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A Classification of Facial Wrinkles

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An increasing number of injectable filler materials for facial wrinkles and folds points to the need for objective measurements of their effectiveness. Patient satisfaction is the goal, but proof of the value of a particular product requires objective measurement. A wrinkle assessment scale was developed as a simple tool for use by plastic surgeons, dermatologists, and aesthetic surgeons who want to assess the changes resulting from injecting filler materials in their patients. By correlating the grade of the wrinkle in the reference photographs with the wrinkle in a patient's face, a classification of 0 to 5 is assigned. Reliability of the scale was assessed by "live" judgment of 76 wrinkles by nine observers. The same rating was given to 92.7 percent of all wrinkles. In a second trial, photographs from 130 wrinkles were presented to eight observers who rated 89.4 percent of all wrinkles equally. A significant correlation of 87 percent was found between subjective ratings and objective wrinkle depth measured by profilometry on 40 silicone impressions. Manufacturers, monitors of clinical trials, health authorities, and most important, patients will benefit from objective data on current and new injectable materials. (*Plast. Reconstr. Surg.* 108: 1735, 2001.)

The treatment of facial wrinkles, furrows, and folds has become a major issue in many offices of plastic surgeons, dermatologists, and aesthetic surgeons. The judgment of its success, however, still depends on the subjective feelings of the physician and on the positive or negative perceptions of the patient. Little has been published on objective measurements of wrinkles, furrows, and folds, and physicians are overly dependent on the manufacturers' information and reliability.

New filler substances are developed every year. Based purely on patient and physician satisfaction, some manufacturers claim a lasting effect of their injectables[1] without objective assessment before and after injection. Other companies are convincing physicians and patients with preinjection and postinjection pho-

tographs without information on the time interval between pictures.[1] Furthermore, there is a difference in long-term quality and persistence of a filler substance in animal experiments and in humans: whether it is implanted as a bulge under the skin of a rat's forehead[2] or injected intradermally into a dynamic facial wrinkle. The onus is on all serious physicians to objectively evaluate these products before they become extensively implemented.

TERMINOLOGY

A discussion of wrinkles, furrows, and folds is difficult because there is no commonly accepted classification or body of terminology that is based on anatomic, dimensional, or etiologic criteria. Words such as wrinkles, lines, furrows, and folds are used with heavy reliance on the intuitive grasp of such terms (Fig. 1).

Superficial wrinkles are associated with textural changes of the skin surface caused by intrinsic aging and photoaging of topographically defined areas. The fine lines of wrinkling may be discrete at first and then, over time, become grouped and multidirectional as noted by Stegman.[3] Apart from cutis rhomboidalis caused by elastosis, they occur as wrinkling in the face or as regional static wrinkles over the whole body. Wrinkle lines are usually limited to superficial dermal creasing; thus, they are amenable to treatments such as chemical peeling, dermabrasion, and laser resurfacing.[4–7]

Mimetic wrinkles, commonly referred to as lines (partial thickness) or furrows (full thickness), are the visible effects of deep dermal creasing caused by repeated facial movement and expression combined with dermal elastosis. They are therefore perpendicular to the
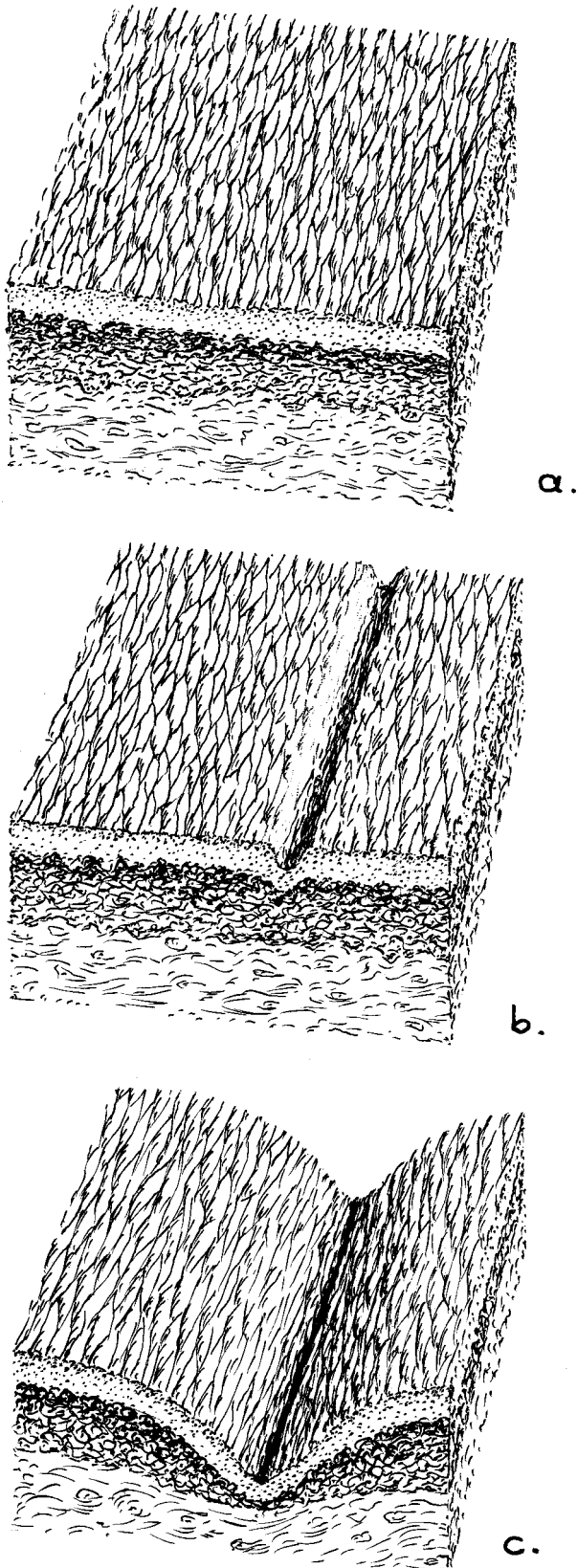
FIG. 1. Textural changes of the facial skin: (*above*) wrinkling, (*center*) mimetic wrinkles, and (*below*) folds.

direction of the underlying facial muscles. They occur with aging as forehead and glabellar lines, nasolabial folds, radial lip lines, marionette lines, and lines in the corners of the mouth.

Glabellar lines result from frequent frowning, and periorbital lines and nasolabial folds result from smiling. Radial lip and marionette lines, however, are caused by concomitant movement of mimetic muscles during chewing. Therapeutically, mimetic wrinkles or furrows do not respond well to resurfacing procedures, but react preferentially to muscle resection (musculus frontalis, musculus corrugator palpebrae), botulinum toxin, or injectable skin filler materials.[1,2,8–13]

Folds are the result of overlapping skin caused by genetic laxity, intrinsic aging, loss of tone, bony atrophy, gravity, and consequent sagging. They occur as upper and lower lid folds in blepharoptosis, as nasolabial folds in midface sagging, and as horizontal neck folds in lax skin. The correction of folds requires tightening procedures such as blepharoplasty, face lift, or direct skin excision.[14] Augmentation of the bony skeleton by implants, bone grafts, or skeletal osteotomies may also be necessary to treat folds in properly selected cases. Combinations of mimetic wrinkles and folds are commonly present. For example, a sagging nasolabial fold may be temporarily eliminated by manual elevation, exposing a crease or furrow in its center.

CLASSIFICATIONS

Fitzpatrick[7] proposed a classification of perioral and periorbital wrinkling for use in establishing the effect of laser resurfacing of the skin (Table I). Fitzpatrick's classification was

TABLE I
Fitzpatrick's Classification of Facial Wrinkling (Perioral and Periorbital)

Class	Score	Wrinkling	Degree of Elastosis
I	1–3	Fine wrinkles	Mild (fine textural changes with subtly accentuated skin lines)
II	4–6	Fine to moderate depth wrinkles, moderate number of lines	Moderate (distinct papular elastosis, individual papules with yellow translucency, dyschromia)
III	7–9	Fine to deep wrinkles, numerous lines, with or without redundant skin	Severe (multipapular and confluent elastosis, thickened yellow and pallid cutis rhomboidalis)

directed toward generalized wrinkling and elastosis rather than specific wrinkle depth. Wrinkle depth analysis, which is not accounted for by the Fitzpatrick scale, is a more important measurement when considering wrinkle augmentation with injectable fillers. Glogau[8] has proposed a classification consisting of type I (no wrinkles), type II (wrinkles in motion), type III (wrinkles at rest), and type IV (only wrinkles). These classifications are confined to generalized wrinkles and do not address specific mimetic wrinkles or folds.

