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A Comprehensive Examination of Topographic Thickness of Skin in the Human Face

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Abstract

Background: Knowledge of topographic skin thickness is important to plastic surgery of the face as it may guide resection and restoration in oncologic, aesthetic, and reconstructive procedures.

Objective: The purpose of this study is to report the relative thickness of the face throughout 39 distinct subunits.

Methods: Full-thickness punch biopsy samples were obtained at 39 predetermined anatomic locations of the face from 10 human cadaveric heads. Tissue was fixed in paraffin-embedded slides and analyzed using triplicate measurement of dermis and epidermis using computerized measurements. Data were analyzed using univariate statistical analysis and expressed as mean thickness values and relative thickness (RT) values based on the thinnest portion of the face.

Results: The area of the face with the thickest dermis was the lower nasal sidewall (1969.2 μm, dRT: 2.59), and the thinnest was the upper medial eyelid (758.9 μm, dRT: 1.00). The area with the thickest epidermis was the upper lip (62.6 μm, eRT: 2.12), and the thinnest was the posterior auricular skin (29.6 μm, eRT: 1.00). Our results confirm that eyelid skin is the thinnest in the face. The thickest portions of the skin appeared to be in the lower nasal sidewall, but the measurements are comparable to those in the ala and posterior auricular skin, which are novel findings.

Conclusions: The greatest epidermal, dermal and total skin thickness are found in the upper lip, right lower nasal sidewall, and left lower nasal sidewall respectively. The least epidermal skin thickness is in the posterior auricular skin. The least dermal skin thickness, and the least total skin thickness, are both in the upper medial eyelid.

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Knowledge of topographic skin thickness is important to plastic surgery of the face as it may guide resection and reconstruction in oncologic procedures, needle placement for injectable neuromodulators or soft tissue fillers in aesthetic procedures, or guide the degree of osseocartilaginous modification in a rhinoplasty.[1] The authors anecdotally understood that eyelid skin is thin, and that nasal skin is thick, but plastic surgery operations often bridge multiple facial subunits, and our review of the literature revealed few clinically relevant descriptions of facial skin thickness, none of which were comprehensive.

The authors sought to comprehensively examine the thickness of the human face and to corroborate previously described relative thickness index (RTI) values,[2] and to further describe the thickness of the skin in the entire human face. We hypothesized that the lower third of the nasal dorsum would have the greatest skin thickness and the upper eyelid would be thinnest. Hence, in order to verify our premise, we designed a cadaveric study using punch biopsy and microscopic pathological analysis.

METHODS

The investigators designed a cadaveric study to evaluate skin thickness in the human face. Fresh frozen cadavers were obtained from the State Anatomy Board (Baltimore, Maryland). Cadavers were excluded if they had evidence of facial burns, open wounds, or unhealed surgical wounds at the time of death. Cadavers were selected only if they had an age greater than or equal to 18 years at the time of death. All data collection was performed on one date in March 2014 utilizing available cadavers. Institutional Review Board approval is not required for cadaveric studies at our institution.

Full-thickness 4 mm punch biopsy samples were obtained at 39 surgically relevant anatomic locations of the face from each cadaveric specimen. The authors sought to create a comprehensive topographic map of human facial skin thickness, and in order to provide a clinical context for the data-points, the 39 named facial anatomic locations listed in Table 1 were selected. Faculty from the surgical pathology department at University of Maryland School of Medicine were available to immediately fixate the tissue specimens in paraffin embedded slides and perform thickness analysis via triplicate measurement of dermal (D) and epidermal (E) thickness using computerized measurements (Aperio Technologies, Vista, California). Three separate blinded pathologist observers performed the analysis on each specimen and their results were averaged. Output data were analyzed using univariate statistical analysis.

