Determination of Soft Tissue Thickness of Face for Facial Reconstruction - An Autopsy Study

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ABSTRACT

BACKGROUND

Facial reconstruction aims to reconstruct the face of an unknown individual for identification. It is a process of recreating the face of a human being based on skull remains and can be used to identify otherwise unknown individuals or to reconstruct faces of historical figures. The measurement of facial soft tissue thickness is the basis of this method. The data obtained from various studies are charted and used as a guide for facial reconstruction. This study intended at determining the average soft tissue thickness of the face in 21 different points for the purpose of facial reconstruction in males and females.

METHODS

For the study, 144 cases belonging to the age of 21 to 60 years were brought for autopsy in the Department of Forensic medicine, Medical College, Thiruvananthapuram. They were divided into equal number of males and females. The soft tissue thickness was taken by needle puncture technique. Statistical analysis was done and the mean values in males and females and their age wise comparisons were obtained. Males and females showed strong positive correlation with age at certain points and the data obtained from this study provides a basis for facial reconstruction in the South Indian population.

RESULTS

Differences in mean values of general parameters and soft tissue thickness of face in different age groups and in both sexes and the coefficient of variation were also calculated at all points in both sexes. The mean values of height, weight were more in males than in females. The difference in the mean values of width of nose, width of forehead and the width of upper lip in females in different age groups was statistically significant. Among the soft tissue thicknesses at midline points of face, the difference in the mean values at the region of mid philtrum was statistically significant in males and females in different age groups. The difference in the mean values of soft tissue thickness in the lower lip in different age groups showed a statistical significance in males and females. Among the bilateral points of face, the difference in the mean values of soft tissue thickness of face in the region of right supraorbital, right and left gonion region showed a statistical significance in males in different age groups. In females, the left suborbital, right and left occlusal line and left mid zygomatic region showed a statistical difference.

CONCLUSIONS

The results of the study gave a set of average soft tissue thickness of face at 21 different points for an accurate reproduction of the skull in the South Indian population. In this study, the soft tissue thickness at midline and bilateral points were established. Further research in this field of facial reconstruction should incorporate various components of facial anatomy using modern imaging technology. A statistical analysis of multiple variables including other landmarks and various characteristics of the face could open up more relationships and would eventually lead to much more precise reconstruction.

KEY WORDS

Soft Tissue Thickness; Facial Reconstruction; South Indian Population

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DOI: 10.14260/jemds/2021/663

How to Cite This Article:
Samuel B. Determination of soft tissue thickness of face for facial reconstruction-an autopsy study. J Evolution Med Dent Sci 2021;10(37):3267-3271, DOI: 10.14260/jemds/2021/663

Submission 28-06-2021,
Peer Review 25-08-2021,
Acceptance 31-08-2021,
Published 13-09-2021.

BACKGROUND

Identification of human skeletal remains has been a major challenge for the medicolegal system. According to the statistics, hundreds of unidentified skeletal remains are being disposed of without a match. If the identity is not known, it becomes difficult for the investigating officer to solve a crime. Identification is important in decomposed bodies, mutilated bodies and in skeletons. Photographs, dental records, fingerprinting, and DNA matching will all be helpful for identification in such cases. But if the skeletal remains alone are obtained where there are no photographs, dental records, and inability to obtain fingerprints and DNA samples, the identity of the deceased may remain a mystery.[1,2,3]

Identity means the determination of an individuality of a person.[2] Individuals can be identified from their skull alone in the majority of cases. The age, sex, and race can easily be determined from an unknown skull. But the identification of facial morphology is yet another important factor which helps in medico-legal investigations. Superimposition of the skull from a recent photograph is one of the standard techniques used in identification of an individual. But if a recent photograph of the deceased is not available, superimposition cannot be performed and the law enforcement officials are unable to obtain a positive identification. In such cases the method of facial reconstruction comes to the rescue.[4] The method of facial reconstruction from soft tissue thickness has evolved as a major tool in the identification of persons from skeletal remains. This technique is often practiced in western countries in medico-legal cases to determine the identity of an unknown individual. This is mainly based on the principle that the shape of the face depends upon the facial soft tissue thickness. That is, to reconstruct the lost soft tissues of the face and determine how the individual looks like in life.[5]