The only classification to include facial wrinkles, furrows, and folds was published by Hamilton.[15] A choice of appropriate therapy results simply from categorizing the patient's problems with this comprehensive and easily understandable chart (Table II). However, this classification, oriented toward treatment selection, provides no scale to objectively measure the outcome of treatment.

MEASUREMENTS

The first attempts to use quantitative methods have been described only recently[4–6] and developed for the assessment of facial skin rejuvenation after laser treatment of wrinkles. Negative silicone rubber replicas of facial wrinkles were measured directly by use of a simple light microscope, a technique confirmed by electron microscopy.[6] Replicas have also been converted into hard, positive epoxy resin impressions.[16] A mechanical or optical profilometer[17,18] was then used along with an image-analyzing computer to measure wrinkle depth.[19,20] These measurements were confined to superficial wrinkles only, not facial furrows or folds.

OBJECTIVES

To develop a scale for the assessment of skin fillers used in the treatment of facial mimetic wrinkles or furrows, our goal was to determine whether a photographically based classification
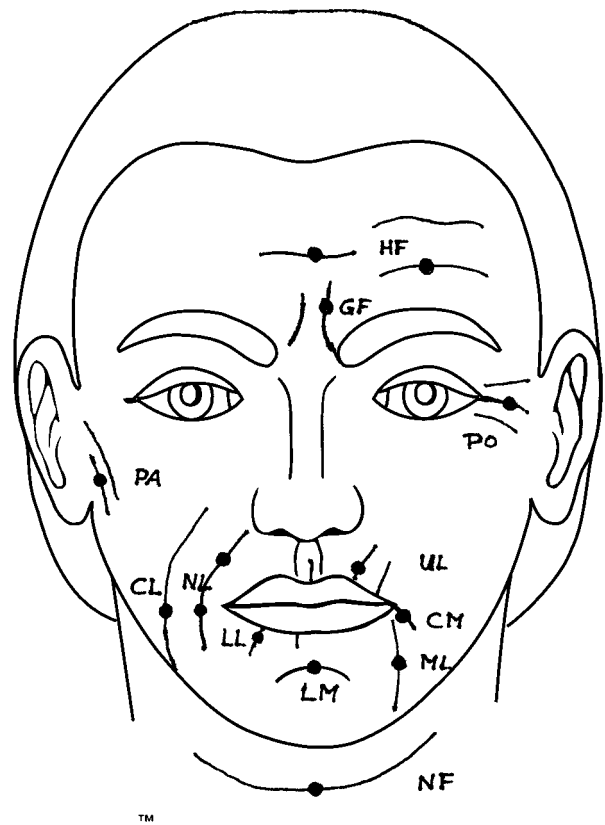

FIG. 2. Anatomic reference points for assessment and measurement of wrinkle depth. If the deepest point of the wrinkle is outside of this point, it can be marked or described separately. *HF*, horizontal forehead lines; *GF*, glabellar frown lines; *PO*, periorbital lines; *PA*, preauricular lines; *CL*, cheek lines; *NL*, nasolabial folds; *UL*, upper radial lip lines; *LL*, lower radial lip lines; *CM*, corner of the mouth lines; *ML*, marionette lines; *LM*, labiomental crease; *NF*, horizontal neck folds.

of mimetic wrinkles could be used reliably and consistently by clinicians and to determine whether this classification correlated with measurement of wrinkle depth as determined by profilometry on negative silicone replicas of facial wrinkles.

A review of the literature[3,7,8,15] and current practice revealed that there is not an appropriate classification system for deep facial wrinkles

TABLE II
Hamilton's Classification of Contour Changes of Facial Skin

| Facial Aging	Clinical Morphology	Tissue Location	Clinical Location	Etiology	Optimal Treatment
A	Folds	Muscular	Nasolabial folds, neck, eyelids	Loss of tone, gravity	Rhytidectomy, blepharoplasty
B	Furrows	Musculocutaneous	Forehead, smile lines	Repeated facial expressions	Filler substances, injectables, implants
C	Wrinkles	Cutaneous	Cheeks, crow's feet, perioral	Intrinsic aging, photoaging	Resurfacing, laser, chemical peel
D	Combination				Combined approach

Horizontal Forehead Lines
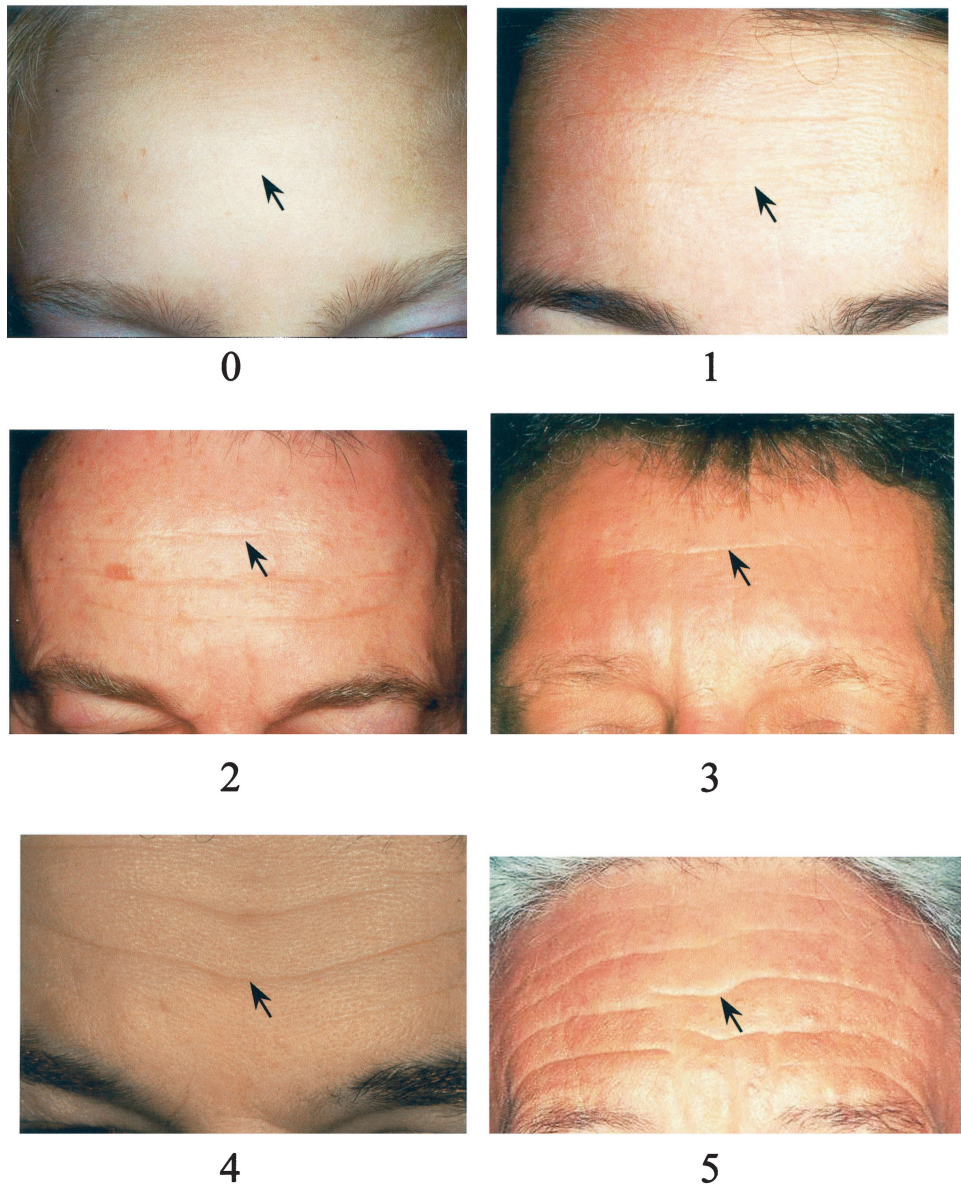
FIG. 3. Wrinkle Assessment Scale of horizontal forehead lines.

and folds. Objective measurements, however, are necessary to rate the effect of treatments with injectable materials. In daily practice, a simple look at a reliable reference scale would enable clinicians to classify the deep mimetic wrinkles and folds on a patient's face.

MATERIALS AND METHODS

Wrinkle Assessment Scale

From hundreds of pictures taken from randomized patients in the first author's practice (G. Lemperle), one reference photograph was selected for each class (0 to 5) of facial wrinkles from 11 different regions (Fig. 2). As a result, reference picture sheets were created (Figs. 3 through 13) for use in validating the reliability of photographic classification.[21] For this study, four of the regions were selected: right-side and left-side glabellar lines, right-side and left-side radial upper lip lines, right-side and left-side nasolabial folds, and right-side and left-side marionette lines.

