Analysis of Facial Skin Thickness: Defining the Relative Thickness Index

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Background: The determination of human skin thickness has been achieved through various methods, both in vivo and in vitro. Ultrasound and histometric analyses have been the most commonly used. However, absolute values of epidermal and dermal thicknesses have demonstrated variability among the different modalities, leaving questions regarding the ability to standardize or compare results of different studies.

Methods: A cadaver study was designed to examine skin thicknesses in multiple anatomical sites from the same subject. Using three fresh adult cadavers, skin biopsy specimens were obtained at 15 facial sites that were identified as clinically relevant locations: upper lip vermilion, lower lip vermilion, philtral column, chin, upper eyelid, lower eyelid, brow/forehead, submental crease, right cheek, left cheek, right neck, left neck, malar eminence, nasal dorsum, and nasal tip. Histometric measurements were obtained at each location.

Results: In all subjects, the upper eyelid had the thinnest skin and was used as the denominator to calculate relative ratios of skin thicknesses with respect to other sites of the face. Using the upper eyelid average skin thickness, the nasal tip skin thickness was 3.30 times thicker and the brow/forehead was 2.8 times thicker.

Conclusions: The authors propose a standardized and clinically useful method of skin thickness analysis by defining the relative thickness index. By examining *relative* values of skin thickness, using each subject as his or her own control, the authors demonstrated consistent ratios of dermal and epidermal thickness from one facial site to another. (*Plast. Reconstr. Surg.* 115: 1769, 2005.)

The determination of human skin thickness has been achieved through various methods, both in vivo and in vitro. Measuring skin thickness is useful clinically in the evaluation of dermal atrophy caused by corticosteroids, detection of osteoporosis, assessment for acromegaly, and indirect body fat calculation. Historically, in vitro, or histometric, measurements have been primarily used. In vivo modalities, such as the use of a Harpenden caliper,[1] radiography,[2,3] micrometer screw gauges,[3] or high-frequency pulsed ultrasound,[3,4] have been proposed to be superior in obtaining absolute, reproducible results with more pertinent clinical relevance. Absolute values of epidermal and dermal thicknesses have demonstrated variability among the different modalities, leaving questions regarding the ability to standardize or compare results of different studies. Tan et al.[5] cited large differences in correlating in vivo (ultrasound) and in vitro (histometric) skin thickness measurements of the forearm; they found in vitro thicknesses greater than in vivo for the same skin samples. Their explanation of the discrepancy was the loss of resting dermal tension and potential distortion of the sample during biopsy.

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There have been several studies demonstrating skin thickness values for various sites of the body using the different modalities discussed. A preliminary study of skin thickness was performed by Southwood.[6] In 1954, Gonzales-Ulloa et al.[7] forwarded the concept of subunit repair at various facial sites.

As plastic surgeons, an understanding of skin thickness at various body sites allows for improved reconstructive outcomes when matching donor and recipient tissues. In particular, providing durable results while considering recipient site color, contour, and thickness is important in optimizing facial skin reconstruction. Our ability to obtain accurate measurements of skin thickness is less relevant than understanding *relative* tissue characteristics when considering reconstructive options. Understanding these relative differences can provide important clinical information regarding tissue characteristics and help guide plastic surgeons in their reconstructive decisions. It is apparent that skin thickness varies with age, race, gender, and degree of photodamage.[5,8–12] Thus, it is a particular challenge in translating tissue characteristics of one patient to another.

We propose a standardized scheme of skin thickness analysis by defining the relative thickness index. By examining relative values of skin thickness, using each subject as their own control, we demonstrated consistent ratios of dermal and epidermal thickness from one facial site to another. The relative thickness index serves as a useful way to quantify relative tissue characteristics and can help guide plastic surgeons in their reconstructive decisions.

Materials and Methods

Full-thickness skin biopsy specimens were taken using scalpels from three fresh adult cadavers acquired through the Willed Body Program at the University of Texas Southwestern Medical Center at Dallas. We used two female subjects, aged 82 and 51 years, and one male subject, aged 78 years. The biopsy specimens were taken at each of 15 facial sites identified as clinically relevant locations: upper lip vermilion, lower lip vermilion, philtral column, chin, upper eyelid, lower eyelid, brow/forehead, submental crease, right cheek, left cheek, right neck, left neck, malar eminence, nasal dorsum, and nasal tip.

Biopsy specimens were preserved in formalin, sectioned, stained with hematoxylin and eosin, and mounted on slides. Three sections were mounted per slide. Skin thickness measurements were performed under light microscopy using 100× magnification. Skin thickness (epidermis and dermis) was determined at two different locations per section and then averaged to one data set. Three averaged readings per slide were acquired, and a total of 45 readings were obtained from each cadaver. Three observers performed readings for each of the three cadavers. A total of 405 measurements were tabulated using an Excel (Microsoft Corp., Redmond, Wash.) spreadsheet.