Forensic facial reconstruction or forensic facial approximation is the process of recreating the face of an individual, whose identity is often not known from their skeletal remains, through an amalgamation of artistry, forensic science, anthropology, and anatomy.[6,7,8,9]

Though eyes, ears, and nose are individualistic; shape of the face is the basis of personal identity. Depth of tissues at 21 important anatomical points on the face is determined from dead bodies of both sexes,[10] according to the average thickness of tissues at various points on the face, clay or paper pulp applied on the skull and mandible. The face thus reconstructed will have close resemblance to the actual face of the deceased. But the shape of the nose, ears, and hair style are not based on scientific data.[11] The factors are not relevant as the shape of the face is the most important aspect to fix the identity. Even if those factors are not congruous with the actual shape and size, acquaintances of the deceased will be able to identify the reconstructed face as that of the deceased.

Every year several unidentified skeletons are brought for medico-legal examination. The law enforcement officials find it difficult to establish the identity of these skeletons. The role of facial reconstruction comes to the rescue in this scenario. The investigator might recognise the right person or it can lead the public to identify the person from the reconstructed image. Scientifically validated research publications are scanty despite several efforts in the field of facial reconstruction. Facial reconstruction requires a standardization of the facial soft tissue thickness data in order to reconstruct the face. The purpose of the study was to get standardized values for the soft tissue thickness of the face and thereby aid in establishing the identity.

METHODS

This cross-sectional study was done in the State Medicolegal Institute, Department of Forensic medicine, Government Medical College, Thiruvananthapuram, Kerala. The study period was from 01.04.2011 to 31.03.2012. For the study, 144 cases belonging to the age of 21 to 60 years which were brought for autopsy were selected in order to get a sufficient number of cases in both genders. They were divided into equal number of males and females and each group was further divided into four equal groups - Group I 21 – 30 years, Group II 31 – 40 years, Group III 41 – 50 years, Group IV 51-60 years.

Ethical Clearance

A prior approval was obtained by Institutional ethical committee.

Inclusion Criteria

Dead bodies brought for autopsy at the Department of Forensic Medicine, Thiruvananthapuram in the age group of 21 – 60 years of both sex.

Exclusion Criteria

Dead bodies with any facial distortion due to injuries, burns or oedema and dead bodies brought in decomposed state were excluded.

The cases were selected after evaluating the inquest reports from the investigating officer. A structured proforma was designed to enter the details which was pretested and validated by subject experts. The proforma consisted of serial no. pm no. cr no and police station, sex, age, weight, height and facial land marks. The recording of soft tissue thickness of face was done according to STEWART METHOD (His 1895).

A sharp lumbar puncture needle with a piece of rubber cork fitted on to the needle was used for measuring the soft tissue thickness. The distance between needle tip and the cork fitted on to the needle was taken to obtain the facial thickness. The needle bearing small cork was gently pushed into the soft tissues perpendicular to the bone, at a number of sites, until the point of the needle struck bone. As the needle penetrated, the piece of cork was pushed downwards up to the skin surface. The needle with the cork was withdrawn gently.

The interspace between the cork and the needle tip was recorded in millimetres using digital vernier calipers, which represents the tissue thickness at that point.[12] Tissue depth was recorded at twenty one standard points consisting of ten

midline and eleven bilateral points, which are described below.

In addition to these, general measurements like height, weight, BMI of the person, nasal bridge length, ear length, distance between angles of mouth, forehead width at the wider points, and the nose width were also noted.