The photographs of the Wrinkle Assessment Scale were used "live" in direct comparison with the corresponding wrinkle or fold in the
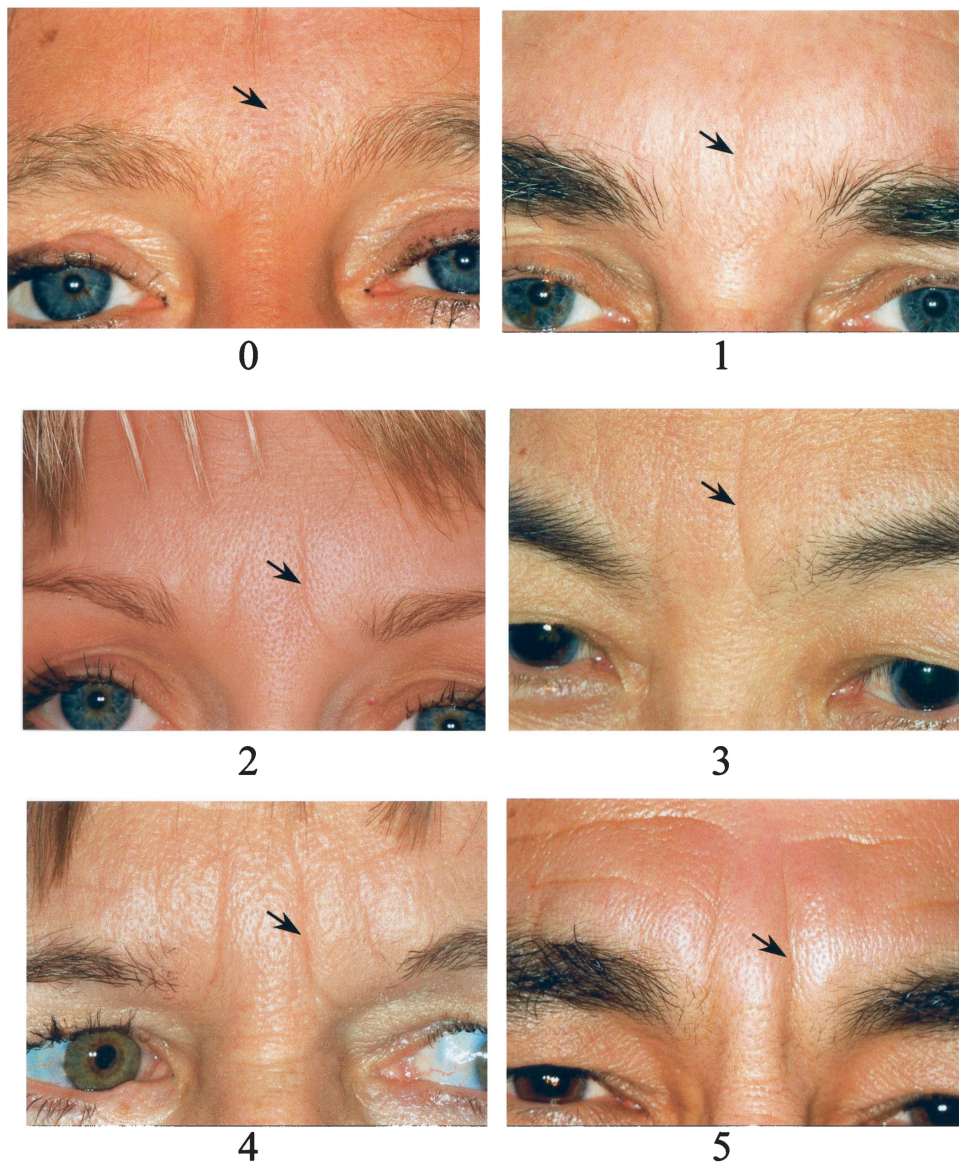
Glabellar Frowns

FIG. 4. Wrinkle Assessment Scale of glabellar frown lines.

patient's face or "indirectly" by comparing a patient's photograph with the pictures of the scale. The assessment was always made at the same location by use of anatomic landmarks (Fig. 2). Horizontal forehead lines were measured at their intersection with the vertical pupillary line. Glabellar frown lines were measured at the level of the upper border of the eyebrows. Periorbital lines were measured 1.5 cm lateral to the lateral canthus. Preauricular lines were measured at the level of the lower groove of the tragus. Nasolabial folds were measured midway between the alar rim and corner of the mouth (upper nasolabial) and at

the level of the corner of the mouth (lower nasolabial). Cheek lines were also measured at the level of the corner of the mouth. The corner of the mouth lines were measured 5 mm below the commissure. Radial lip lines were measured 2 mm above or below the vermilion border. Marionette lines were measured midway between the corner of the mouth and the border of the lower jaw. The labiomental crease and the neck folds were measured in the midline.

In the case of multiple wrinkles as in an upper lip, only the deepest wrinkle was assessed and marked on the photograph or a
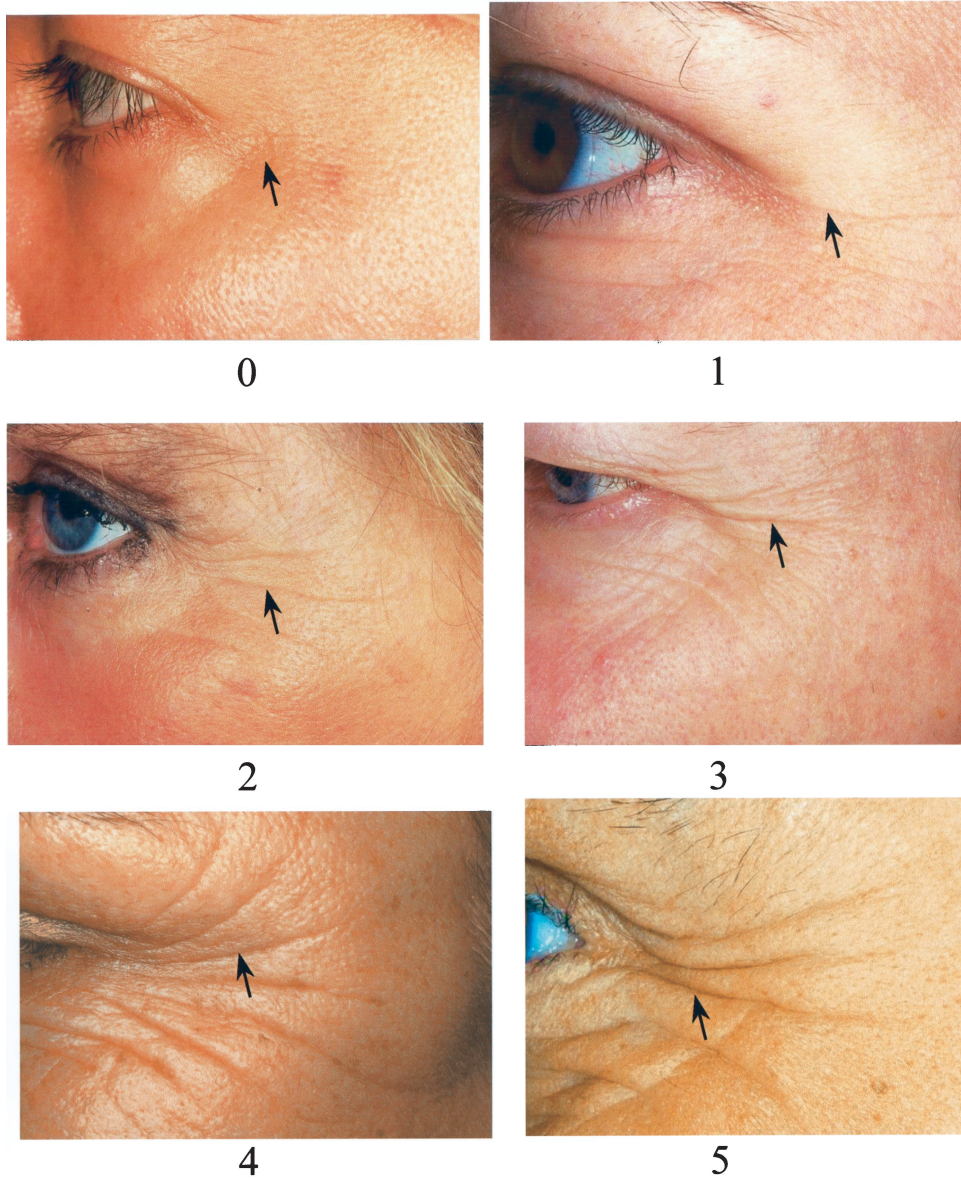
Periorbital Lines

FIG. 5. Wrinkle Assessment Scale of periorbital lines.

chart for later reference. In cases of asymmetry, the wrinkles of the right and left upper lip were assessed separately. The depth of the wrinkle at its reference point (Fig. 2) was considered and compared, not its length or overlapping skin fold. Some elderly patients have a pronounced skin fold or redundancy of skin rather than a wrinkle or crease in the dermis. In such cases, only the wrinkle was classified. If it was not evident whether to rate a wrinkle as a class 3 or class 4, for example, it was rated as a class 3.5. All ratings were noted on a special classification sheet (Fig. 14).