When performing histological analysis of skin, there are a few areas that may complicate measurements, including: A) the presence of rete ridges/pegs, B) the presence of sebaceous glands, C) determination of the epidermal/dermal junction, and D) differentiating the epidermis from the hypodermis. With respect to rete ridges, although the presence of irregular areas of thickness may represent a potential problem for reproducibility of the measurements, thin skin as found in the face has multiple areas devoid of rete ridges. Measurements were specifically done in segments of epidermis between rete ridges. Similarly to the rete ridges, even in the presence of sebaceous glands, hair follicles, and other appendageal structures, there were abundant areas of “flat” squamous epithelium/epidermis that were measured. Sebaceous glands did not interfere with measurement of the dermoepidermal junction because they are embedded in stroma with the typical characteristics of dermal connective tissue. This applied to all the glandular and vascular structures associated with the epidermis. Identification of the dermal/epidermal junction was not difficult. This boundary is defined by the epidermal basement membrane; the latter is irregular as it outlines all epidermal appendages, including the sebaceous glands. However, we systematically chose to measure the epidermis in areas devoid of rete ridges and appendageal structures, including sebaceous glands. The presence of abundant sebaceous glands results in a thicker dermis but this by itself does not interfere with the measurements of the epidermis or dermis, which are based on other specific histological features. With regard to the dermis/hypodermis border, specific features guided recognition of the various tissue layers. In areas of skin with significant subcutaneous fat, the transition between the compact collagenous rich dermal tissue with a specific orientation of the larger collagen bundles were differentiated from the loose, well vascularized connective tissue containing adipose lobules. In areas with no significant subcutaneous fat, different arrangement of the vessels and collagen bundles in each layer was easily distinguished on microscopic examination.

A relative thickness (RT) measurement system was used to compare the average thickness of the anatomic sites. The ratio was calculated by dividing the thickness of each site by the thinnest anatomic site. This resulted in the thinnest site being set to a value of 1 on our relative thickness scale and each subsequent measurement being expressed as a multiple of that value. This was performed for each thickness value measured: epidermal (eRT), dermal (dRT), and total thickness (tRT). A dermal to epidermal ratio (D/E) ratio was also calculated for each location of the face. In reconstructive procedures, the goal is to replace like-with-like; therefore, local flaps are often an ideal solution (eg, bilobed flap for nasal defect reconstruction). However, when the defect is too large (eg, total nasal subunit defect) or there are no local tissues available, an ideal tissue may be selected if it has similar epidermal/dermal ratios in addition to similar color and hair-bearing characteristics.

Table 1. Epidermal and Dermal Thickness Average Values and Relative Thickness (RT) Values for Facial Anatomical Landmarks

Site #	Location	Average Epidermal Thickness (μm)	Standard Deviation	Average Dermal Thickness (μm)	Standard Deviation	D/E	D + E	eRT[a]	dRT[a]
1	Upper Medial Forehead	44.70	13.99	1200.93	297.23	26.87	1245.63	1.51	1.58
2	Lower Medial Forehead	45.76	14.25	1176.11	342.84	25.70	1221.88	1.55	1.55
3	Upper Lateral Forehead	44.80	16.69	1252.50	566.26	27.96	1297.30	1.52	1.65
4	Lower Lateral Forehead	39.86	11.29	1172.34	541.04	29.41	1212.20	1.35	1.54
5	Upper Medial Eyelid	40.31	12.76	758.85[b]	444.91	18.83	799.16[b]	1.36	1.00[b]
6	Upper Lateral Eyelid	42.39	10.40	1088.58	528.57	25.68	1130.98	1.43	1.43
7	Lower Lateral Eyelid	38.58	8.82	1227.10	780.79	31.81	1265.67	1.30	1.62
8	Tear Through	47.00	17.57	1178.64	704.89	25.08	1225.63	1.59	1.55
9	Glabella	46.59	15.16	1339.52	466.82	28.75	1386.11	1.58	1.77
10	Upper Nasal Dorsum	52.19	13.40	1475.42	527.70	28.27	1527.60	1.77	1.94
11	Lower Nasal Dorsum	61.60	15.02	1198.61	699.94	19.46	1260.21	2.08	1.58
12	Medial Canthus	42.81	13.11	840.36	578.64	19.63	883.16	1.45	1.11
13	Mid-Nasal Sidewall	48.45	13.43	1746.27	486.38	36.05	1794.71	1.64	2.30
14	Lower Nasal Sidewall	46.70	11.80	1969.20[b]	674.69	42.17	2015.89[b]	1.58	2.59[b]
15	ALA	51.57	16.22	1941.03	596.44	37.64	1992.59	1.74	2.56
16	Columella	44.17	14.88	1160.76	419.57	26.28	1204.92	1.49	1.53
17	Philtrum	48.07	13.85	1196.17	534.95	24.88	1244.24	1.63	1.58
18	Nasal Tip	49.77	11.53	1288.00	403.25	25.88	1337.78	1.68	1.70
19	Soft Triangle	51.44	13.89	1477.47	297.98	28.72	1528.91	1.74	1.95
20	Malar	45.73	14.96	1040.46	408.69	22.75	1086.20	1.55	1.37
21	Lower Cheek	44.66	11.12	1291.26	427.13	28.92	1335.91	1.51	1.70
22	Upper Lip	62.62[b]	57.79	1433.49	571.09	22.89	1496.12	2.12[b]	1.89
23	Nasolabial Fold	48.91	18.28	1250.18	607.87	25.56	1299.08	1.65	1.65
24	Marionette Fold	40.87	16.10	989.41	588.19	24.21	1030.28	1.38	1.30
25	Chin	45.37	17.07	1165.77	403.48	25.69	1211.14	1.53	1.54
26	Temporal	42.18	12.93	1245.77	817.51	29.53	1287.95	1.43	1.64
27	Preauricular	37.53	14.19	1251.84	671.83	33.35	1289.37	1.27	1.65
28	Upper Helix	42.29	13.21	1074.90	615.74	25.42	1117.19	1.43	1.42
29	Mid-Helix	56.89	21.57	1052.43	355.91	18.50	1109.32	1.92	1.39
30	Conchal Bowl	32.92	12.17	999.14	248.82	30.35	1032.06	1.11	1.32
31	Ear Lobe	44.65	23.18	1191.90	447.32	26.70	1236.55	1.51	1.57
32	Lower Medial Eyelid	48.01	13.98	868.39	457.37	18.09[b]	916.40	1.62	1.14
33	Anterior Neck	40.69	14.86	1237.68	555.27	30.42	1278.36	1.38	1.63

