investigation of the lip skin barrier by Raman spectroscopy. Total water, ceramide, and NMF–depth profiles were acquired on the lower lip of volunteers. As for skin at other body sites, water content profiles show two distinct slopes, corresponding to the lip SC and the tissue below, and enabling estimation of the lip SC thickness. Overall, average total water content of the lip was a little higher than the average forearm value. SC thickness in the lip skin was similar to volar forearm and leg values; however, lip SC was thicker than cheek skin SC. Ceramide content was also similar to forearm values, whereas NMF content was lower in lip skin than in forearm skin. For each measured parameter, a detailed statistical analysis showing the number of volunteers required to obtain a given error is provided.

55.4.2.5 Effects of Age on Major Skin Components

Water and NMF. A number of studies have formally investigated the effect of age (young vs. elderly volunteers) on the distribution of major skin components using CRM. In general, the SC of elderly volunteers contains less water and is thicker than for younger populations (up to about 30 years of age). It also contains higher amounts of NMF and *t*-UCA in the forearm skin (Egawa and Tagami 2008; Binder et al. 2017). Egawa and Tagami (2008) did not observe any significant differences in water or NMF in the cheeks of their studied populations. Comparing the age groups 18 to 30, 30 to 40, 40 to 55, and 55 to 70 years of age and estimating SC thickness from water content profiles, Boireau-Adamezyk et al. (2014) showed an increase in facial, volar, and dorsal forearm SC thickness with age. This increase was more pronounced in the forearms than in the facial skin. There was, however, no significant difference between the SC thickness increase in the two forearms, leading the authors to conclude that SC thickness increase is more related to chronological aging rather than photoexposure (extrinsic aging). Interestingly, their data from volunteers aged 50 to 70 years are more widely dispersed than that of their younger subjects. The increased variability in the data of elderly could be due to more pronounced cumulative lifestyle factors (e.g., sun exposure, stress, smoking, cosmetics application).

Nakagawa et al. (2010) compared the water content of forearm dermis (depth of 70 μm in the skin) and showed significantly higher dermal water content in skin of the elderly.

Choe et al. (2018a) used CRM to compare the hydrogen bonding state of water in an older vs. younger population. They tracked the ratio of the DA (single donor–single acceptor, weakly bound) to DDAA (double donor–double acceptor, strongly bound) water molecule types in the high wavenumber region, i.e., the ratio of intensities I_{3450}/I_{3250}, as a function of depth in the SC. Within the top 10% to 30% of the dermis, elderly skin was shown to contain more hydrogen-bound water. This finding may be linked to the dryness of elderly skin compared to younger skin. Furthermore, these authors showed a significantly higher mean NMF amount in elderly skin within the top 20% to 40% of the SC, in agreement with previously mentioned studies.

Nguyen et al. (2013) investigated the hydration of collagen in the dermis of elderly vs. young volunteers and in relation to relative humidity. The Raman spectra were obtained in the reticular dermis at depths of 500 μm from the skin surface. The intensities of the ν(C–C) peak at 938 cm^{-1} and the wavenumber downshift of the amide I maximum from 1672 cm^{-1} to 1665 cm^{-1} were observed with an increase in relative humidity (RH). The ratio of intensities I_{1658}/I_{1668}, a marker of collagen/water interactions, was used to differentiate between the skin samples of the two populations. The authors surmised that these differences could result from differences of compactness of the collagen fiber bundles. The younger skin contains thinner diameters of collagen fiber bundles and consequently a more compact collagen structure.

Fluhr et al. (2012) compared the water content of the volar forearm of full-term newborns (1 to 15 days), babies aged 5 to 6 weeks, babies aged 6 ± 1 months, children aged 1 to 2 years, children aged 4 to 5 years, and adults aged 20 to 35 years. They showed that the SC is less hydrated in the first 2 weeks of postnatal life. There is a decrease in SC water content towards the skin surface for all age groups, but this gradient is lower for the newborns. The mean total amount of NMF in the SC was greater for the newborns than for all other age groups.