Silicone Impressions

A Kerr gun with silicone double cartridges and mixing tips (Kerr Extrude Wash No. 28418, Kerr Corp., Romulus, Mich.) was used for making the impression molds. The double cartridges containing blue silicone fluid and a hardener were fixed to the gun, the mixing tip was applied, and the silicone was mixed with the hardener filled up to the tip. The patient's face was fixed in a horizontal position and all makeup was removed from the wrinkles.

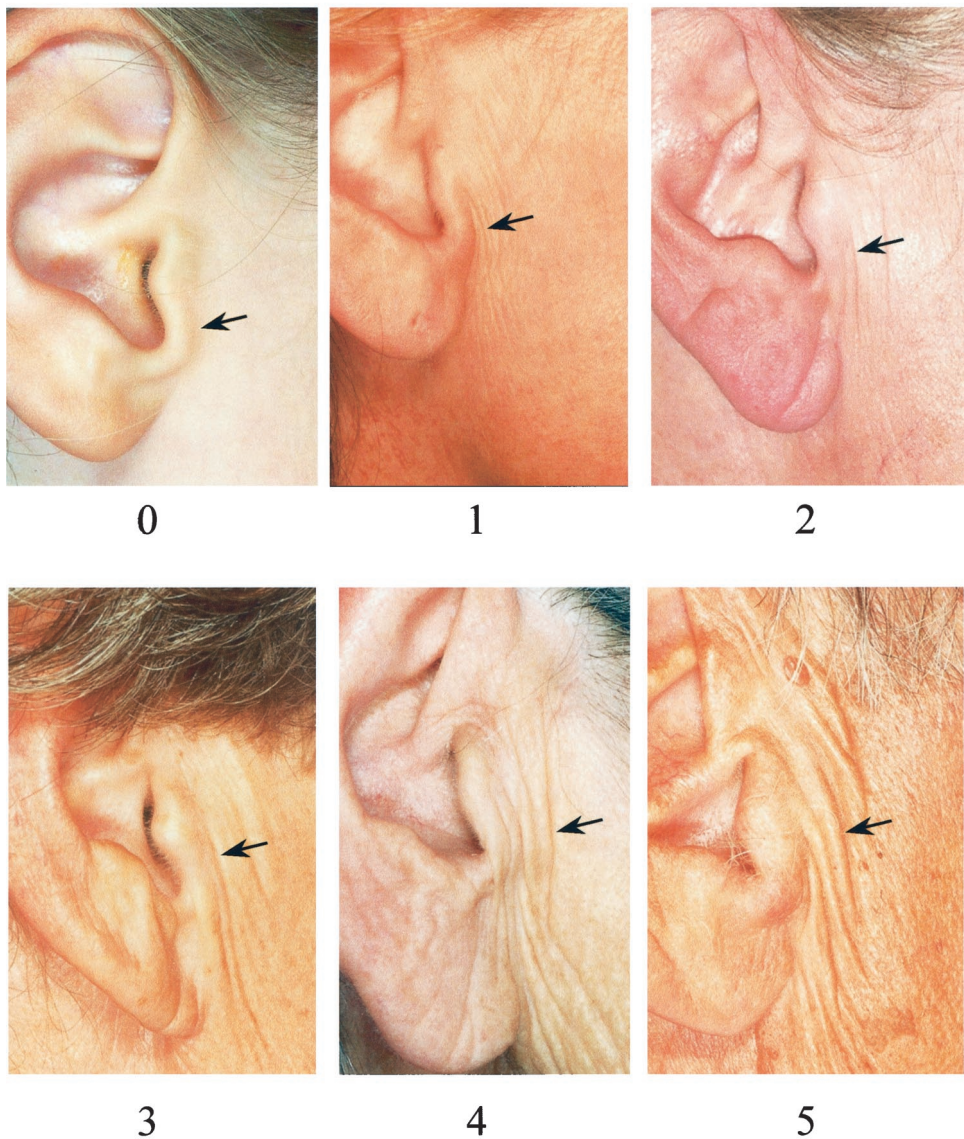The low viscosity of the elastomer coupled

Preauricular Lines

FIG. 6. Wrinkle Assessment Scale of preauricular lines.

with its hydrophobic properties promotes its penetration into all irregularities of the skin. The crease was filled with blue silicone in its full length with one stroke from the gun to prevent air bubbles. A landmark of the face such as inner eye brow, alar base of the nose, or corner of the mouth was included in the impression mold.

An ordinary tissue cassette for histologic preparations or a perforated Aquaplast splint,[22] a 2 × 1 inch section cut from a 1/16-inch-thick sheet (A 962-50, Smith and Nephew, German-town, Wis.), was pressed gently into the still soft silicone impression until half of its holes were filled with blue silicone. The silicone polymer hardens within 1 minute. Therefore, a new mixing tip was used for each patient.

After 1 minute of polymerization, the impression was removed together with the adherent splint without touching the ridge of the furrow. A transparent tape was pressed to the back of the splint and the patient's initials, date, side, and wrinkle abbreviation (see Table III) were recorded with a permanent marker. A
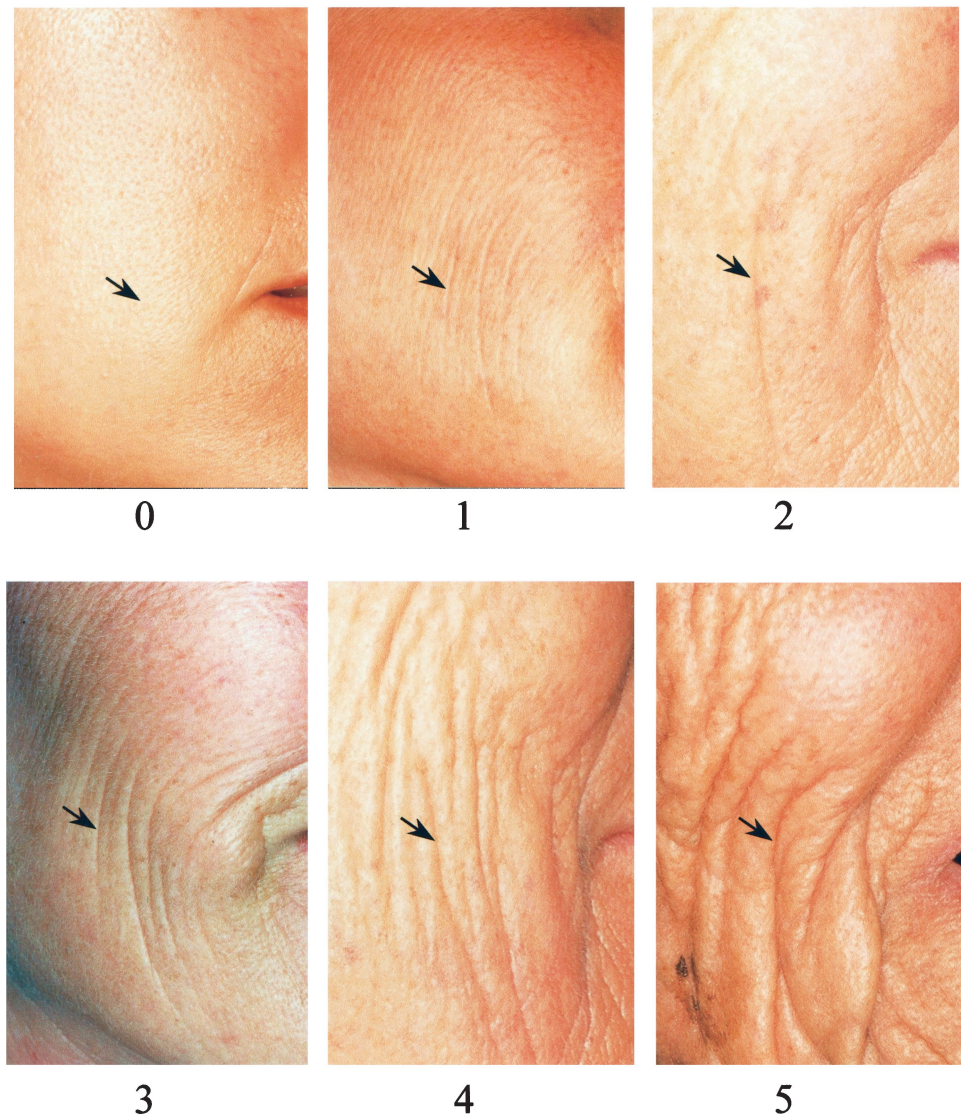
Cheek Folds

FIG. 7. Wrinkle Assessment Scale of cheek folds.

black line was drawn to indicate the highest point for profilometry, and this point was also marked on the patient's photographic chart.