Midline Points of the Face

- Supraglabella – The highest point of the middle of the forehead, right, at the start of the hairline, 1cm above the level of glabella.
- Glabella – The most projecting point on the midline between the ridges above the eye sockets, 1cm above and directly between the subject's eyebrows.
- Nasion – The indentation between the eye sockets and above the nose.
- End of nasals – The tip of the nasal bones.
- Midphiltrum – The deepest midpoint on the indentation between the bottom of the nose opening and the tooth line.
- Upper lip margin – The midpoint of the tooth line between the two front upper teeth.
- Lower lip margin – The midpoint of the tooth line between the two front lower teeth.
- Chin lip fold – The midpoint on the indentation in the middle of tooth line and the chin.
- Mental eminence – The forward most prominent point at the midline of the chin.
- Beneath chin – The lowest point on the midline of the jaw, centred on the inferior surface of the mandible.

Bilateral Points of the Face

- Frontal eminence -The highest point of the forehead, above the top point of the eye socket.
- Supraorbital – The centre of the top ridge of the eye socket.
- Suborbital – The centre of the bottom ridge of the eye socket.
- Inferior malar- The indentation below the cheek bone and above the tooth line, in line with the bottom point of the eye socket.
- Lateral orbit – The bulge of the cheekbone just below the outer ridge of the eye socket.
- Midzygomatic arch – The farthest extent of the cheek bone to the side.
- Supraglenoid – The back of the cheekbone, just above the ear.
- Occlusal line – A point on the upper curve of the jaw in line with where the teeth meet.
- Gonion – The point at the back lower corner of the jaw line.
- Sub M2 – A point on the tooth line above the second upper molar.
- Supra M2 – A point on the tooth line below the second lower molar

Statistical Analysis

The data obtained was subjected to statistical analysis by SPSS (Statistical Package for the Social Sciences) version 17 in which the following statistical methods were used.

Analysis of variance (ANOVA) test was used to find out the significance in the different age groups.

F value – is the calculated statistic from the mathematics behind ANOVA

Coefficient of variation to measure the dispersion.

CV = (SD/ Mean) X 100

Where, SD is the Standard deviation.

Coefficient of variation was calculated at all points in both sexes. The lesser the coefficient of variation (CV) the greater the predictability which showed that at landmarks the mean values of the measurements were more precise and consistent.

P value – probability. When the P-value is less than 0.05 or 0.01, it is considered statistically significant.

BMI was calculated using the formula (weight in kg) / (height in meter)^2

RESULTS

A total of 144 cases which were brought for autopsy were selected. They were divided into equal numbers of males and females and each group was further divided into four equal groups.

Different dimensions of face were taken and a descriptive analysis was done to find out the mean, SD and the statistical significance.

Differences in mean values of general parameters and soft tissue thickness of face in different age groups and in both sexes were studied. Coefficient of variation was calculated at all points in both sexes.

In males the mean values of body mass index ranged from 21.1 to 22.9 and in females from 20.3 to 21.4. The differences in the mean length of ear and nose in males and females in different age groups showed no statistical significance.

Midline Points	Group I				Group II			
	Males		Females		Males		Females	
	Mean (mm)	SD	Mean (mm)	SD	Mean	SD	Mean (mm)	SD
Supra Glabella	3.44	0.680	3.18	0.664	3.13	0.782	3.58	0.745
Glabella	3.68	1.190	3.03	0.541	3.24	0.667	3.44	0.882
Nasion	3.12	0.848	2.75	0.822	2.71	0.682	2.74	0.790
End of nasals	2.35	0.451	1.70	0.579	2.20	0.661	2.05	0.998
Mid Philtrum	8.40	2.065	6.67	1.668	7.03	2.050	6.29	1.235
Upper Lip	8.00	2.024	6.41	1.783	7.26	2.239	6.40	1.409
Lower Lip	7.50	1.410	6.36	1.422	7.69	1.360	6.07	1.670
Chin lip	8.00	2.076	6.66	1.641	7.62	2.163	7.00	1.375
Mental eminence	7.00	1.578	6.82	1.751	7.20	2.374	6.95	1.530
Beneath chin	4.47	1.150	3.25	0.983	4.82	2.160	3.83	1.151

