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FACIAL SOFT TISSUE THICKNESS (FSTT): A REVIEW OF POPULATION-SPECIFIC FACTORS AND IMPLICATIONS IN FORENSIC ANTHROPOLOGY

[i]Muhammad Faiz Mohd Fauad,[ii,iii,iv]Aspalilah Alias, [v,vi]Ker Woon Choy, [vii]Helmi Mohd Hadi, [viii]Maher A M Abumosameh

[i]Department of Medical Sciences 1, Faculty of Medicine and Health Sciences, Universiti Sains Islam Malaysia,
[ii]Department of Basic Sciences and Oral Biology, Faculty of Dentistry, Universiti Sains Islam Malaysia, Kuala Lumpur,
[iii]Department of Forensic Odontology, Faculty of Dental Medicine Universitas Airlangga, Indonesia,
[iv]Centre of Research for Fiqh Forensics and Judiciary (CFORSJ), Universiti Sains Islam Malaysia, Malaysia,
[v]Department of Anatomy, Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Selangor, Malaysia,
[vi]Institute of Pathology, Laboratory and Forensic Medicine (I-PPerForM), Faculty of Medicine, Universiti Teknologi MARA, Sungai Buloh Campus, Selangor, Malaysia,
[vii]Forensic Science Unit, Faculty of Health Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan,
[viii]Department of Basic Sciences, Faculty of Dentistry, Universiti Sains Islam Malaysia

*Corresponding Author: draspa76@usim.edu.my

ABSTRACT

Facial Soft Tissue Thickness (FSTT) plays a crucial role in forensic anthropology, especially for reconstructing the features of a face. Over time, various studies focused on the influence of age, sex and ancestry on these tissue measurements. By reviewing the literature, we present some insights into the application of different approaches for evaluation of FSTT ranging from imaging modalities to the traditional measurement and highlight the main results obtained for several populations. The present barriers to adoption of uniform FSTT guidelines and increasing use of FSTT in forensic examination are also being explored. With the proper understanding of the FSTT, which varies in different populations, improvement of the facial reconstructive techniques can be achieved, and as a result, the reliability of forensic identification could be enhanced.

Keywords: *Facial soft tissue thickness (FSTT), forensic anthropology, identification*

Introduction

Facial soft tissue thickness (FSTT) is an important element in forensic anthropology, especially for facial reconstruction of human remains by using the skull (Moritsugui et al., 2022). The accuracy of forensic facial reconstructions used for human identification is affected by the thickness of soft tissues that overlay the skull (Bulut et al., 2014). FSTT research has been influential in the field of facial reconstruction over the years due to its need to create facial reconstructions most lifelike as possible (Chung et al., 2015). Although this field has come a long way, there are still gaps in knowledge that would benefit from an understanding of age, sex and ancestral influences on FSTT and its variation in forensic reconstructions (Ayoub et al., 2019). The ultrasound measurement (Stephan & Preisler, 2018) to advanced imaging like magnetic resonance images (MRI) (Sandamini et al., 2018), computed tomography (CT) scans (Chung et al., 2015) are few methodologies have been developed to measure the FSTT. The result of these technological uprising is that one can now get more robust data figures and a clear mapping of the variations in tissue thickness across different populations (Bulut et al., 2014; Hamid & Abuaffan, 2016). Nevertheless, there is little consensus with respect to standardized guidance for the application of FSTT in forensic practice. Outcomes were found to differ by method, origin of the sample and population-specific peculiarities. Therefore, the aim of this review is to give an overview of the literature on FSTT, with a particular emphasis on the effects of age, sex and ancestry. Besides, we consider the approaches taken to validate FSTT and the obstacles that emerges in developing standard guidelines for FSTT measurement in forensic anthropology field. This will help in accurate and reliable forensic facial reconstruction in forensic identifications and can promote our understanding of FSTT.

Significance of FSTT in forensic anthropology

In forensic reconstructions, the FSTT has been used to help define facial height and width measurements (Kotrashetti & Mallapur, 2016). Soft tissue thickness can give clues in a facial reconstruction and developed into face images that would have appeared like the individuals in life (Nilendu & Johnson, 2023). These reconstructions are crucial to establish the identity of the remains, typically in cases of mass disasters i.e flood or tsunamis (Forrest, 2019). Most of the time, the body are severely decomposed and leaving only skeletal remains (Dirkmaat & Cabo, 2016; Forrest, 2019; Sorg, 2019). The facial reconstruction obviously will facilitate the identification process in these cases.

