recognition systems is to match the two photographs of the same individual from different age groups. Several researchers have highlighted this temporal performance degradation.[1–3] To meet this challenge, the approach which needs to be followed is to research the adult age-related craniofacial morphological changes to better understand the process of aging individuals from a facial image, or rather, develop workable artificial age progression techniques to anticipate how an individual's face may appear after several years have passed.

The appearance of a human face is affected considerably by aging as shown in a diagrammatical representation in Fig. 1. Albert et al. and Rhodes. Have reported that facial aging is mainly attributed to bone movement and growth, and skin related deformations associated with the introduction of wrinkles and the reduction of muscle strength.[4,5] Usually bone growth takes place during childhood whereas during adulthood the most intense age-related deformations are linked with texture changes. The observation of aging-related features on faces allows humans to estimate the age of other persons just by looking at their face. However, researchers studying the process of age estimation by humans have concluded that humans are not so accurate in age estimation and hence the possibility of developing automatic facial age estimation methods poses an attractive area of research.[5]

As adults age, myriad changes occur diachronically within the craniofacial complex. Notable soft tissue modifications can be seen across each decade of adult life that passes. Subtle hard tissue or bony changes slightly alter the overall shape of the human face, mainly in the dentoalveolar region. These age-related changes affect the accuracy and efficacy of biometric techniques concerning automated facial recognition. A lot of researchers worldwide are working on a wide variety of aspects related to face aging, facial age progression or synthetic facial aging, and facial expression, with the goal of improving computer automated face recognition systems. In this study, we provide an overview of intrinsic and extrinsic factors that affect human adult craniofacial aging and the details of the effects of changing facial soft tissue thickness with age and its impact on the overall appearance of the face. This study will ultimately help in establishing personal identification in forensic cases.

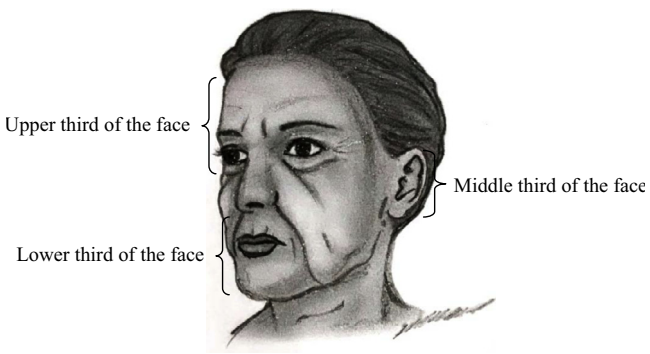

Figure 1 Typical aging skin changes.

2. Materials and methods

2.1. Collection of samples

Four hundred photographs of 400 individuals (200 males and 200 females) from four different age groups were collected from the individuals belonging to a Punjabi Sikh population. The photographs of individuals from age groups: 30–40 years, 40–50 years, 50–60 years and 60+ years were collected. The individuals with head and neck trauma or other pathological conditions that could distort the normal facial structures were excluded from the present study. Before collecting the samples, the participants were informed about the purpose of collection of the photographs and their written consent was also obtained. The participants in the present study were selected from a residential area in the vicinity of Punjabi University. The medical history of the participants was checked before taking their photographs and the participants who had undergone some treatment to enhance their looks or appearance were also excluded from the study.

2.2. Analysis of samples

Various features like – changes in skin texture, appearance of rhytids and other morphological changes were noticed and recorded in the form of a table. Their characteristic appearance was categorized as – none, minimal, fair, marked and prominent.

- **None** (Showing 0% signs of aging) – The characteristics which were totally absent in an individual were classified as none.
- **Minimal** (Showing 10–20% signs of aging) – The characteristics which were present in the form of fine lines were classified as minimal.
- **Fair** (Showing 20–40% signs of aging) – The characteristics which were present in the form of deep lines were classified as fair.
- **Marked** (Showing 50–70% signs of aging) – The characteristics which were present in the form of deep grooves were classified as marked.
- **Prominent** (Showing 70–100% signs of aging) – The characteristics which were present in the form of deep groves and folds were classified as prominent.

The various features considered for the present study were:

- **Transverse forehead rhytids**: These are caused by lifting of the brows which happens in our normal daily facial animation. Over a lifetime, this results in thinning of the tissues beneath these lines and ultimately results in wrinkles even when we are not animating. Forehead lines can also be caused by a subconscious effort to raise the brows constantly if they droop with age.
- **Glabellar frown lines**: These are vertical or slightly diagonal lines in between the brows that form when we frown or scowl. Initially they only form on animation, but with time they can be nearly permanent and very difficult to remove. Frown lines are caused by a very powerful muscle that moves the brows toward one another. The stronger the muscles, the deeper these wrinkles are.