Table 1. The Mean Values of Soft Tissue Depth at Midline Points in All Groups I and II in Both are Shown in Table 1

Midline Points	Group III				Group IV			
	Males		Females		Males		Females	
	Mean (mm)	SD	Mean (mm)	SD	Mean	SD	Mean	SD
Supra Glabella	3.74	0.871	3.46	0.903	3.15	0.929	3.24	0.591
Glabella	3.81	1.238	3.41	1.011	3.25	0.922	3.29	0.608
Nasion	3.52	1.221	2.62	0.907	2.93	1.085	2.42	0.574
End of nasals	2.72	1.267	2.08	0.516	2.00	0.725	1.91	0.266
Mid Philtrum	8.89	2.711	5.36	10185	7.05	2.721	5.77	0.923
Upper Lip	8.81	2.910	6.39	0.969	7.34	2.222	6.28	0.877
Lower Lip	9.18	2.446	8.01	1.852	7.63	1.724	8.27	1.397
Chin lip	8.52	1.496	6.27	1.643	7.31	1.624	6.47	1.152
Mental eminence	7.43	1.787	6.88	1.500	7.13	2.158	7.13	0.921
Beneath chin	5.45	2.355	3.93	1.812	5.61	5.61	3.33	0.822

Table 2. The Mean Values of Soft Tissue Depth at Midline Points in All Groups III and IV in Both are Shown in Table 2

Bilateral Points	Side	Group 1 Male Mean (mm)	Male SD	Female Mean (mm)	Female SD	Group II Male Mean (mm)	Male SD	Female Mean (mm)	Female SD
Frontal eminence	Right	3.36	0.626	2.68	0.498	3.03	0.584	3.24	0.763
	Left	3.20	0.507	2.72	0.683	3.02	0.636	3.29	0.700
Supraorbital	Right	4.37	0.809	4.09	0.610	4.30	0.870	4.32	0.833
	Left	4.33	0.867	4.17	0.590	4.32	0.812	4.31	0.812
Suborbital	Right	4.22	1.924	4.12	1.126	4.35	1.987	3.43	0.923
	Left	4.33	0.867	4.17	.590	4.26	1.796	3.57	1.237
Inferior malar	Right	9.39	2.548	10.37	2.481	9.86	3.352	12.43	7.497
	Left	9.99	3.168	10.04	2.696	9.94	2.756	10.66	2.809
Lateral orbit	Right	2.71	0.769	3.26	1.541	2.65	1.198	3.01	0.720
	Left	2.77	0.773	3.13	1.074	2.77	1.265	2.89	0.735
Mid zygomatic arch	Right	5.39	1.661	5.50	1.703	5.31	1.891	5.97	1.433
	Left	5.41	1.492	5.26	1.226	5.31	1.748	6.06	1.453
Supraglenoid	Right	9.01	3.557	8.83	2.437	8.52	2.678	8.87	1.747
	Left	8.30	2.900	9.06	2.642	8.62	2.502	8.79	1.789
Occlusal line	Right	16.59	4.963	13.45	3.234	15.10	4.021	14.32	3.841
	Left	15.86	3.688	13.76	2.402	16.21	3.841	15.42	2.714
Gonion	Right	10.78	3.732	9.09	2.426	10.06	4.458	9.62	2.731
	Left	11.10	3.515	8.84	2.452	10.28	4.153	9.70	2.528
Sub m2	Right	7.38	2.314	7.28	3.676	9.70	2.528	6.46	1.365
	Left	7.44	2.508	7.40	4.048	7.26	2.457	6.74	1.448
Supra m2	Right	17.42	3.753	17.43	5.028	17.65	4.710	16.43	3.934
	Left	17.99	4.687	17.40	4.818	17.71	4.565	16.95	3.453

Table 3. The Mean Values of Soft Tissue Depth at Bilateral Points in Groups I and II in Both are Shown in Table 3