Features are added onto the skull based on average FSTT information and skull morphology (Gupta et al., 2015). The thickness variation of tissues from one part of the face to another, i.e. forehead/cheeks/nose/chin, alters how the result looks and feels on exposed facial regions (Chen et al., 2021). Understanding these variations is crucial for forensic anthropologists and the relationship with current biological profiles i.e, sex, ancestry and age (Miller, 2018; Spradley & Jantz, 2011).

Traditional measurement

Traditional measurement approaches refer to a collection of quantitative and qualitative assessment procedures that have been identified as common practices for use in the forensic identification (Kewal Krishan, 2013) . In previous works on FSTT, direct measurements from cadaver tests were frequently used (Domaracki & Stephan, 2006). While this method is useful, there are several drawbacks, mainly attributable to postmortem changes in tissue stiffness and volume (Pasca & Ulasan, 2014). Facial anthropometry involves placement of pins on the body's face then applying a thin measuring gauge between the skin surface and an underlying bone point (Perez-Rojas et al., 2011). Although this method offers a simple way to obtain data, it is intrusive, and the cadaveric tissues are not similar as in the physiological state when living (Pasca & Ulasan, 2014).

Imaging Modalities

As science and technology continued to improve, FSTT measurement technique has been expanded to the imaging analysis using computed tomography (CT) and magnetic resonance imaging (MRI) (Chung et al., 2015; Yadav & Aggarwal, 2010). This technique provides three dimensional (3D) measurements of tissue thickness in living subject better than previous techniques (Kumar & Vijai, 2012; Leth, 2007). Apart from its less invasiveness, the imaging can present soft tissue variability more accurately (Tilotta et al., 2009). CT scanning has emerged as the reference method primarily because it offers the possibility of tissue differentiation and the visualization of both bones and soft tissues (Yadav & Aggarwal, 2010). MRI is also helpful, particularly in revealing soft tissues, but it tends to be more costly, and certainly more time-consuming than CT (Desroche et al., 2024). Ultrasound has also been used for FSTT determination since it is non-invasive, of relatively low cost, and free of side effects, thus making it suitable for repeated applications. However, its efficiency is reduced by the level of the operator's experience and the subject's movement (Pellacani & Seidenari, 1999.; Stephan & Preisler, 2018).

3D Scanning

Newer technologies that have been applied in last few years include three-dimensional (3D) scanning and modelling (Bulut et al., 2017; Gupta et al., 2015). These methods enable the production of detailed 3D skull models and the restoration of the overlying soft tissues (Gupta et al., 2015). With 3D scanning, one can make complex reconstructions of the size and the relief of the skull, while FSTT data is superimposed virtually for the reconstruction of the facial elements (VanKoevering et al., 2019). This approach remains non-invasive, highly accurate, as well as easy to reproduce for forensic purposes (Kurkcuoglu et al., 2011).

Factors Influencing FSTT

Sex Differences

There has been much concern in nearly all the research works addressing FSTT with regards to sexual dimorphism (Ajwa et al., 2020; Hamid & Abuaffan, 2016; Park et al., 2023). It was also established that the average density of the facial soft tissues is higher in males compared to that of females, particularly in the lower face areas that include the chin and jaw line (Koudelová et al., 2015). Such differences are contributed by the differences in hormonal effects, body composition that reflects muscle strength, and fat distribution patterns between male and female (Khosla et al., 2012). More insight into variations in FSTT regarding sex could enhance precision in facial reconstructions (Dempsey & Townsend, 2001).

A previous study revealed sex differences in FSTT at various anatomical sites for both sexes. Of all these variations, the most distinct were recorded at the lower face and this involves the mandible and the mental regions, which were thicker in the male (Alhumadi et al., 2022). Another study involved Korean population also showed significance differences in FSTT between different sex. Males generally having thicker tissue at all landmarks measured on cone bean computed tomography (CBCT) imagings (Park et al., 2023) Similarly, males were found to have thicker soft tissue in lower regions mainly upper, lower lip and chin areas in a study that conducted on Arabic subjects who undergone cephalograms for various reasons (Ajwa et al., 2020). These studies concluded that, there is a need to incorporate sex-specific FSTT data into forensic reconstructions in order to obtain a correct facial estimate.