Wrinkle Metrology

Measurements of wrinkle impressions were made using a stylus profiler (Surfanalyzer 5000 Surface Analysis System, Federal Products Co., Providence, R.I.). This instrument uses a diamond ball-tipped stylus mounted to a linear variable differential transducer with a counter-balanced downward force of 200 mg. The stylus/transducer assembly is mounted to a precision reference bar that is straight to within 25 nm over a traverse of 25 mm. The vertical resolution of the transducer is 25 nm. Thus, the sample surface being traversed by the stylus is compared with the reference bar surface. The peaks and valleys of the sample surface are displayed as distance versus height (Fig. 15).

On the drawing of the wrinkle's profile on a graph paper, the deepest points of the skin
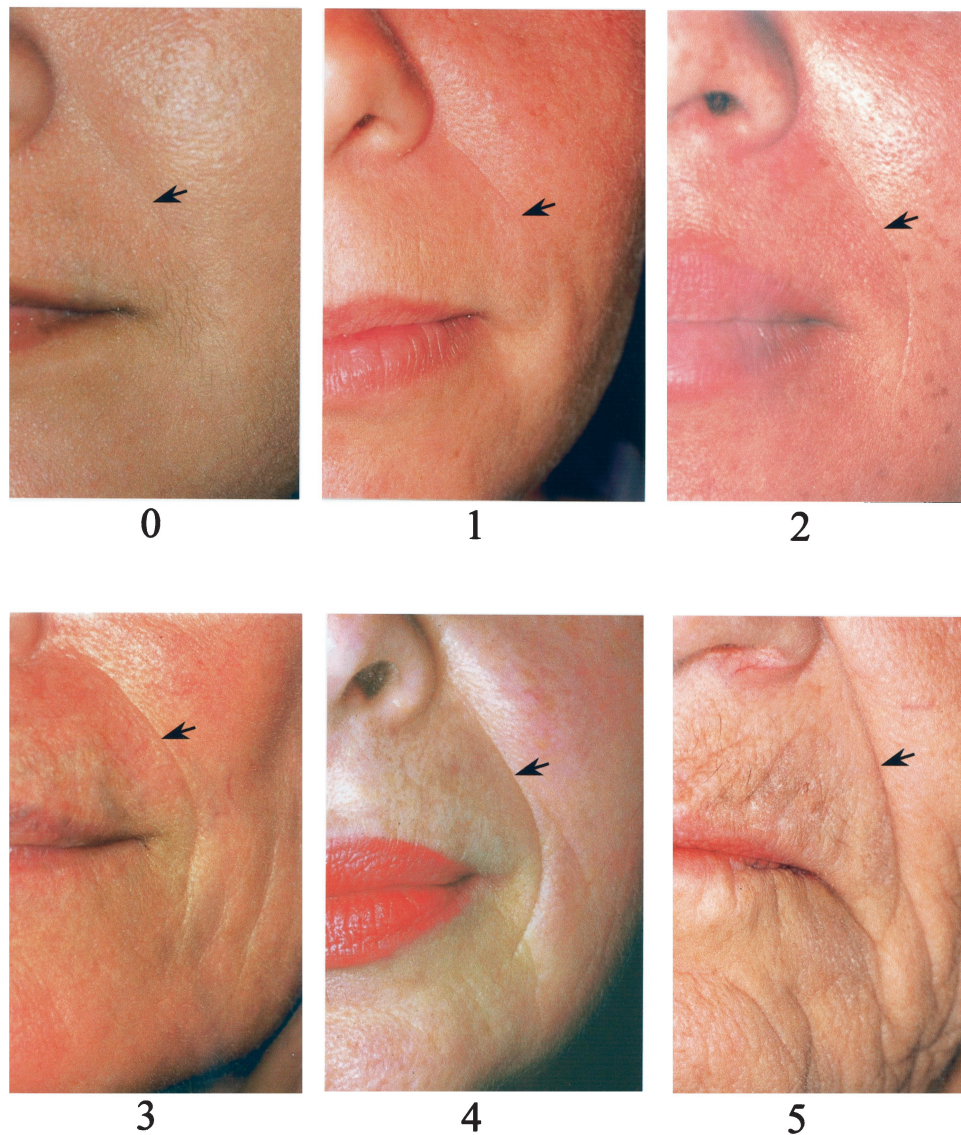
Nasolabial Folds

FIG. 8. Wrinkle Assessment Scale of nasolabial folds.

surface on both sides of the wrinkle were located and connected, and the depth of the wrinkle was measured perpendicular to this line (Fig. 14).

RESULTS

Live Ratings

The first test of the Wrinkle Assessment Scale was made by nine observers (three plastic surgeons, three aesthetic surgeons, and three dermatologists) who were asked to judge the depth of 76 mimetic wrinkles on the faces of 32

colleagues during a plastic surgery meeting in Cyprus in 1999. Using the reference photographs depicting the Wrinkle Assessment Scale (Figs. 4 and 8 through 10), 689 individual ratings of wrinkle depth were made on the faces of these 32 colleagues (Table IV).

Interobserver variation occurred in 50 of 689 wrinkles; 92.7 percent of the wrinkles got the same ratings (Table IV). The variations in the ratings of three plastic surgeons, three aesthetic surgeons, and three dermatologists showed no significant differences: 6.5 percent,
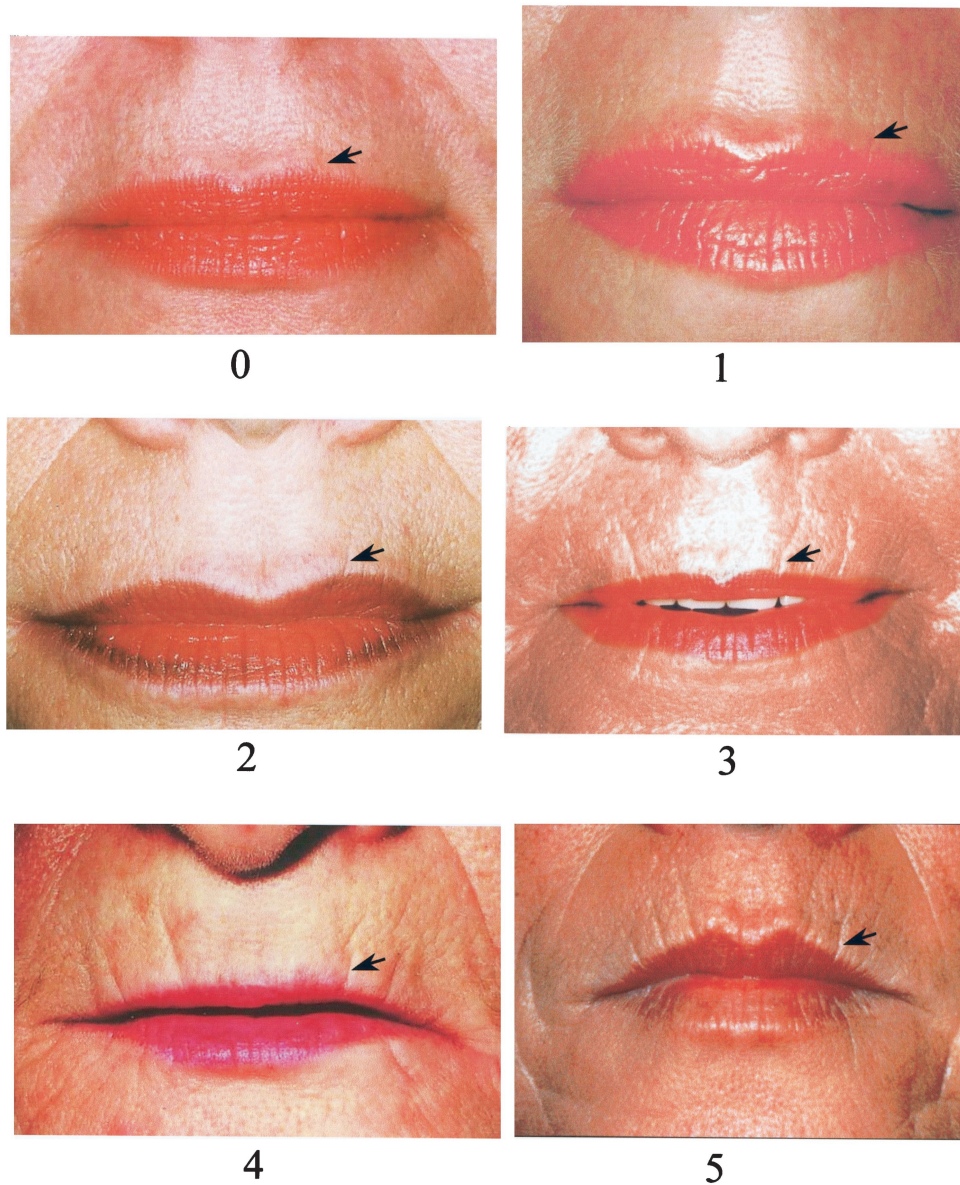
Upper Lip Lines