(*Continued*)

Table 1. (Continued)

Site #	Location	Average Epidermal Thickness (μm)	Standard Deviation	Average Dermal Thickness (μm)	Standard Deviation	D/E	D + E	eRT[a]	dRT[a]
34	Lateral Neck	32.89	10.98	1440.71	623.97	43.80	1473.60	1.11	1.90
35	Posterior Scalp	35.36	13.35	1443.86	554.19	40.84	1479.21	1.20	1.90
36	Posterior Auricular	29.57[b]	9.15	1724.21	677.95	58.31[b]	1753.78	1.00[b]	2.27
37	Temporal Scalp	33.25	9.19	1349.52	543.40	40.59	1382.77	1.12	1.78
38	Anterior Scalp	37.54	10.90	1146.13	403.14	30.53	1183.67	1.27	1.51
39	Vertex	37.42	13.58	919.45	537.95	24.57	956.87	1.27	1.21
	Minimum value	29.57		758.85		18.09	799.16	1.00	1.00
	Maximum value	62.62		1969.20		58.31	2015.89	2.12	2.59

D/E, dermis thickness divided by epidermis thickness; D + E, dermis + epidermis thickness = total thickness (μm); eRTI, epidermal relative thickness index; dRTI, dermal relative thickness index; tRTI, total relative thickness index; μm, micrometers. [a]RTIs are normalized ratios calculated by dividing each thickness by the thinnest value in each category. [b]Minimum values highlighted in red color, maximum values highlighted in blue.

RESULTS

A total of 10 fresh cadaveric subjects were evaluated (3 male, 7 female) with a mean age of 81.6 ± 11.3 years (range, 66-99 years). A summary of demographics for each cadaver is provided in Table 2. Detailed measurements of average thickness values from all cadavers are displayed in Table 1. Relative thickness values are displayed quantitatively in Table 1 and visually in Figures 1 and 2 (epidermis), and Figures 3 and 4 (dermis). The thickest dermis in face was found in the lower nasal sidewall (1969.2 μm, dRT: 2.59), and the thinnest was the upper medial eyelid (758.9 μm, dRT: 1.00). The area of the face with the thickest epidermis was the upper lip (62.6 μm, eRT: 2.12), and the thinnest was the posterior auricular skin (29.6 μm, eRT: 1.00). The area with the greatest total skin thickness the lower nasal sidewall (2015.9 μm, tRT: 2.52), and the thinnest was the upper medial eyelid (799.2 μm, tRT: 1.00). The posterior auricular region had the highest dermal to epidermal ratio (58.31), and the lowest was the lower medial eyelid (18.09). Overall, the dermal pattern of thickness dictated total thickness, with the contribution of epidermal thickness on total thickness being minimal.