Ancestry

There are also significant differences between population data of FSTT and people's ancestry (Eggerstedt et al., 2020) Several studies point to the fact that ancestry give effects onto the FSTT. For instance, the facial soft tissues of Latin Americans were thicker than African and Asian Americans in the population (Eggerstedt et al., 2020) . Another study has found significant differences in most of the FSTT landmarks using cephalograms between black and coloured juvenile age groups, in which black children have thinner, soft tissue compared to coloured (Briers et al., 2015).These differences are probably genetic, environmental, and in some ways, due to adaptation to climate in the different areas of the world (Cunha et al., 2006). In the context of forensic anthropology and for providing accurate reconstructions, FSTT and related parameters' variations between two groups are informative, and so is the general knowledge of population differences (Eggerstedt et al., 2020; Wysong et al., 2013).

Age variation

There is ample evidence on the process of aging and the changes in FSTT, where the subject's age decreases the thickness of the tissue in most cases (Wysong et al., 2013). Such decrease is most marked in the mid-face area, including the cheeks and particularly the eyes (Kotrashetti & Mallapur, 2016; Wysong et al., 2013). The age-related changes which have been identified include skin elasticity loss, muscle atrophy and fat pad shift which explains why lean faced persons are commonly observed in elder people (Dąbrowska et al., 2018). Knowledge of these changes is important to the forensic reconstructions, as faces improve and change over each phase of the life cycle.

The thickness of facial tissue was revealed to decrease as age increase in a study conducted on Hispanic, Non-Hispanic White and Asian population who were divided into young, middle and elder age groups. The FSTT measured on MRI was found to be deteriorated at infra-orbital, temporal and cheek regions as age increased (Wysong et al., 2013) In addition, the thickness of tissue at zygomatic region was decreased in elder age groups in a study that conducted at Boston, United States (Watanabe et al., 2015).In contrast, the midfacial regions were revealed to be thicker in elderly Korean population. It has been suggested that the thickness was attributed to accumulation of fat pads at that region (Jang et al., 2015) According to these findings, it was evident that age must be taken into consideration during the reconstruction of faces of old people for more precise identification.

Barriers to standardizing FSTT guidelines

Despite advancement in this field, several limitations of this FSTT measurement should be addressed. One of them is unstandardized in FSTT measurement approaches associated with studies (Domaracki & Stephan, 2006). Researchers consider different modalities like CT, MRI, and ultrasound supported by other anatomical features, as tools for FSTT measurements, which could lead to imprecise FSTT data collection (Agbolade et al., 2020; Nilendu & Johnson, 2023; Perez-Rojas et al., 2011).

Moreover, the small sample size and narrow study scope in many of the FSTT studies exposed the data to the bias (Cooper & Meterko, 2019). In order for researchers to come up with standards of FSTT that can be used on a wider population, larger and more heterogeneous samples are required (Dror & Rosenthal, 2008). Standardized guidelines on FSTT will also warrant consideration of population-based differences in FSTT because it is not acceptable to reconstruct FSTT of other population groups using the mean data of one group only (Dror & Rosenthal, 2008; Eggerstedt et al., 2020; Park et al., 2023).

Applying FSTT data for the purpose of reconstructions is also exposed to some challenges in forensic practice. For instance, there could be cultural issues where, in some communities, it may be unacceptable to carry out facial reconstruction, especially if it involves a deceased person (O'Neill & Godden, 2009). This example is some of the ethical issues that forensic personnels have to consider before proceed with the procedure (Kalliainen, 2010; O'Neill & Godden, 2009) .