FIG. 9. Wrinkle Assessment Scale of upper lip lines.

6.9 percent, and 8.8 percent of the wrinkles were rated differently from the majority of the observers. A difference of two classes was rated in only three of the 50 ratings in which observers differed.

Photographic Ratings

The next test of the wrinkle scale was performed on 130 different mimetic wrinkles by eight independent observers (four plastic surgeons, four lay persons). The wrinkles were marked with an arrow at their deepest point. With the aid of the photographic Wrinkle As-

sessment Scale (Figs. 4 and 8 through 10), the eight observers were asked to score the depth of each of the 130 wrinkles. There was an 89.4 percent agreement among the eight observers in their classification of wrinkle depth using the Wrinkle Assessment Scale (Table V).

Profilometry

To determine whether the Wrinkle Assessment Scale correlates with the measurement of wrinkle depth as determined by profilometry, 40 negative silicone impression replicas were measured (Figs. 16 and 17) and compared with
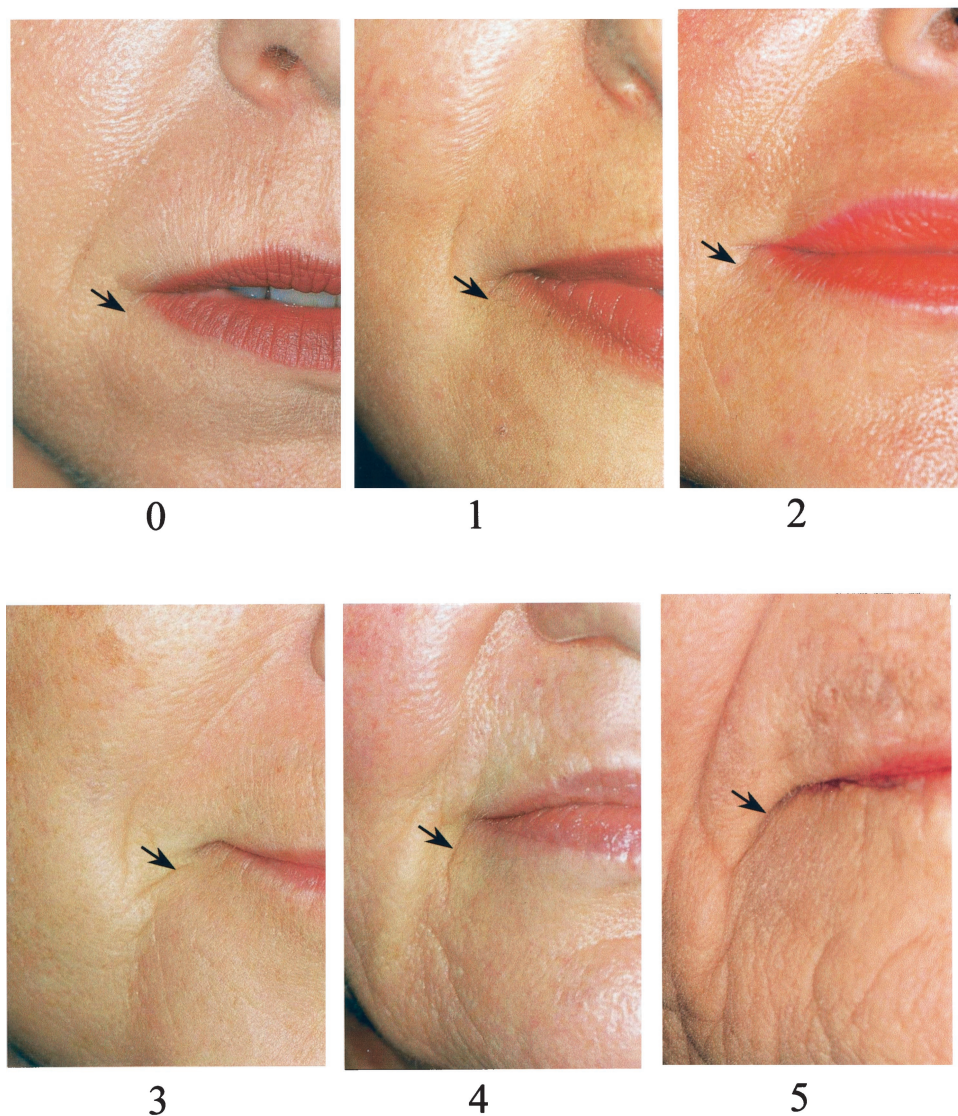
Corner of Mouth Lines

FIG. 10. Wrinkle Assessment Scale of corner of the mouth lines.

the photographic ratings by the eight independent observers (four plastic surgeons, four lay persons) of the same wrinkles. There was an 87.0 percent agreement between the impression mold measurements and the observer ratings with the use of the Wrinkle Assessment Scale (Table VI).

By listing the average impression depth for each wrinkle score, a proposed range of wrinkle depth was defined for each wrinkle score (Table VII).

Statistical Analysis

The intraclass correlation,[24] which applies to the case in which more than two wrinkle types

(eight in this instance) are correlated, was significant with a $p < 0.001$ in each case. The magnitude of intraclass correlations ranged above 0.80; the correlation is considered highly significant when greater than 0.70 to 0.80.

DISCUSSION

The Wrinkle Assessment Scale was an easy, consistent, and reliable tool for the assessment of deep facial wrinkles. The scale correlated well with an objective profilometry measurement of the wrinkle depth.