Statistical analyses were performed by calculating average values for skin thickness. Each measurement was treated as an independent determination per cadaver. Skin thickness measurements were evaluated by analysis of variance to determine whether significant differences among cadavers warranted further segregation and evaluation. Ratios of skin thickness were calculated using the upper eyelid as a referent site. As the smallest average value, the upper eyelid skin served as the denominator and all ratios were expressed as a relative index of this site. Because some measurements were significantly different among the three observers by analysis of variance, relative ratios were calculated for each cadaver and each observer.

The ratios were analyzed per face location to determine the difference among cadavers. Three cadavers' homoscedastic variance was statistically determined using the Bartlett test. If the result of the Bartlett test was less than 0.05 (variances of the three cadavers were not similar), a Kruskal-Wallis test was performed to determine whether there was a significant difference between cadavers. If this value was greater than 0.05 (variances of the three cadavers were considered to be the same), a one-way analysis of variance was performed to determine whether there was a significant difference between the three cadavers. Tukey's tests were also performed for each facial location and for each statistical method. Finally, an average skin thickness ratio was tabulated for each facial site.

Results

Epidermal thickness measurements were significantly different between cadavers ($p < 0.0001$) and thus were combined with their corresponding dermal thickness measurements and a total skin thickness value tabulated for each data point. Average skin thick-

TABLE I
Average Skin Thickness Measurements

Site	Subject A*(mm)	Subject B*(mm)	Subject C*(mm)	AVG ABC
Upper lip	0.68 ± 0.09	1.01 ± 0.01	0.79 ± 0.16	0.83 ± 0.17
Lower lip	0.78 ± 0.21	0.83 ± 0.07	0.85 ± 0.15	0.82 ± 0.15
Philtrum	0.90 ± 0.08	0.83 ± 0.09	0.76 ± 0.09	0.83 ± 0.10
Chin	1.16 ± 0.10	1.24 ± 0.05	1.06 ± 0.11	1.15 ± 0.11
Upper eyelid	0.41 ± 0.13	0.40 ± 0.06	0.32 ± 0.05	0.38 ± 0.09
Lower eyelid	0.84 ± 0.06	1.04 ± 0.04	0.57 ± 0.05	0.82 ± 0.21
Forehead	0.90 ± 0.13	1.16 ± 0.11	1.04 ± 0.04	1.03 ± 0.15
Right cheek	1.04 ± 0.10	1.07 ± 0.06	1.11 ± 0.11	1.07 ± 0.09
Left cheek	1.11 ± 0.09	1.20 ± 0.09	1.20 ± 0.04	1.17 ± 0.08
Malar eminence	0.97 ± 0.07	1.62 ± 0.05	0.57 ± 0.04	1.05 ± 0.45
Submental	1.06 ± 0.04	0.97 ± 0.05	0.65 ± 0.09	0.89 ± 0.19
Nasal tip	1.37 ± 0.14	1.17 ± 0.09	1.11 ± 0.06	1.22 ± 0.15
Nasal dorsum	0.60 ± 0.06	0.79 ± 0.06	0.81 ± 0.09	0.73 ± 0.12
Right neck	0.55 ± 0.09	0.25 ± 0.04	0.77 ± 0.07	0.52 ± 0.23
Left neck	0.38 ± 0.04	0.43 ± 0.03	0.80 ± 0.05	0.54 ± 0.20

Subject A was an 82-year-old female subject, subject B was a 51-year-old female subject, and subject C was a 78-year-old male subject.

ness values are shown in Table I. There was some variability in the absolute measurements of skin thickness between observers. Statistical analyses were performed (Table II). The nasal dorsum ($p < 0.005$), right neck ($p < 0.005$), and left neck ($p < 0.005$) demonstrated significant differences among the three cadavers. The remaining facial sites were not significantly different among the cadavers.

Relative ratios of skin thickness to the referent site were calculated in efforts to reduce the interobserver variability by allowing each cadaver to serve as its own control. We postulated that biases in measurements would be consistent throughout the 15 sites of one cadaver for a particular observer. The relative thickness index was developed by averaging the relative ratios between cadavers/readers and determining standard deviations (Table II). Using the upper eyelid average skin thickness, the nasal tip skin thickness was 3.30-fold thicker and the brow/forehead was 2.8-fold thicker, as shown in Table III. A "map" of facial relative skin thickness values is depicted in Figure 1.

DISCUSSION

Variations in epidermal and dermal thicknesses (among different measuring modalities) have posed a challenge in examining meaningful absolute comparisons for clinical use.[3,5,13] We describe the relative thickness index, based on histometric measurements, which can serve as a useful, standardized method for clinical analysis of skin thickness. We have supported its use by confirming similar ratios of facial skin thickness, with each subject in our study serving as their own referent.

