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Three-dimensional analysis of nasolabial fold depth as a support for facial reconstruction methods for corpse identification: A literature review

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ARTICLEINFO

Article history:

Received May 21, 2024
Revised May 29, 2024
Accepted Jun 7, 2024

Keywords:

Facial Reconstruction
Identification of Deceased
Nasolabial Sulcus
Soft Tissue

ABSTRACT

Identification of human remains is one of the most important stages in forensic science among the various methods commonly used in the process of identifying unknown human remains. Identification of remains is an issue in both criminal and civil cases. Determining the correct identity of the body is very important in the investigation as a mistake could have fatal consequences. Facial reconstruction is a method that is developing rapidly. The aim of this review is to acknowledge the importance of the nasolabial fold as one of the parameters required for identification using facial reconstruction methods. The depth of soft tissue is important in facial reconstruction. Aging of the face is associated with loss of soft tissue support in the nasolabial sulcus. The nasolabial sulcus is made up of both soft and hard tissue. The depth of the nasolabial sulcus can affect facial expression. 3D computerized facial reconstruction has been developed for a long time, but still requires continuous development using approaches to reconstruct the face. The nasolabial sulcus influences facial expression in facial reconstruction. Technological advances improve or facilitate the work of forensic odontologists, anthropologists, and dentists compared to traditional methods.

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INTRODUCTION

Facial reconstruction is one of the options in the process of identification of a deceased body, based on an estimate of the shape and density of the soft tissues of the unidentified skull. (Mekkadath Jayakrishnan et al., 2022) Severe postmortem decomposition or lack of antemortem information is the main indication for forensic purposes. (Moritsugui et al., 2022) Facial reconstruction is one of the branches of forensic odontology. It aims at medical-legal, investigative verification, and

identification. (Deng et al., 2020; Mekkadath Jayakrishnan et al., 2022) A combination of scientific and artistic methods can be used to reconstruct the soft tissues of the skull to obtain an image of a person. (Deng et al., 2020; Mekkadath Jayakrishnan et al., 2022; Nitya et al., 2022)

Forensic facial reconstruction requires additional shape estimation data such as hair color, eyelids, ear shape, and soft tissue depth. (Mekkadath Jayakrishnan et al., 2022) Soft tissue depth is required for facial reconstruction because all facial organs have been lost or damaged. (Johari et al., 2017) Information on facial soft tissue depth is important. Facial soft tissue depth can be measured by several techniques. For example, it can be measured at anatomical points on the head and neck by examining deceased individuals. (Moritsugui et al., 2022) The depth of the nasolabial sulcus can affect facial expression. (Tanaka et al., 2023) The nasolabial sulcus is one of the most visible signs of facial aging. (Grablowitz et al., 2019; Hur et al., 2020) The aim of this review is to acknowledge the importance of the nasolabial fold as one of the parameters required for identification using facial reconstruction methods.

RESEARCH METHOD

Literature Review

Identification With Face Reconstruction

The identification of remains in cases where identity cannot be established by standard identification methods is a problem for both the medical and legal systems. The human skull provides a wealth of information on sex, age, and ethnicity and can provide a basic biological profile of the individual, but rarely leads to positive identification. This is when identification methods such as dental examination, x-rays, DNA analysis, and fingerprints are not possible. (Article et al., 2021; Kadam et al., 2020; Moritsugui et al., 2022) In such cases, facial reconstruction can be a last resort to help establish a person's identity. Forensic identification agencies around the world have used forensic facial reconstruction to perform craniofacial recognition and identification. (Thiemann et al., 2017)

Facial reconstruction is a branch of forensic odontology. It aims at medical-legal, investigative verification and identification. (Deng et al., 2020; Nitya et al., 2022) A combination of scientific and artistic methods. A combination of scientific and artistic methods that can be used to reconstruct the soft tissues of the skull to obtain an image of a person (Moritsugui et al., 2022), (Deng et al., 2020; Nitya et al., 2022)

Facial reconstruction requires the morphology of the face. The face is the front of the head. The anatomical position of the face is from the hairline to the base of the mandible and both ears. (Marur et al., 2014) The determination of facial reconstruction is based on the anatomical principles of the eyes, nose, mouth, and ears. (Wilkinson, 2010) The skull consists of 22 bones, 4 facial bones and 8 cranial bones. The skull is a complex structure and small variations during development and growth, together with differences in soft tissues, create the enormous variation in facial appearance seen in the human population. (Stephan & Simpson, 2008)