The most accurate description of the photographed lines and creases in our wrinkle scale
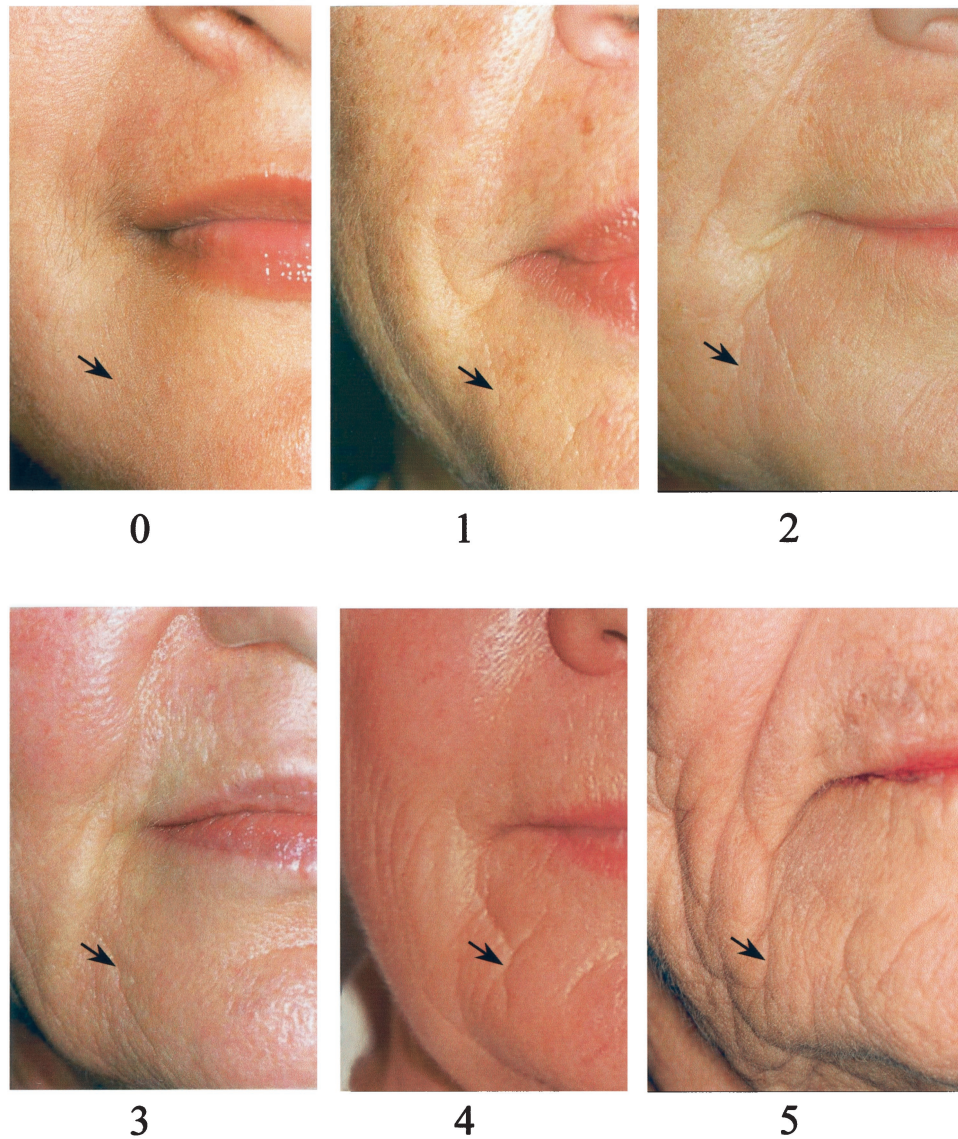
Marionette Lines

FIG. 11. Wrinkle Assessment Scale of marionette lines.

is probably furrows, not folds or wrinkles. However, furrows is not a commonly used and understood term, hence our rationale behind the selection of mimetic wrinkles to differentiate these deeper wrinkles, furrows, or creases from generalized elastosis or folds. The etiology of mimetic wrinkles or furrows is rather simple and does not differ from that of the wrinkles or creases in the fabric of one's gloves or shoes. Smooth when new, the fabric develops grooves at sites of long-sustained stress. There is no chemical or architectural alteration, purely a conformational change.[25] Wrinkles occur with

relaxation of the skin caused by receding papillae and degeneration of elastic and collagen fibers at the dermal-epidermal junction. This degeneration starts as early as age 30 and increases with time, regardless of care and protection.

The thickness of the living dermis can be determined by either ultrasound[26,27] or xeroradiographic technique. Skin thickness increases linearly up to the age of 20 years and decreases linearly with age subsequently. Depending on race, genetics, and location of measurement, the thickness of the dermis will vary. For exam-
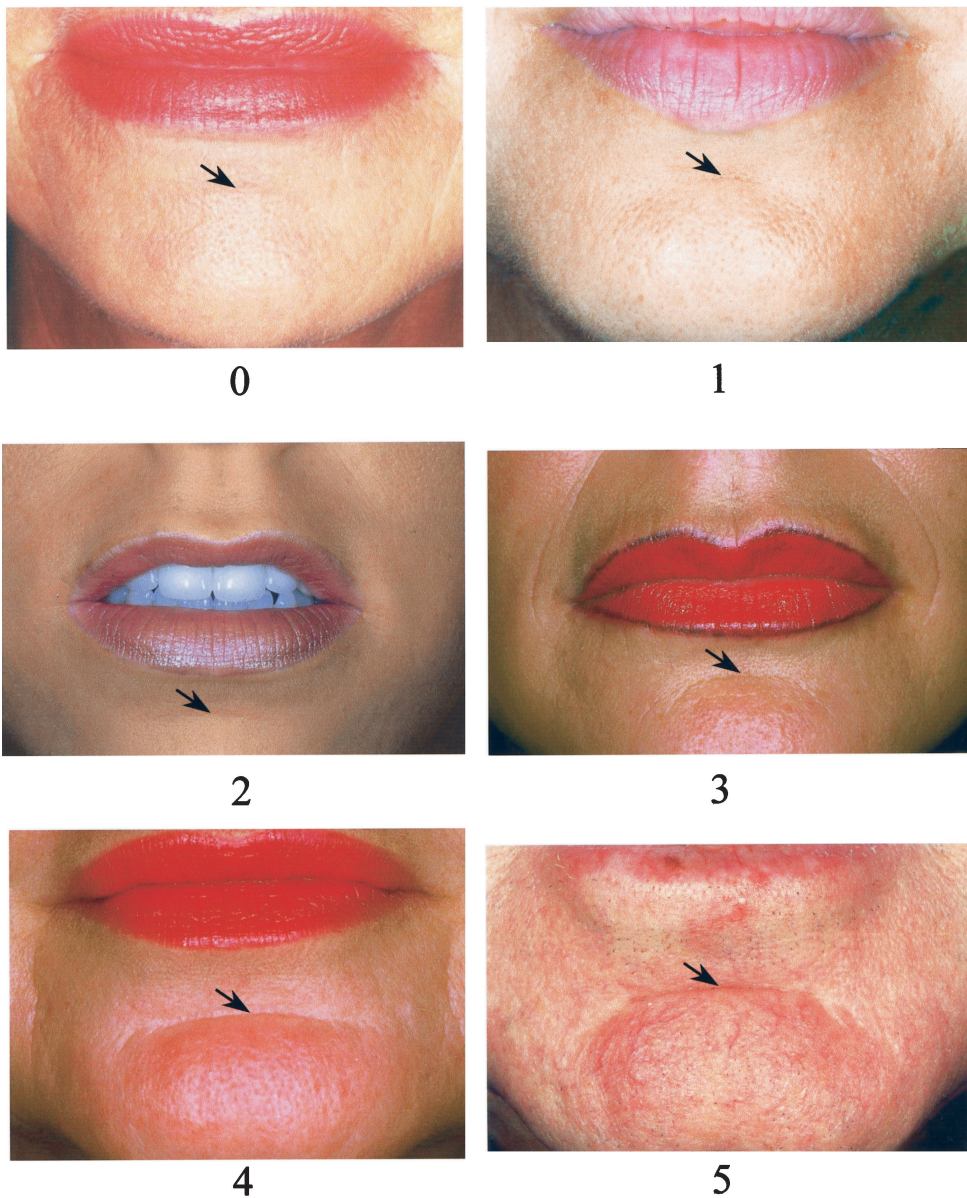
Chin Crease

FIG. 12. Wrinkle Assessment Scale of the labiomental crease.

ple, dermal thickness in the medial forearm varies from 0.6 to 1.0 mm in women and from 0.8 mm to 1.2 mm in men. In the lateral arms or legs, Tan et al.[26] found a mean dermal thickness of 1.32 mm, on the chest of 1.62 mm, and on the back of 2.50 mm.

In the face, the dermal thickness increases from lids (~ 0.2 mm), to corners of the mouth (~0.4 mm), to nasolabial folds (~ 0.6 mm), to forehead and glabellar dermis (~0.8 mm).[10] For comparison, a 30-gauge needle has an

outer diameter of 0.3 mm, and a 26-gauge needle has a diameter of 0.45 mm.