FSTT application in forensic anthropology

The utilization of FSTT data for human identification is increasingly applied by forensic anthropologists in human identification (Kundu et al., 2021; Moritsugui et al., 2022; Saadeh et al., 2020). FSTT data can facilitate identifying an individual with respect to their age, sex and ancestry which are critical for components of biological profiles (Perez-Rojas et al., 2011). In cases where the skeletal remains are incomplete or damaged, FSTT data can be used to reconstruct their face for giving clues on how the deceased might be looked (Gupta et al., 2015; Pinheiro & Cunha, 2006). Such information would be helpful in cases of severe decomposition, where only skeletal remains are left (Pasca & Ulasan, 2014). Additionally, with increasing numbers of expertise in implementing imaging technologies, the FSTT measurement becomes more practical to be employed (Chung et al., 2015; Randolph-Quinney et al., 2011; Sandamini et al., 2018). The shift to digital and 3D modeling applications in the field of forensic anthropology will lead to more precise FSTT values for experts to quantify (Yadav & Aggarwal, 2010).

Conclusion

FSTT measurement is a main component for precise facial reconstruction. Appropriate soft tissue depth measurement is necessary for reproducible and reliable outcome of facial reconstruction. While the collection of FSTT data has become more accurate with improvements in imaging technologies, there still remain many concerns to establishing standardized guidelines for forensic practice within this field.

Due to influence of population specific factors including age, sex and ancestry on FSTT, there is a need to calibrate and standardize the forensic reconstructions in respect to the factors. Forensic anthropologists can therefore participate in continuous and serial trainings for more accurate forensic facial reconstruction.

Suggestions

The pursuit of a larger and more diverse data set involving FSTT procedures is necessary for future research using advanced imaging techniques, i.e. CT or MRI. The use of a diverse ancestry in developing FSTT standards and establishing its validity is preferred, so we would need an effort to be made that includes different ancestral groups. Finally, interdisciplinary efforts among anthropologists, radiologists and forensic researchers will be essential to further develop FSTT measurement techniques as well as apply our results in a real-world forensic context.

References

Agbolade, O., Nazri, A., Yaakob, R., Ghani, A. A., & Cheah, Y. K. (2020). Morphometric approach to 3D soft-tissue craniofacial analysis and classification of ethnicity, sex, and age. *PLoS ONE*, *15*(4), 1–24. https://doi.org/10.1371/journal.pone.0228402

Ajwa, N., Alkhars, F. A., AlMubarak, F. H., Aldajani, H., AlAli, N. M., Alhanabbi, A. H., Alsulaiman, S. A., & Divakar, D. D. (2020). Correlation between sex and facial soft tissue characteristics among young Saudi patients with various orthodontic skeletal malocclusions. *Medical Science Monitor*, *26*. https://doi.org/10.12659/MSM.919771

Alhumadi, A., Al-Khafaji, T. J., Alyassiri, A. M. H., & Alhamadi, W. W. (2022). Gender differences in lower facial soft tissue thickness among different skeletal patterns, based on soft tissue cephalometric analysis. *Journal of Orthodontic Science*, *11*(1). https://doi.org/10.4103/jos.jos_38_22

Ayoub, F., Saadeh, M., Rouhana, G., & Haddad, R. (2019). Midsagittal facial soft tissue thickness norms in an adult Mediterranean population. *Forensic Science International*, *294*, 217.e1-217.e7. https://doi.org/10.1016/j.forsciint.2018.10.021

Briers, N., Briers, T. M., Becker, P. J., & Steyn, M. (2015). Soft tissue thickness values for black and coloured South African children aged 6-13 years. *Forensic Science International*, *252*, 188.e1-188.e10. https://doi.org/10.1016/j.forsciint.2015.04.015

Bulut, O., Jessica Liu, C. Y., Koca, F., & Wilkinson, C. (2017). Comparison of three-dimensional facial morphology between upright and supine positions employing three-dimensional scanner from live subjects. *Legal Medicine*, *27*, 32–37. https://doi.org/10.1016/j.legalmed.2017.06.002

Bulut, O., Sipahioglu, S., & Hekimoglu, B. (2014). Facial soft tissue thickness database for craniofacial reconstruction in the Turkish adult population. *Forensic Science International*, *242*, 44–61. https://doi.org/10.1016/j.forsciint.2014.06.012

Chen, H. S., Hsiao, S. Y., & Lee, K. T. (2021). Analysis of Facial Skeletal Morphology: Nasal Bone, Maxilla, and Mandible. *BioMed Research International*, *2021*. https://doi.org/10.1155/2021/5599949