Table 2. Demographic Data of Cadaver Heads

Cadaver	Ethnicity	Age (years)	Gender
1	Caucasian	80	Female
2	Caucasian	68	Male
3	Caucasian	66	Female
4	Caucasian	99	Female
5	Caucasian	80	Male
6	Caucasian	90	Female
7	Caucasian	98	Female
8	Caucasian	84	Male
9	Caucasian	76	Female
10	Caucasian	75	Female
		Average: 81.6 ± 11.3	70% Female, 30% Male

DISCUSSION

The investigators aimed to comprehensively examine the thickness of skin in the human face using pathologic analysis of punch biopsy specimens from fresh human cadavers. We hypothesized that the lower third of the nasal dorsum would have the greatest thickness of skin and that the upper eyelid would be the thinnest. Our specific aims were to determine the absolute and relative thickness of the epidermis, dermis, and total skin from each anatomic site of the human face.

The results of this study confirm the hypothesis that the thickest skin in the human face is in the lower third of the nose (specifically the lower nasal sidewall), and that the thinnest skin is at the medial aspect of the upper eyelid. Although the areas of greatest dermal thickness and least dermal thickness were at the same location as greatest total skin thickness and least total skin thickness, the areas of epidermal thickness were not dictated by the total skin

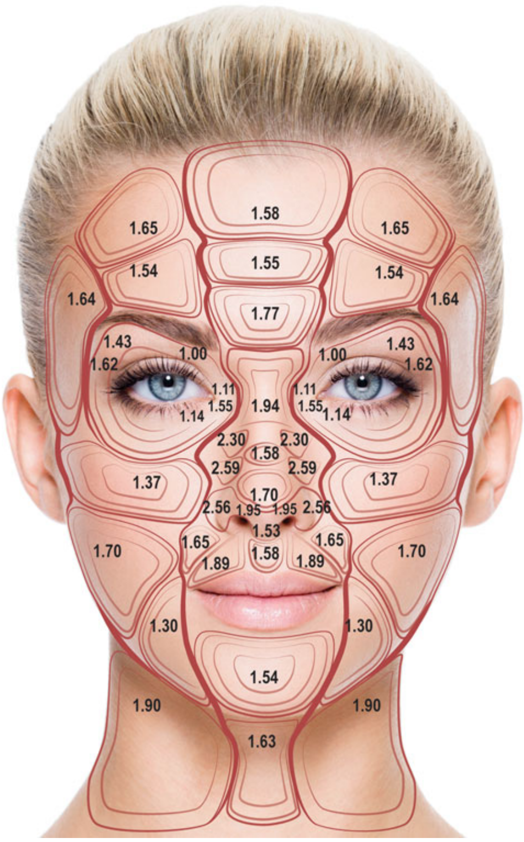

Figure 1. Anterior view of epidermal relative thickness (RT) values.

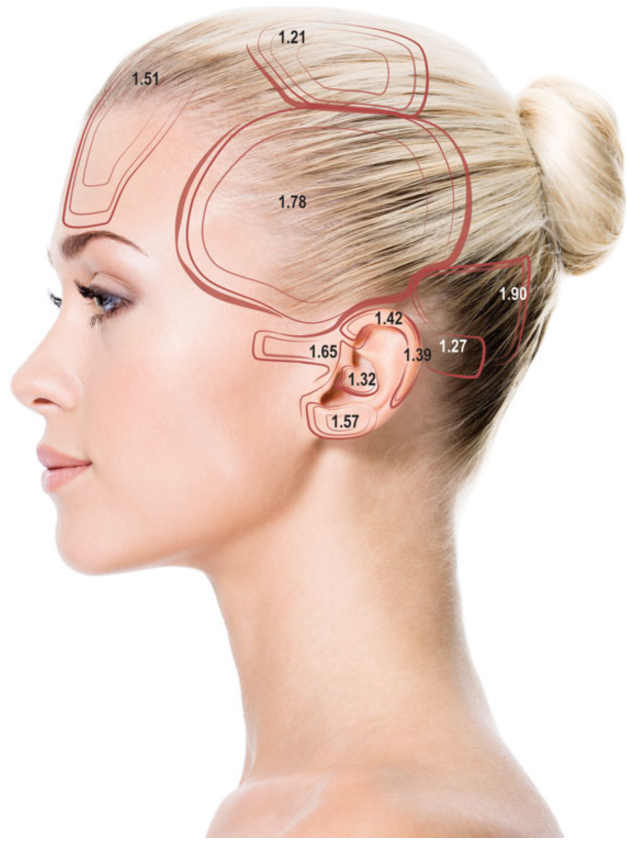

Figure 2. Lateral view of epidermal relative thickness (RT) values.

thickness or the dermal thickness. In fact, an unexpected finding was that the thickest epidermis was found at the upper lip, and the thinnest epidermis was posterior auricular skin.