Facial Reconstruction Methods

Facial reconstruction methods include 2-dimensional methods, 3-dimensional methods, and modified 2- and 3-dimensional methods based on computer programs with anatomical markers on the skull. (Gupta et al., 2015; Nitya et al., 2022) The 2-dimensional method was first performed by Karen Taylor. This method works in collaboration with artists and forensic anthropologists. With antemortem photographs and skulls with reconstructed tissues. The 3-dimensional method also requires artists and forensic anthropologists, manual labor using clay, plastic, or wax done directly on the skull. Anatomical markers are placed on the skull for soft tissue depth. (Gupta et al., 2015)

The manual methods of facial reconstruction are the American method, the Russian method, and the Manchester method. In 1946, Krogman developed the American method as

a method of facial reconstruction using soft tissue depth. The American method can determine sex, age, and race anthropometrically. The American method is most used by law enforcement agencies because the results can be explained. (Mekkadath Jayakrishnan et al., 2022; Navic et al., 2023) The American method uses needles, X-rays, or ultrasounds to take measurements. The method requires precision to record the facial muscles in the correct anatomical position. This is why it is rarely used today. (Mekkadath Jayakrishnan et al., 2022)

In 1971, Gerasimov developed the Russian method by anatomical conformance of the face. (Mekkadath Jayakrishnan et al., 2022; Navic et al., 2023) The Russian method does not require soft tissue depth measurement. The Russian method uses limited craniofacial musculature and generally average soft tissue thickness and is further anatomically shaped. (Navic et al., 2023) This method is rarely used today as it requires a proper anatomical knowledge base when performing facial reconstruction. (Mekkadath Jayakrishnan et al., 2022)

In 1977, Richard Neave created the Manchester method, which combines the Russian and American methods (combination method). (Mekkadath Jayakrishnan et al., 2022; Navic et al., 2023) The Manchester method is considered the most accurate because it takes into account the thickness of the soft tissues, and facial and neck muscles to create the details of the facial shape. Stephan said that all the above methods rely on soft tissue depth information and anatomical knowledge. (Gupta et al., 2015)

Facial reconstruction using computer-aided methods is a new method that was developed in the 20th century. (Wilkinson, 2010) In computer-aided methods, computer software creates reconstructions using CT, CBCT, scans, and photographs. (Mekkadath Jayakrishnan et al., 2022; Rao et al., 2019; Wilkinson, 2010) This method is influenced by technological advances that make it more flexible, objective, and able to analyze larger amounts of data more quickly than conventional methods. (Navic et al., 2023)

Computer-aided 3D facial reconstruction has been in development for a long time but still requires continuous development using face reconstruction approaches. With the advancement of 3D technology, a fast, efficient, and cost-effective computerized method for forensic facial reconstruction has been developed. The use of computer technology is an acceptable scientific method of facial reconstruction. (Navic et al., 2023) However, this system requires anthropological and computer expertise. This reduces the subjectivity and skill of the practitioner. It also produces many images of the same face quickly and efficiently. (Kadam et al., 2020; Short et al., 2014)

Soft Tissue Depth In Facial Reconstruction

The needling technique was the first method used to obtain soft tissue depth data. This method has the disadvantages of soft tissue distortion as a result of the decomposition process associated with the nature of the sample, difficulty in identifying the measurement site, and incorrect measurements that can be caused by the horizontal position of the body due to the action of gravity, but this technique also has some advantages, such as the immobility of the subject, the cheapness and simplicity of the equipment required, and the ability to measure any point on the head. (Domaracki & Stephan, 2006; Wilkinson, 2004) The position of the soft tissue over the hard tissue on the skull to obtain anatomical landmarks of the soft tissue is easier to estimate. (Saadeh et al., 2020) There are more anatomical landmarks in soft tissue than in hard tissue. Although the morphology of soft tissue follows that of hard tissue. (Lin et al., 2016)

In recent years, many studies have been carried out to obtain accurate soft tissue depth data using computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (USG), and radiography. (Nitya et al., 2022) It is very important to know the average value of facial soft tissue depth in a particular part of the face. Various studies of facial reconstruction have produced databases of soft tissue depth in relation to gender, race, and body mass index. (Shui et al., 2016; Snider et al., 2017) Facial soft tissue depth is an important aspect of cranial identification methods. Methods for measuring soft tissue depth vary widely, and measurement error is generally not given much attention. (Stefura et al., 2021; Wang et al., 2022) In 95 studies, less than 44% of

measurement errors were present, and not all provided specific quantification. (Shui et al., 2016; Snider et al., 2017)