Chung, J. H., Chen, H. T., Hsu, W. Y., Huang, G. S., & Shaw, K. P. (2015). A CT-scan database for the facial soft tissue thickness of Taiwan adults. *Forensic Science International*, *253*, 132.e1-132.e11. https://doi.org/10.1016/j.forsciint.2015.04.028

Cooper, G. S., & Meterko, V. (2019). Cognitive bias research in forensic science: A systematic review. In *Forensic Science International* (Vol. 297, pp. 35–46). Elsevier Ireland Ltd. https://doi.org/10.1016/j.forsciint.2019.01.016

Cunha, E., Pinheiro, J., & Nuno Vieira, D. (2006). Identification in forensic anthropology: Its relation to genetics. *International Congress Series*, *1288*, 807–809. https://doi.org/10.1016/j.ics.2005.12.068

Dąbrowska, A. K., Spano, F., Derler, S., Adlhart, C., Spencer, N. D., & Rossi, R. M. (2018). The relationship between skin function, barrier properties, and body-dependent factors. In *Skin Research and Technology* (Vol. 24, Issue 2, pp. 165–174). Blackwell Publishing Ltd. https://doi.org/10.1111/srt.12424

Dempsey, P. J., & Townsend, G. C. (2001). Genetic and environmental contributions to variation in human tooth size. *Heredity*, *86*(Pt 6), 685–693. https://doi.org/10.1046/j.1365-2540.2001.00878.x

Desroche, C. N., Johnson, A. P., Hore, E. B., Innes, E., Silver, I., Tampieri, D., Kwan, B. Y. M., Jimenez, J. O., Boyd, J. G., & Islam, O. (2024). Feasibility and Cost Analysis of Portable MRI Implementation in a Remote Setting in Canada. *Canadian Journal of Neurological Sciences*, *51*(3), 387–396. https://doi.org/10.1017/cjn.2023.250

Dirkmaat, D. C., & Cabo, L. L. (2016). Forensic Archaeology and Forensic Taphonomy: Basic Considerations on how to Properly Process and Interpret the Outdoor Forensic Scene. In *Academic Forensic Pathology* (Vol. 6, Issue 3, pp. 439–454). SAGE Publications Inc. https://doi.org/10.23907/2016.045

Domaracki, M., & Stephan, C. N. (2006). Facial soft tissue thicknesses in Australian adult cadavers. *Journal of Forensic Sciences*, *51*(1), 5–10. https://doi.org/10.1111/j.1556-4029.2005.00009.x

Dror, I., & Rosenthal, R. (2008). Meta-analytically quantifying the reliability and biasability of forensic experts. *Journal of Forensic Sciences*, *53*(4), 900–903. https://doi.org/10.1111/j.1556-4029.2008.00762.x

Eggerstedt, M., Rhee, J., Buranosky, M., Batra, P. S., Tajudeen, B. A., Smith, R. M., & Revenaugh, P. C. (2020). Nasal Skin and Soft Tissue Thickness Variation Among Differing Races and Ethnicities: An Objective Radiographic Analysis. *Facial Plastic*
Surgery & Aesthetic Medicine, *22*(3), 188–194. https://doi.org/10.1089/fpsam.2019.0008

Forrest, A. (2019). Forensic odontology in DVI: current practice and recent advances. In *Forensic Sciences Research* (Vol. 4, Issue 4, pp. 316–330). Taylor and Francis Ltd. https://doi.org/10.1080/20961790.2019.1678710

Gupta, S., Gupta, V., Vij, H., Vij, R., & Tyagi, N. (2015). Forensic facial reconstruction: The final frontier. In *Journal of Clinical and Diagnostic Research* (Vol. 9, Issue 9, pp. 26–28). Journal of Clinical and Diagnostic Research. https://doi.org/10.7860/JCDR/2015/14621.6568

Hamid, S., & Abuaffan, A. H. (2016). Facial soft tissue thickness in a sample of Sudanese adults with different occlusions. *Forensic Science International*, *266*, 209–214. https://doi.org/10.1016/j.forsciint.2016.05.018