The Wrinkle Assessment Scale is intended to bring objective and comparable measurements into the field of aesthetic medicine. Aside from the standard of collagen injections, new injection or filler alternatives arrive on the market every 6 months. Other resorbable filler materials such as hyaluronic acids (Restylane,[1] Hylaform[9]), autologous collagen (Autologen[12]), allogeneic collagen matrix (Dermalogen,[12]
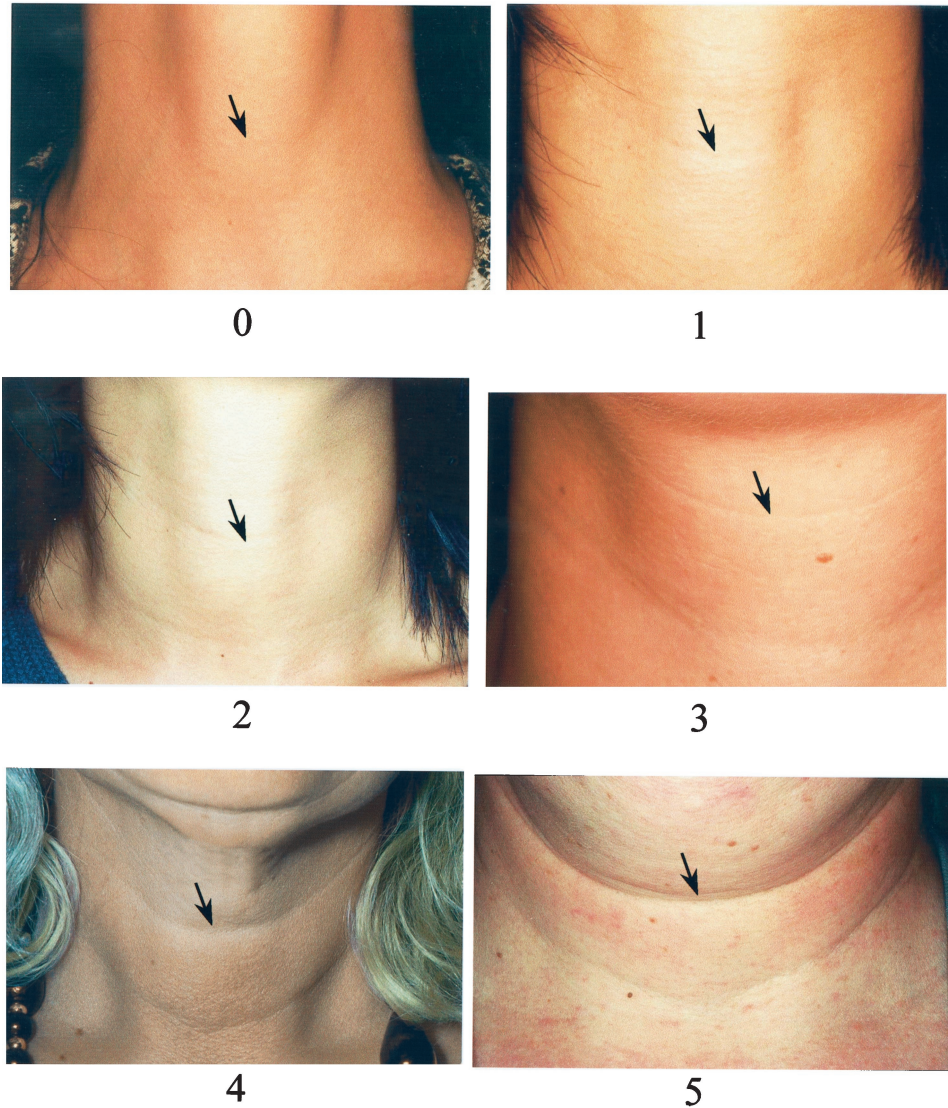
Neck Folds

FIG. 13. Wrinkle Assessment Scale of horizontal neck folds.

AlloDerm[11]), dextran microspheres (Reviderm), polymethylacrylate particles (Dermalive), and others have gained increased popularity. All claim to last longer than collagen, but none have shown any statistically convincing proof. On the other hand, long-term persistence of artificial products (Artecoll,[10] Softform) may also cause problems after poor placement and subsequent dislocation.

The Wrinkle Assessment Scale should be an excellent tool in the hands of every aesthetic surgeon or dermatologist to objectively assess the short-term and long-term effects of an injected product and to establish a real price-value relationship for patients.

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FIG. 14. Masked observer's classification sheet of the four most bothering lines.

TABLE III

Classification of Facial Wrinkles

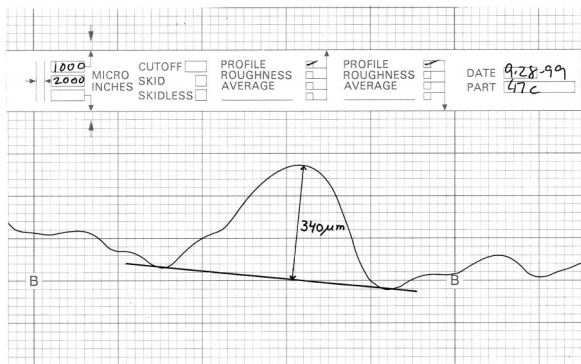| Facial Wrinkle	Class	Description
Horizontal forehead lines		
Glabellar frown lines		
Periorbital lines		
Preauricular lines	0	No wrinkles
Cheek lines	1	Just perceptible wrinkle
Nasolabial folds	2	Shallow wrinkles
Radial upper lip lines	3	Moderately deep wrinkle
Radial lower lip lines	4	Deep wrinkle, well-defined edges
Corner of the mouth lines	5	Very deep wrinkle, redundant fold
Marionette lines		
Labiomental crease		
Horizontal neck folds		

FIG. 15. The Surfanalyzer provides a profile of each impression mold. The depth is measured from a baseline connecting the adjacent skin surface.

TABLE IV

Significance of the "Live" Study of 689 Ratings of 76 Wrinkles by Nine Observers

Wrinkles	Different Ratings	Percentage	Significance
Glabellar frowns	11 out of 191	5.8	$p < 0.001$
Nasolabial folds	14 out of 192	7.3	$p < 0.001$
Radial lip lines	5 out of 114	4.4	$p < 0.001$
Marionette lines	20 out of 192	10.4	$p < 0.001$
TOTAL	50 out of 689	7.3	$p < 0.001$

No lip lines grade 0 were excluded.

TABLE V

Intraclass Correlations in the Wrinkle Assessment Scale According to the Ratings of Eight Observers of 130 Facial Wrinkles on 80 Photographs*

Wrinkles	n	Mean	SD	Intraclass Correlation
Glabellar frowns	20	2.872	1.538	0.828
Nasolabial folds	40	2.451	1.293	0.921
Radial lip lines	30	1.762	1.281	0.904
Marionette lines	40	2.098	1.211	0.923
TOTAL	130	2.250	1.342	0.894

* There is 89.4 percent agreement among the eight observers.

FIG. 16. Silicone impressions of a glabellar fold before second treatment and 6 weeks and 3 months after a second treatment.[10]
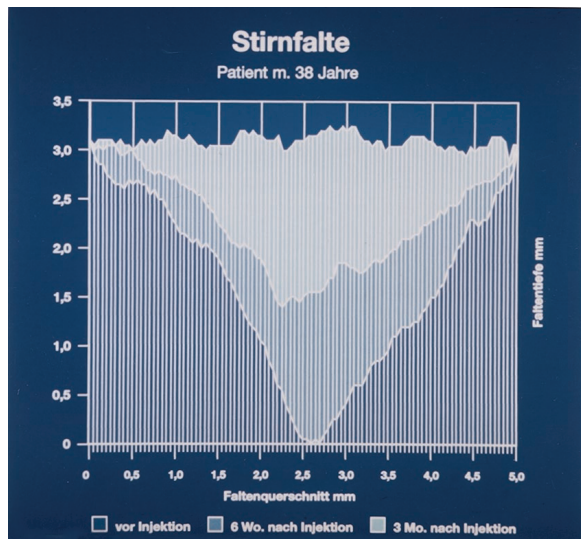

FIG. 17. The depth of three impressions molds after three treatments of the same glabellar fold measured by CEREC computer imaging.[23]

TABLE VI

Intraclass Correlations between Wrinkle Measurement on 40 Impression Molds and Judgments from Photographs of the Same Wrinkles

Molds	n	Mean Ratings	SD	Intraclass Correlation
Glabellar frown	10	2.337	1.264	0.828
Nasolabial folds	10	2.637	1.314	0.872
Radial lip lines	10	2.097	1.278	0.884
Marionette lines	10	2.423	1.541	0.828
TOTAL	40	2.380	1.309	0.870

TABLE VII

Validation of the Wrinkle Scale in Comparison with the Measurements from Silicone Impressions of Facial Wrinkles

Wrinkle	Score I	Mean Depth of Impressions (mm)	Proposed Margins (mm)
Glabellar folds	1	0.115	<0.20
	2	0.225	0.21–0.30
	3	0.320	0.31–0.40
	4	0.460	0.41–0.50
	5	0.565	>0.51
Nasolabial folds	1	0.060	<0.20
	2	0.290	0.21–0.40
	3	0.485	0.51–0.60
	4	0.650	0.61–0.80
	5	0.940	>0.81
Marionette lines	1	0.140	<0.20
	2	0.300	0.21–0.40
	3	0.450	0.41–0.60
	4	0.575	0.61–0.80
	5	0.840	>0.81
Radial lip lines	1	0.100	<0.10
	2	0.150	0.11–0.20
	3	0.295	0.21–0.30
	4	0.350	0.31–0.40
	5	0.415	>0.41

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