The soft tissue depth of each region is different because the individual facial shape of each region is different. The identification of human skeletal remains of unknown origin remains a challenge for forensic identification. In such cases, identification data is lacking. Methods that develop facial images from individual skulls. Human skulls are also unique, complex, and different, like fingerprints. (Rao et al., 2019)

Previous studies have used soft tissue depth on sparsely distributed anatomical landmarks, where different definitions of anatomical landmarks may affect contrast results. In this study, a total of 90.198 one-to-one correspondence skull sections were created from CT images in 171 individuals, and all soft tissue depth anatomical landmarks of each correspondence section were calculated for statistical analysis and facial reconstruction. The basic descriptive statistics of mean and standard deviation for the calculated soft tissue depth were reported separately by gender and age. The results showed that 76.12% of the total showed that soft tissue depth was greater in males than females, except for sections around the zygoma, zygomatic arch, and middle lateral orbit. These sex-related significant differences were found in 55.12% of all nodules, and age-related statistically significant differences were delineated between the four age groups in most of them, 73.31% for males and 63.43% for females. (Rao et al., 2019)

In a database study of soft tissue depth in facial reconstruction in the Turkish adult population, there were differences in soft tissue depth between males and females examined from 31 anatomical landmarks. (Bulut et al., 2014) Facial reconstruction studies of eye morphology in the South African population using 3D CT and CBCT methods revealed differences in eye morphology in the South African population with existing guidelines. (Dorfling et al., 2018) However, Stephan and Simpson conducted an analytical review of published adult data on soft tissue depth and found that the effect of race was not significant, suggesting that the effect of race on soft tissue depth is minimal. However, Stephan and Simpson conducted an analytical review of published data on facial soft tissue depth in adults and showed that the effect of race on soft tissue depth data was not significant, suggesting that the effect of race on soft tissue depth is minimal. (Fernandes et al., 2012)

Nasolabial Sulcus In Facial Reconstruction

The nasolabial sulcus, also known as the "smile line" or "laugh line", starts at the alar groove and the alar facial fold and runs down the side of the upper lip. The nasolabial sulcus can be divided into the following five types based on its anatomical and histological characteristics: skin, fat pad, muscle, bone retrusion, and hybrid types. Factors that influence the formation of the nasolabial sulcus include loss of skin thickness over the sulcus, presence of excessive skin drooping over the sulcus, excessive fat deposits on the sides of the sulcus, weakness of the malar fat pad, and muscle hyperactivity. (Kaur et al., 2015)

The nasolabial sulcus is an important aesthetic landmark consisting of fibrous tissue to which the levator muscles are attached. The nasolabial sulcus becomes more pronounced with age. (Bhama et al., 2014) Patterns of facial deformity associated with facial soft tissues have been of interest in facial reconstructive identification, surgery, and aesthetics. Individual facial soft tissues on the skull are subject to gravity. 30 The nasolabial sulcus is composed of both soft and hard tissue. (Lin et al., 2016)

The nasolabial sulcus is in the middle third of the face. The nasolabial sulcus develops with the shifting of the malar fat pads, which is minimal and natural in people aged 30-40 years, marked at 40-50 years, and increased at 50-60 years. This shifting of the malar fat pads and reduction of fat makes the cheeks appear hollow. Nasolabial lines begin to form at the age of 20-30, deepen at the age of 30 and beyond, and gradually wrinkles appear, deepening at the age of 40-50 and continuing to deepen until the age of 60 and beyond. (Kaur et al., 2015)

In a study using 3D photogrammetry to monitor facial changes in the nasolabial sulcus, it was found that there was a decrease in soft tissue volume around the nasolabial sulcus, accompanied by soft tissue compression of the cheek laterally and inferiorly to the nasolabial sulcus. Gravity-induced changes in facial morphology occur in adults of all ages. (Fernandes et al., 2012) In the 3D method results, the nasolabial sulcus can be measured. With the face in a horizontal position, the subnasal point is passed and the depth and width of the nasolabial sulcus is measured. (Wang et al., 2022) The 3D method is an effective method of measuring the length and depth of the nasolabial sulcus and is therefore objective. (Wang et al., 2022)