Bilateral Points	Side	Group III Male Mean (mm)	Male SD	Female Mean (mm)	Female SD	Group IV Male Mean (mm)	Male SD	Female Mean (mm)	Female SD
Frontal eminence	Right	3.11	0.719	3.01	0.839	2.82	0.823	2.91	0.590
	Left	3.13	0.574	2.96	0.863	2.83	1.143	2.85	0.598
Supraorbital	Right	5.11	1.136	3.85	1.232	4.06	0.893	3.82	0.644
	Left	4.51	1.219	3.97	1.105	4.11	0.818	3.75	0.637
Suborbital	Right	4.30	2.342	3.21	1.270	3.31	2.021	3.42	1.185
	Left	4.46	2.739	3.23	1.245	3.22	1.613	3.60	1.131
Inferior malar	Right	9.74	2.305	10.23	2.163	8.87	2.746	10.24	1.490
	Left	10.27	2.402	10.26	2.003	8.78	2.850	1.27	1.412
Lateral orbit	Right	2.97	1.387	2.60	0.714	2.43	0.767	2.60	0.658
	Left	2.84	1.320	2.54	0.740	2.38	0.847	2.59	0.625
Mid zygomatic arch	Right	6.19	2.150	6.57	1.980	4.48	1.680	6.74	1.732
	Left	5.77	2.306	6.44	1.847	4.49	1.681	6.87	1.922
Supraglenoid	Right	8.74	3.273	9.33	2.266	6.88	2.063	9.95	1.838
	Left	8.95	3.297	9.42	20113	6.85	1.997	9.61	1.616
Occlusal line	Right	15.73	4.799	16.60	2.496	14.19	4.589	16.16	2.517
	Left	19.92	4.910	16.28	2.494	14.45	4.637	16.40	1.971
Gonion	Right	11.13	3.110	8.59	2.233	7.87	3.110	8.27	1.912
	Left	11.06	2.886	8.77	2.294	7.98	3.352	8.26	1.852
Sub m2	Right	8.88	3.646	7.14	2.592	7.46	2.786	7.17	2.221
	Left	8.91	3.421	7.37	2.742	7.62	2.819	7.26	2.364
Supra m2	Right	17.60	4.334	17.15	4.096	14.88	3.879	19.92	2.947
	Left	17.55	4.422	17.28	4.097	14.93	4.012	19.98	2.975

Table 4. The Mean Values of Soft Tissue Depth at Bilateral Points in All Groups III and IV in Both are Shown in Table 4.

No.	Landmarks	Mean (mm) Male	Female
1	Supra Glabella	3.36	3.36
2	Glabella	3.49	3.29
3	Nasion	3.07	2.63
4	End of nasals	2.31	1.93
5	Mid Philtrum	7.84	6.02
6	Upper Lip	7.85	6.37
7	Lower Lip	8.00	7.17
8	Chin lip	7.86	6.6
9	Mental	7.19	6.94
10	Beneath chin	5.08	3.58
11	Frontal eminence	3.06	2.95
12	Supraorbital	4.38	4.03
13	Suborbital	4.05	3.59
14	Inferior malar	9.60	10.56
15	Lateral Orbit	2.69	2.82
16	Mid Zygomatic arch	5.29	6.17
17	Supraglenoid	8.23	9.23
18	Occlusal line	15.50	15.29
19	Gonion	10.03	8.89
20	Sub m2	8.08	7.10
21	Supra m2	16.96	17.81

Table 5. Mean Values of Soft Tissue Depth in Twenty One, Both Midline and Bilateral Points of Face in Both Males and Females in All the Age Groups (21 to 60 yrs)

The difference in the mean values of width of nose in females in different age groups was statistically significant. In males there was no significant difference. The F value and P value in females were 2.998 and 0.037 respectively. Width of forehead in females showed a statistically significant difference. The difference in the mean values of width of upper lip in different age groups in females was statistically significant. The F value was 2.881 and P value was 0.042.