Jang, M. S., Kim, H. Y., Dhong, H. J., Chung, S. K., Hong, S. D., & Cho, H. J. (2015). An analysis of Asian midfacial fat thickness according to age group using computed tomography. *Journal of Plastic, Reconstructive and Aesthetic Surgery*, *68*(3), 344–350. https://doi.org/10.1016/j.bjps.2014.10.037

Kalliainen, L. K. (2010). Supporting facial transplantation with the pillars of bioethics. In *Journal of Reconstructive Microsurgery* (Vol. 26, Issue 8, pp. 547–553). https://doi.org/10.1055/s-0030-1262949

Kewal Krishan, T. K. (2013). Personal Identification in Forensic Examinations. *Anthropology*, *02*(01). https://doi.org/10.4172/2332-0915.1000114

Khosla, S., Oursler, M. J., & Monroe, D. G. (2012). Estrogen and the skeleton. In *Trends in Endocrinology and Metabolism* (Vol. 23, Issue 11, pp. 576–581). https://doi.org/10.1016/j.tem.2012.03.008

Kotrashetti, V. S., & Mallapur, M. D. (2016). Radiographic assessment of facial soft tissue thickness in South Indian population - An anthropologic study. *Journal of Forensic and Legal Medicine*, *39*, 161–168. https://doi.org/10.1016/j.jflm.2016.01.032

Koudelová, J., Brůžek, J., Cagáňová, V., Krajíček, V., & Velemínská, J. (2015). Development of facial sexual dimorphism in children aged between 12 and 15 years: A three-dimensional longitudinal study. *Orthodontics and Craniofacial Research*, *18*(3), 175–184. https://doi.org/10.1111/ocr.12096

Kumar, T. S., & Vijai, A. (2012). 3D reconstruction of face from 2D CT scan images. *Procedia Engineering*, *30*, 970–977. https://doi.org/10.1016/j.proeng.2012.01.952

Kundu, A., Streed, M., Galzi, P. J., & Johnson, A. (2021). A detailed review of forensic facial reconstruction techniques. *Medico-Legal Journal*, *89*(2), 106–116. https://doi.org/10.1177/0025817221989591

Kurkcuoglu, A., Pelin, C., Ozener, B., Zagyapan, R., Sahinoglu, Z., & Yazici, A. C. (2011). Facial soft tissue thickness in individuals with different occlusion patterns in adult Turkish subjects. *HOMO- Journal of Comparative Human Biology*, *62*(4), 288–297. https://doi.org/10.1016/j.jchb.2011.06.001

Leth, P. M. (2007). The use of CT scanning in forensic autopsy. *Forensic Science, Medicine, and Pathology*, *3*(1), 65–69. https://doi.org/10.1385/fsmp:3:1:65

Miller, E. (2018). Forensic Anthropology. In *Multidisciplinary Medico-Legal Death Investigation: Role of Consultants*. https://doi.org/10.1016/B978-0-12-813818-2.00010-7

Moritsugui, D. S., Fugiwara, F. V. G., Vassallo, F. N. S., Mazzilli, L. E. N., Beaini, T. L., & Melani, R. F. H. (2022). Facial soft tissue thickness in forensic facial reconstruction: Impact of regional differences in Brazil. *PLoS ONE*, *17*(7 July). https://doi.org/10.1371/journal.pone.0270980

Nilendu, D., & Johnson, A. (2023). Role of soft-tissue thickness on the reproducibility in forensic facial approximation: A comparative case study. *Forensic Science International: Reports*, *7*. https://doi.org/10.1016/j.fsir.2022.100293

O'Neill, H., & Godden, D. (2009). Ethical issues of facial transplantation. *British Journal of Oral and Maxillofacial Surgery*, *47*(6), 443–445. https://doi.org/10.1016/j.bjoms.2009.05.008

Park, E., Chang, J., & Park, J. (2023). Facial Soft Tissue Thickness Differences among Three Skeletal Classes in Korean Population Using CBCT. *International Journal of Environmental Research and Public Health*, *20*(3). https://doi.org/10.3390/ijerph20032658

Pasca, P., & Ulasan, K.: (2014). Decomposition Process and Post Mortem Changes: Review. In *Sains Malaysiana* (Vol. 43, Issue 12).