This is not the first study to evaluate thickness of the human skin. Early studies can be found in the forensic pathology literature where skin topography studies aimed to aid in facial approximation.[3-8] Although the most heavily used and published method of skin thickness measurement is histometric punch-needle biopsy, current studies characterizing skin thickness use ultrasound[6] or magnetic resonance imaging techniques. Other cited techniques employ the use of calipers or gauge screws.[2] Although deemed by some to be more accurate, MRI and CT imaging access is limited, are expensive modalities, and expose subjects to radiation. Further, absolute values of thickness have varied significantly compared with more traditional histometric methods, leading us to question the use of these modalities for accurate measurement at a submillimeter level.[2] Hence, cadaveric histometric studies continue to be the standard for the study of facial soft tissue as it is the oldest and most heavily published technique for soft tissue depth approximation. Advantages to this needle-puncture biopsy based method are the utilization of stationary subjects, inexpensive equipment, direct measurement of samples, and control over measurement sites.[5]

Furthermore, the reported skin thickness areas vary significantly between studies where imaging modalities were used to determine skin thickness.[2] The only recent study with plastic surgery relevance was performed by Ha et al, and utilized punch-needle biopsy and direct pathologic measurement. We found this technique to be the most relevant, but their study was limited with a small sample size of only 3 cadavers, and only 15 anatomic sites on the face. Further, Ha et al developed the first standardized measurement of thickness, the RTI, which utilizes a patient's own thickness as a standard to build measurements, giving researchers a standard tool moving forward. The RTI system expresses all thickness values from an individual body as a ratio compared to the thinnest portion of that body. This same concept was applied in our study, with reporting of data in relative thickness values. We expand the current number of locations for which absolute and relative skin thickness values exist in a larger sample size.

Ha et al found that the lower third of the nose had the thickest skin and the upper eyelid had the thinnest skin. Our results corroborate their findings and build upon them by utilizing adding an additional 24 sites on the human

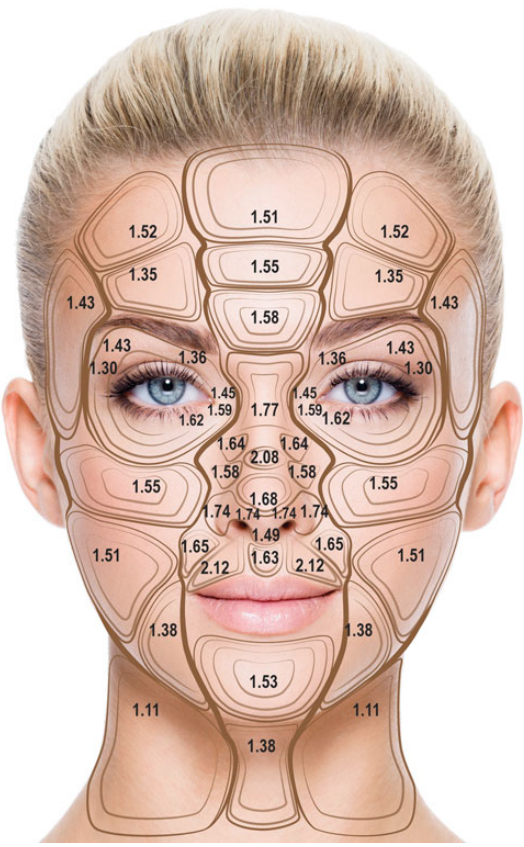

Figure 3. Anterior view of dermal relative thickness (RT) values.