The CV of group II females was 5.8. So the value was more consistent in group II. Among the soft tissue thicknesses at midline points of face, the difference in the mean values at the region of mid philtrum was statistically significant in males and females in different age groups. The CV was 24.6 in group 1 males and 16 in group IV females. The F and p values of males were 2.782 and 0.048 and in females 3.649 and 0.017 respectively.

The difference in the mean values of soft tissue thickness in the lower lip in different age groups showed a statistical significance in males and females. Among the bilateral points of face, the difference in the mean values of soft tissue thickness of face in the region of the right supraorbital region showed a statistical significance in males in different age groups. For the right supraorbital region the value was more consistent in group 1 in males (CV =4.06) and for the left supraorbital in group II.

In females left suborbital region showed a statistical difference. F value was 2.78 and p value was 0.048. Left mid zygomatic region showed a statistical difference in females. F value was 3.155 and P value was 0.030. In males right and left gonion showed a statistically significant difference.

The F and P values were 2.897 and 0.041 for right gonion and for left gonion 3.154 and 0.030 respectively. In females, right and let occlusal line showed statistically significant difference. The F and p values in right occlusal line were 4.272 and 0.008 and for left occlusal line 4.604 and 0.005 respectively. The mean values of height, weight, were more in males than females.

DISCUSSION

Different dimensions of face were taken and a descriptive analysis was done to find out the mean, SD and the statistical significance. Differences in mean values of general parameters and soft tissue thickness of face in different age groups and in both sexes were studied.

All the age groups in the study had a normal body mass index. In all the age groups the dimensions of general parameters of face such as forehead, ear, nose and lips showed significant differences in both males and females. The mean values of these parameters in most of the age groups were higher in males than females. But on age wise comparison, no significant differences were noted in the dimensions of the above areas. With the differences in the soft tissue thickness of the face in 21 points, (both midline and bilateral) only 7 points showed a statistically significant difference in both males and females in different age groups.

The present study was compared with a study of American Caucasoids by Rhine J S and Moore C E (1982), and also with a similar study which was done on American Blacks (Negroids), and Japanese (Mongoloids).

When compared to the data obtained from the American white population the present study showed comparatively lesser values at all points except for frontal eminence,

suborbital, inferior malar, mid zygomatic arch, supraglenoid, and gonion. When compared to American Blacks (Negroes) at all the 21 points the present study showed a comparatively lesser value. When compared to the Japanese population, different values were observed in the present study. In them comparatively higher values were observed at the end of nasals, mental eminence, beneath chin, supraorbital, mid zygomatic arch, gonion, and supra m2. Lesser values were observed at nasion, chin lip margin, lateral orbit, and subm2.

The difference in the mean values of the present studies with those of the other studies can be explained by the fact that those studies were based on Caucasians and African cadavers, the reflection of the racial and ethnic differences. But Japanese population showed similarities in facial thickness as compared to Indians in this study. In none of the studies used for comparison, age groups were specified.[13]

When compared to Stewart table the present study gives a lower value of soft tissue thickness in the corresponding sites except for mandibular border in both males and females. This may be because of the racial variation and his study was on a small number of European adult males and females.[13]

If the age is known from anthropological measurements, or in historical figures, the mean values from the tables corresponding to the age group can be taken.

CONCLUSIONS

The results of the study laid out the average soft tissue thickness of the face at 21 different points contributing to a more precise reconstruction of a face. In this study, the soft tissue thickness at midline and bilateral points were established. Present day techniques of facial reconstruction are based on this method, with the application of various components on the skull resulting in an exact replica which helps in the reconstruction of the face. This study provides data regarding facial reconstruction in South Indian population.[14] Further research in this field of facial reconstruction should incorporate various components of facial anatomy using modern imaging technology. A statistical analysis of multiple variables including other landmarks and various characteristics of the face could open up more relationships and would eventually lead to much more precise reconstruction.

Data sharing statement provided by the authors is available with the full text of this article at jemds.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jemds.com.

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