RESULT AND DISCUSSION

The face undergoes the effects of aging mainly due to bone movement, skin-related growth, and deformation associated with the introduction of wrinkles, and reduction in fat and muscle strength. Usually, bone growth occurs during childhood whereas, during adulthood, the most intense age-related deformations are associated with textural changes. Observation of aging-related facial organs to estimate approximate human age. Human aging is an important aspect of biometrics and has not been extensively researched. (Kaur et al., 2015)

The aging of the adult face is affected by various environmental disturbances such as solar radiation, wind, dry air, smoking, drug use, and psychological stress. Factors of craniofacial aging in adults and naturally occurring changes in size and shape of the head and face are age-related changes in hard and soft tissues. (Kaur et al., 2015) Typical clinical manifestations of more advanced facial aging are laxity of the skin and subcutaneous tissue, expression of wrinkles in the upper third of the face, tearing, lowering of the angle of the mouth, loss of defines at the mandibular border, changes in skin pigmentation and visible blood vessels. (Grablowitz et al., 2019)

Facial aging is associated with soft tissue loss. Perioral signs of facial aging can add years to a person's appearance and even affect facial expressions in smiling and non-smiling images. Loss of soft tissue support in certain areas such as the periorbital, frontal, malar, temporal, mandibular, mental, and perioral areas, and persistence or hypertrophy of fat in others such as the nasolabial sulcus and marionette lines. Facial wrinkles and folds interfere with emotional expression. Although not very noticeable, they are enough to cause problems with social interaction. The older a person gets; the more facial emotions are perceived by others due to the appearance of wrinkles and folds. (Faris et al., 2018). The nasolabial sulcus is in an important position in the front of the face. It is one of the most visible signs of facial aging. The nasolabial groove deepens with age. (Gupta et al., 2015)

Two aspects of facial reconstruction techniques are cranial morphology and soft tissue depth data. It is necessary to obtain soft tissue depth data in the population to achieve accurate facial reconstruction. (Thiemann et al., 2017) Historically, soft tissue depth data has been obtained by needle puncture of the cadaveric face using invasive techniques. (Hwang et al., 2012; Thakur & Sehrawat, 2023) Cadaveric preservation causes a decrease in measurements by 50-60%. (Kundu et al., 2021). This is due to skin shrinkage caused by dehydration after. As a result, measurements cannot be taken exactly perpendicular to the bone surface. In addition, the small sample size of cadaver studies limits the collection of soft tissue depth data. In this case, the collection of soft tissue depth data from cadavers has unavoidable limitations. (Marur et al., 2014)

A combination of scientific methods and artistic skills can be used for this purpose in forensic identification, where conventional identification techniques are useless, and samples are scarce. (Kundu et al., 2021) Computer-based 3D facial reconstruction can provide consistent and objective results and allows multiple reconstructions using additional data with different information, such as gender, age, ethnicity, body mass index, and type of malocclusion, as the reconstruction can be completed in a short time. (Dorfling et al., 2018; Gietzen et al., 2019) There has been much debate about facial reconstruction methods by scientists, but by following the

same method, both techniques, conventional and computer-based, have a fairly low degree of artistic interpretation. (Gietzen et al., 2019)

CONCLUSION

Facial reconstruction may be an option for identifying unidentified remains. Soft tissue depth is very important in facial reconstruction. The nasolabial sulcus influences facial expression in facial reconstruction. Technological advances improve or facilitate the work of forensic odontologists, anthropologists, and dentists compared to traditional methods. Various techniques have been used over the years to examine soft tissue, with advances in imaging techniques leading to increasingly accurate measurements.

ACKNOWLEDGEMENTS

We would like to thank the Faculty of Dentistry, University of Indonesia, for allowing the authors access to the literature for the preparation of this manuscript.

References

Article, R., Soni, V., Gupta, S., & Srivastava, A. (2021). *Open Access Journal of Forensic Medicine Evolution In Forensic Facial Imaging "A Valuable Approach of Recognition in Disaster's Victim Management."*

Bhama, P. K., Park, J. G., Shanley, K., & Hadlock, T. A. (2014). Refinements in nasolabial fold reconstruction for facial paralysis. *Laryngoscope*, *124*(12), 2687–2692. https://doi.org/10.1002/lary.24843

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

Deng, C., Wang, D., Chen, J., Li, K., Yang, M., Chen, Z., Zhu, Z., Yin, C., Chen, P., Cao, D., Yan, B., & Chen, F. (2020). Facial soft tissue thickness in Yangtze River delta Han population: Accurate assessment and comparative analysis utilizing Cone-Beam CT. *Legal Medicine*, *44*. https://doi.org/10.1016/j.legalmed.2020.101693