Pellacani, G., & Seidenari, S. (1999). Variations in facial skin thickness and echogenicity with site and age. *Acta dermato-venereologica*, *79*(5), 366–369. https://doi.org/10.1080/000155599750010283

Perez-Rojas, F., Sebastián, , Torres Muñoz, R., Cantín, M., Javier, F., Rojas, P., & Galdames, I. S. (2011). Evaluation of Facial Asymmetry Using Soft-Tissue Thickness for Forensic Purposes Evaluation of Facial Asymmetry Using Soft-Tissue Thickness for Forensic Purposes Evaluación de la Asimetría Facial Mediante el Grosor de Tejidos

Blandos para Propósitos Forenses. In *Article in International Journal of Morphology* (Vol. 29, Issue 3). https://www.researchgate.net/publication/287542168

Pinheiro, J., & Cunha, E. (2006). Forensic investigation of corpses in various states of decomposition a multidisciplinary approach. *Forensic Anthropology and Medicine: Complementary Sciences From Recovery to Cause of Death*, 159–195. https://doi.org/10.1007/978-1-59745-099-7_7

Randolph-Quinney, P. S., Black, S. M., & Mallett, X. (2011). Forensic anthropology. In A. Jamieson & A. Moenssens (Eds.), *Wiley Encyclopedia of Forensic Science* (Issue January, pp. 1–27). John Wiley & Sons Ltd.

Saadeh, M., Fayyad-Kazan, H., Haddad, R., & Ayoub, F. (2020). Facial soft tissue thickness differences among different vertical facial patterns. *Forensic Science International*, *317*. https://doi.org/10.1016/j.forsciint.2020.110468

Sandamini, H., Jayawardena, A., Batuwitage, L., Rajapakse, R., Karunaratna, D., Vidanapathirana, M., & Pallewatte, A. (2018). Facial soft tissue thickness trends for selected age groups of Sri Lankan adult population. *Forensic Science International*, *293*, 102.e1-102.e11. https://doi.org/10.1016/j.forsciint.2018.10.001

Sorg, M. H. (2019). Differentiating trauma from taphonomic alterations. *Forensic Science International*, *302*. https://doi.org/10.1016/j.forsciint.2019.109893

Spradley, M. K., & Jantz, R. L. (2011). Sex estimation in forensic anthropology: Skull versus postcranial elements. *Journal of Forensic Sciences*, *56*(2), 289–296. https://doi.org/10.1111/j.1556-4029.2010.01635.x

Stephan, C. N., & Preisler, R. (2018). In vivo facial soft tissue thicknesses of adult Australians. *Forensic Science International*, *282*, 220.e1-220.e12. https://doi.org/10.1016/j.forsciint.2017.11.014

Tilotta, F., Richard, F., Glaunès, J., Berar, M., Gey, S., Verdeille, S., Rozenholc, Y., & Gaudy, J. F. (2009). Construction and analysis of a head CT-scan database for craniofacial reconstruction.

Forensic Science International, *191*(1–3), 112.e1-112.e12. https://doi.org/10.1016/j.forsciint.2009.06.017

VanKoevering, K. K., Zopf, D. A., & Hollister, S. J. (2019). Tissue Engineering and 3-Dimensional Modeling for Facial Reconstruction. In *Facial Plastic Surgery Clinics of North America* (Vol. 27, Issue 1, pp. 151–161). W.B. Saunders. https://doi.org/10.1016/j.fsc.2018.08.012

Watanabe, M., Buch, K., Fujita, A., Christiansen, C. L., Jara, H., & Sakai, O. (2015). MR relaxometry for the facial ageing assessment: The preliminary study of the age dependency in the MR relaxometry parameters within the facial soft tissue. *Dentomaxillofacial Radiology*, *44*(7). https://doi.org/10.1259/dmfr.20150047

Wysong, A., Joseph, T., Kim, D., Tang, J. Y., & Gladstone, H. B. (2013). Quantifying soft tissue loss in facial aging: A study in women using magnetic resonance imaging. *Dermatologic Surgery*, *39*(12), 1895–1902. https://doi.org/10.1111/dsu.12362

Yadav, N., & Aggarwal, A. (2010). *CT Scans-A Compelling Tool in Forensic Facial Reconstruction*. https://www.researchgate.net/publication/224806716