Some variability between readers was observed when comparing absolute thickness measurements. Discerning dermal thickness can be quite variable, depending on where along a rete ridge a measurement is obtained.[14,15] Artifact (created by slide preparation and sectioning) in the epidermal-dermal junction or the dermal-subcutaneous layer junction can also contribute to the variability. Indeed, review of the literature showed wide variability in absolute measurements at a particular anatomical location. However, we postulated that if each cadaver served as its own control, interreader variability would be minimized by comparing ratios of skin thickness to a referent site. Our statistical analyses confirmed our hypothesis for all facial sites except for the right and left neck and the nasal dorsum. These sites demonstrated significant in-

TABLE II
Statistical Analyses

Site	Statistical Analysis (p)
Upper lip	0.169 (one-way ANOVA)
Lower lip	0.148 (K-W)
Philtrum	0.565 (one-way ANOVA)
Chin	0.734 (one-way ANOVA)
Upper eyelid	1
Lower eyelid	0.091 (one-way ANOVA)
Forehead	0.063 (K-W)
Right cheek	0.252 (one-way ANOVA)
Left cheek	0.061 (K-W)
Malar eminence	0.061 (K-W)
Submental	0.235 (one-way ANOVA)
Nasal tip	0.301 (K-W)
Nasal dorsum	0.004 (one-way ANOVA)*
Right neck	0.001 (one-way ANOVA)*
Left neck	0.001 (one-way ANOVA)*

ANOVA, analysis of variance; K-W, Kruskal-Wallis.
* Significantly different between cadavers.

TABLE III
Relative Thickness Index

Site	Relative Skin Thickness Index (±SD)
Upper lip	2.261 ± 0.539
Lower lip	2.259 ± 0.537
Philtrum	2.260 ± 0.375
Chin	3.144 ± 0.464
Upper eyelid	1 ± 0.000
Lower eyelid	2.189 ± 0.475
Forehead	2.850 ± 0.599
Right cheek	2.967 ± 0.661
Left cheek	3.226 ± 0.628
Malar eminence	2.783 ± 1.082
Submental	2.403 ± 0.500
Nasal tip	3.302 ± 0.491
Nasal dorsum	2.020 ± 0.478
Right neck	1.497 ± 0.824
Left neck	1.530 ± 0.764

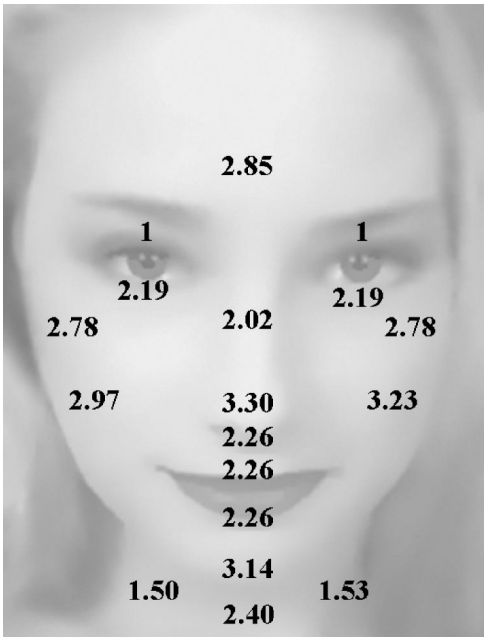

FIG. 1. Facial relative skin thickness map.

tercadaver differences, making it difficult to tabulate a consistent relative thickness index value for these facial sites. It is possible that these particular anatomical sites showed particular variance as a result of the differing ages and sex of the cadavers.

Intuitively and clinically, we all believe that the skin over the nasal dorsum is thicker than the upper eyelid. But by how much? By using the relative thickness index, surgeons have a template that describes the nasal tip skin thickness to be approximately 3.3 times thicker than the upper eyelid. Skin thickness is only one factor to consider when planning a reconstruction. The presence or absence of underlying subcutaneous tissues (e.g., fat, fascia) in a defect and the amount of subcutaneous tissues in a donor flap (i.e., forehead flap) are important considerations when attempting to optimize anatomical contour. Dermal thickness constitutes a varying proportion of soft tissues at any given anatomical site: in the upper eyelid, there is very little subcutaneous fat; in the nasal tip, there is a greater amount of subcutaneous fat and fibrous tissue. The contour deformity that is often visible when attempting to perform skin grafting for full-thickness defects at the nasal tip is largely explained by the relative lack of subcutaneous fat, not dermal thickness. However, the bulkiness that is often seen with skin grafts (noneyelid skin) to the upper eyelid can be explained easily by examination of the relative thickness index. Upper eyelid skin is the thinnest of all the sites reviewed in this study. Skin at all other sites (except neck skin) is at least twice as thick.

This was a study performed on fresh cadavers and thus may not accurately represent in vivo relationships of skin thickness. This research design was chosen to facilitate multiple tissue biopsy sites with one subject; this would not be feasible in a clinical study. Our samples were obtained from an age group between 51 and 82 years (two female subjects and one male subject). Variation in skin thickness related to age, sex, and race is intuitive and well documented. Further investigation with a larger and more representative group regarding age and sex may add more useful information for clinical purposes.

CONCLUSIONS

We conclude that the relative thickness index serves as a quantitative guide for differences in skin thicknesses between areas of the face. This information can help guide reconstructive choices by matching similar skin thickness between donor and recipient sites.

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