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

Dorfling, H. F., Lockhat, Z., Pretorius, S., Steyn, M., & Oettlé, A. C. (2018). Facial approximations: Characteristics of the eye in a South African sample. *Forensic Science International*, *286*, 46–53. https://doi.org/10.1016/j.forsciint.2018.02.029

Faris, C., Heiser, A., Jowett, N., & Hadlock, T. (2018). Minimal nasolabial incision technique for nasolabial fold modification in patients with facial paralysis. *JAMA Facial Plastic Surgery*, *20*(2), 148–153. https://doi.org/10.1001/jamafacial.2017.1425

Fernandes, C. M. S., da Costa Serra, M., da Silva, J. V. L., Yoshito Noritomi, P., de Sena Pereira, F. D. A., & Melani, R. F. H. (2012). Tests of one Brazilian facial reconstruction method using three soft tissue depth sets and familiar assessors. *Forensic Science International*, *214*(1–3), 211.e1-211.e7. https://doi.org/10.1016/j.forsciint.2011.08.017

Gietzen, T., Brylka, R., Achenbach, J., Hebel, K. zum, Schömer, E., Botsch, M., Schwanecke, U., & Schulze, R. (2019). A method for automatic forensic facial reconstruction based on dense statistics of soft tissue thickness. *PLoS ONE*, *14*(1). https://doi.org/10.1371/journal.pone.0210257

Grablowitz, D., Sulovsky, M., Höller, S., Ivezic-Schoenfeld, Z., Chang-Rodriguez, S., & Prinz, M. (2019). Safety and efficacy of princess® FILLER lidocaine in the correction of nasolabial folds. *Clinical, Cosmetic and Investigational Dermatology*, *12*, 857–864. https://doi.org/10.2147/CCID.S211544

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

Hur, M. S., Jehoon, O., Yang, H. M., Kwon, H. J., Lee, S., Lim, H. S., Lim, S. Y., & Oh, C. S. (2020). Heights and spatial relationships of the facial muscles acting on the nasolabial fold by dissection and three-dimensional microcomputed tomography. *PLoS ONE*, *15*(8 August). https://doi.org/10.1371/journal.pone.0237043

Hwang, H. S., Park, M. K., Lee, W. J., Cho, J. H., Kim, B. K., & Wilkinson, C. M. (2012). Facial Soft Tissue Thickness Database for Craniofacial Reconstruction in Korean Adults. *Journal of Forensic Sciences*, *57*(6), 1442–1447. https://doi.org/10.1111/j.1556-4029.2012.02192.x

Johari, M., Esmaeili, F., & Hamidi, H. (2017). Facial Soft Tissue Thickness of Midline in an Iranian Sample: MRI Study. *The Open Dentistry Journal*, *11*(1), 375–383. https://doi.org/10.2174/1874210601711010375

Kadam, S., Murjani, B., Ramaswami, E., Nimma, V., Bhosale, R., Kausadikar, P., & Saju, R. (2020). Prediction methods for soft tissue structures in forensic facial reconstruction: A review for reconstruction of nose, eyes, mouth and ears. *INTERNATIONAL JOURNAL OF ETHICS, TRAUMA & VICTIMOLOGY*, *6*(01), 31–39. https://doi.org/10.18099/ijetv.v6i01.6

Kaur, M., Garg, R. K., & Singla, S. (2015). Analysis of facial soft tissue changes with aging and their effects on facial morphology: A forensic perspective. *Egyptian Journal of Forensic Sciences*, *5*(2), 46–56. https://doi.org/10.1016/j.ejfs.2014.07.006

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

Lin, Y., Lin, H., Lin, Q., Zhang, J., Zhu, P., Lu, Y., Zhao, Z., Lv, J., Lee, M. K., & Xu, Y. (2016). A novel three-dimensional smile analysis based on dynamic evaluation of facial curve contour. *Scientific Reports*, *6*. https://doi.org/10.1038/srep22103

Marur, T., Tuna, Y., & Demirci, S. (2014). Facial anatomy. In *Clinics in Dermatology* (Vol. 32, Issue 1, pp. 14–23). https://doi.org/10.1016/j.clindermatol.2013.05.022

Mekkadath Jayakrishnan, J., Reddy, J., & Kumar B, V. R. (2022). Forensic facial reconstruction using CBCT: A systematic review. In *Stomatologija, Baltic Dental and Maxillofacial Journal* (Vol. 24, Issue 2).