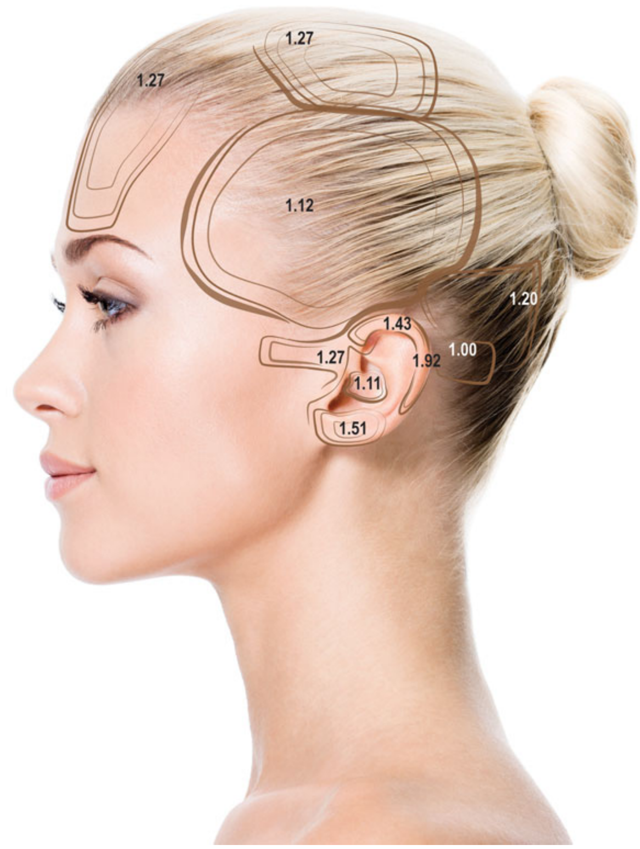

Figure 4. Lateral view of dermal relative thickness (RT) values.

face to truly create a topographic "map" of human facial skin thickness. Our results demonstrate that the dermal pattern (but not epidermal pattern) of thickness dictates total skin thickness. That is, anatomic sites with the greatest dermal thickness also tended to have a greater total skin thickness as well. The posterior auricular region had the highest dermal to epidermal ratio, and the lowest was the lower medial eyelid. Our results confirm that the eyelid skin is the thinnest in the face. The thickest portions of the skin appear to be in the lower nasal sidewall, but is comparable to the ala and posterior auricular skin, which are novel findings. Our results confirm what is known regarding eyelid skin being the thinnest in the face, yet is more detailed in thickness distribution due to the increased number of sites sampled in this study compared to prior studies. Further, the thickest skin is not only around the nasal region, but around the ear and scalp, which are novel findings.

Study Limitations

Using aggregate values for average thicknesses makes only a rough estimate of individual differences between cadavers, creating error due to lack of control over individual differences in thicknesses due to age, race, and a variety of other factors that influence skin thickness, a well-documented phenomenon. An ideal way to study skin thickness is to utilize a normalizing factor applied to each cadaver in the study in order to decrease variation among individuals, as described above. Creating RTI values for each cadaver and comparing them to one another is more accurate than averaging all absolute thicknesses and using an overarching RTI, which was performed in this study. This is something the authors plan to do in the next set of cadaveric studies, along with assessing all of the outcome measures in this study and how/if they change with age, an area of interest to all aesthetic surgeons. However, the use of ten cadavers as opposed to two or three cadavers improves the power to our results.

Furthermore, the use of fresh cadavers as a sample may not accurately correlate with skin thickness in humans. Thickness was likely affected by being frozen and the processing of histologic specimen. The histological results were subject to potential bias from the pathologists who examined specimens. Further, exact details of each cadavers' medical history and body habitus were unavailable, which could have influenced findings.

Future Directions

Moving forward, examining differences in thickness across races, age, gender, and body mass index (BMI) would provide plastic surgeons with vital anatomical information to help plan and execute appropriate adjustments to their surgical approaches when performing rhytidectomy and associated procedures. The current literature describes significant differences between ethnicity, gender, and BMI, yet the amount of data per each population is limited. Further, no cross-cultural study has been performed to confirm such differences[3,4,6] within a single experimental setting. Interestingly, while it is known that soft tissue volume changes contributes to aging of the face,[9] no established, consistent soft tissue depth changes have been cited despite a variety of studies with mixed results.[10-13] While our cadavers were all of Caucasian race, and of a relatively advanced average age, we do feel that the relative thickness concept can be applied to patients of different race, sex, and age since the relative index compares thickness by using the subject as an internal control.

CONCLUSION

Our results showed that the greatest epidermal skin thickness is in the mid-auricular helix. The greatest dermal skin thickness, and the greatest total skin thickness, are both in the lower nasal sidewall. The least epidermal skin thickness is in the posterior auricular region. The least dermal skin thickness, and the least total skin thickness, are both in the upper medial eyelid.

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