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

Navic, P., Inthasan, C., Chaimongkhol, T., & Mahakkanukrauh, P. (2023). Facial reconstruction using 3-D computerized method: A scoping review of Methods, current Status, and future developments. In *Legal Medicine* (Vol. 62). Elsevier B.V. https://doi.org/10.1016/j.legalmed.2023.102239

Nitya, K., Madhushankari, G. S., Narayan, K. V, Basandi, P. S., Ramya, R., & Vasumathi, D. (2022). Ethnic-Guided Soft Tissue Cephalometric Analysis on Lambani Indian Inhabitants for Forensic Facial Reconstruction. *Cureus*. https://doi.org/10.7759/cureus.23430

Rao, K., K, M. S., Nayak, U. K., Babu, G. S., & Shetty, D. P. (2019). Application of facial soft tissue thickness for facial reconstruction using Cone-Beam Computed Tomography: A Review. *Journal of Indian Academy of Forensic Medicine*, *41*(4), 268–271. https://doi.org/10.5958/0974-0848.2019.00078.2

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

Short, L. J., Khambay, B., Ayoub, A., Erolin, C., Rynn, C., & Wilkinson, C. (2014). Validation of a computer modelled forensic facial reconstruction technique using CT data from live subjects: A pilot study. *Forensic Science International*, *237*, 147.e1-147.e8. https://doi.org/10.1016/j.forsciint.2013.12.042

Shui, W., Zhou, M., Deng, Q., Wu, Z., Ji, Y., Li, K., He, T., & Jiang, H. (2016). Densely calculated facial soft tissue thickness for craniofacial reconstruction in Chinese adults. *Forensic Science International*, *266*, 573.e1-573.e12. https://doi.org/10.1016/j.forsciint.2016.07.017

Snider, C. C., Amalfi, A. N., Hutchinson, L. E., & Sommer, N. Z. (2017). New Insights into the Anatomy of the Midface Musculature and its Implications on the Nasolabial Fold. *Aesthetic Plastic Surgery*, *41*(5), 1083–1090. https://doi.org/10.1007/s00266-017-0889-9

Stefura, T., Kacprzyk, A., Droś, J., Krzysztofik, M., Skomarovska, O., Fijałkowska, M., & Koziej, M. (2021). Tissue Fillers for the Nasolabial Fold Area: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. In *Aesthetic Plastic Surgery* (Vol. 45, Issue 5, pp. 2300–2316). Springer. https://doi.org/10.1007/s00266-021-02439-5

Stephan, C. N., & Simpson, E. K. (2008). Facial soft tissue depths in craniofacial identification (Part I): An analytical review of the published adult data. In *Journal of Forensic Sciences* (Vol. 53, Issue 6, pp. 1257–1272). https://doi.org/10.1111/j.1556-4029.2008.00852.x

Tanaka, O., Cavassin, L., Gasparello, G., Meira, T., Miyoshi, C., & Hartmann, G. (2023). The esthetics of the nasolabial fold and age in the elderly via eye-tracking. *Contemporary Clinical Dentistry*, *14*(1), 18–24. https://doi.org/10.4103/ccd.ccd_539_21

Thakur, S., & Sehrawat, J. S. (2023). Age and sex dependent differences in midline facial soft tissue thicknesses measured on MRI scans of Northwest Indian subjects: a forensic anthropological study. *Egyptian Journal of Forensic Sciences*, *13*(1). https://doi.org/10.1186/s41935-023-00356-z

Thiemann, N., Keil, V., & Roy, U. (2017). In vivo facial soft tissue depths of a modern adult population from Germany. *International Journal of Legal Medicine*, *131*(5), 1455–1488. https://doi.org/10.1007/s00414-017-1581-y

Wang, D., Zeng, N., Zhang, Q., & Wu, Y. (2022). Quantitative Evaluation of Nasolabial Fold by Three-Dimensional Imaging: A Comparison with WSRS Score. *Aesthetic Plastic Surgery*, *46*(5), 2189–2193. https://doi.org/10.1007/s00266-021-02682-w

Wilkinson, C. (2004). *Forensic Facial Reconstruction*. Cambridge University Press. https://doi.org/10.1017/CBO9781107340961

Wilkinson, C. (2010). Facial reconstruction - anatomical art or artistic anatomy? In *Journal of Anatomy* (Vol. 216, Issue 2, pp. 235–250). https://doi.org/10.1111/j.1469-7580.2009.01182.x