# The "Brown Sisters": Photogrammetric Analysis of Brow and Cheek Descent

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**ABSTRACT:** **Background:** Due to the absence of accurate tools and appropriate photographic material there is a paucity of objective studies on facial aging in the modern literature.
**Objectives:** To measure changes in two elements of the face: brow ptosis and cheek mass migration, using an objective tool that we developed which we then used to evaluate facial aging in two subjects studying serial professional photographs over a 25 year period.
**Methods:** We studied the photographic atlas of the "Brown Sisters," a record of the yearly group photograph of four sisters taken by the photographer Nicolas Nixon. For technical reasons only two of the sisters fulfilled the criteria we set for the study. We used the interpupillary distance of each photograph studied to standardize the brow height and cheek mass distance from the interpupillary line.
**Results:** We observed progressive medial brow descent occurring at about the age of 30, with apparent stabilization thereafter. In contrast, there was a continuous process of lateral brow descent through the years. A process of gradual cheek mass descent was noted in the second half of the third decade.
**Conclusions:** Our results indicate that the dynamic brow changes start in the second half of the third decade, with more significant lateral brow descent than medial brow descent. The cheek mass reflective point moves in an inferior-lateral direction. The tool we developed can be used to follow aging changes and postoperative results, thereby helping the surgeon achieve true rejuvenation surgery.

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**KEY WORDS:** eyebrow, cheek, facial aging, measurements, brown descent

Facial rejuvenation surgery requires correction of anatomic changes brought about by aging. Yet, there are hardly any objective studies on facial aging, which can be attributed to the lack of objective tools and appropriate photographic material [1]. If such tools existed we would be able to determine how a particular patient's facial features have aged, and plan our surgeries accordingly, thus avoiding cook-book procedures that might change facial expressions rather than rejuvenate. Moreover, objective measurements necessitate standardized consecutive photographs, which are not technically easy to achieve, especially if a retrospective study is done. In this study, we developed an objective tool to measure changes in two elements of the face: brow ptosis and cheek mass migration. We then used this tool to evaluate facial aging in two subjects, studying serial photographs taken over a 25 year period.

## MATERIALS AND METHODS

For this work we studied the photographic atlas of the "Brown Sisters," which is a record of the yearly group photograph of four sisters taken by the photographer Nicolas Nixon. Each year, for 25 years, he took portraits of the four sisters facing the camera in the same order.

To objectively measure changes in the position of facial soft tissues would require standardized criteria for inclusion in the study. We enlarged all full-face photos of each of the four women and studied the portraits, searching for obvious technical biases. We realized that studying the two lateral faces would be technically problematic due to more inconsistent facial positioning and. therefore decided to study only the two girls in the center of the portraits, the oldest and the youngest. The former was photographed from age 25 to 50, and the latter from age 15 to 40. We then excluded those pictures taken in varied conditions of external light, facial position and expressions, and were left with less than half of the pictures, characterized by similar lighting conditions and facial positions. These pictures comprised our database for objective measurements of brow and cheek mass.

With our method we measured the interpupillary distance, which is constant in any healthy adult and does not change with age. We then drew a reference line on the forehead, at that fixed distance. Measurements to the medial and lateral right brow were made from this line [Figure 1]. The measurements were made to the top of the brow, because women do not usually pluck their upper eyebrows, assuring this anatomic structure as a reliable structure for evaluation. Each picture then had a representative Brow Ptosis Index,

which was a fraction comprised of the medial or lateral brow distance divided by the interpupillary distance of the specific photograph. The indexes of both women were plotted graphically, to demonstrate the dynamic changes in brow position through the years.

We also evaluated the cheek mass migration, by measuring the distance from the interpupillary line, and the angle to the vertical median of the face from the most prominent point of the cheek mass. The point measured was the maximum reflectance point of the cheek, as determined by change in shadow gradation on photo enlargements [Figure 2].

We acknowledge that it is very difficult to pinpoint any soft tissue landmark on a photograph, but the validity of this point was proved by having four different plastic surgeons mark this point on photographs and we did not find any significant difference between them. Therefore we feel that the maximal cheek mass can be reliably determined from similarly lighted photos to give us the position of this three-dimensional point, from a two-dimensional picture. Measurements were executed manually and digitally, using the graphic software MB Ruler-the transparent screen ruler and screen loupe 3.3 (a freeware by Markus Bader, www.Markus-Bader.de).

## RESULTS

We observed a progression of medial brow descent from the end of the third decade until the middle of the fourth decade, and then an apparent stabilization of the medial brow position. In contrast, there was a continuous process of lateral brow descent throughout the years, starting in the second half of the third decade [Figure 3]. The lateral brow descended more than the medial brow. Similarly, for both women, a similar process of gradual cheek mass descent was noticed in the second half of the third decade, which seemed to arrest in the first half of the fourth decade and then continued subsequently at around the age of 40 [Figure 4]. The angle between the cheek projection point and the vertical median of the face gradually became more acute during the second half of the third decade, and thereafter appeared to stabilize, with a subsequent descent from the second half of the fourth decade. Our combined results indicated that the reflective point of the cheek mass moved inferolaterally.

## DISCUSSION

One of the earliest signs of facial aging is gradual descent, or ptosis of the unrestricted soft tissues in the face, mainly the lateral brow and the cheek mass [1-4]. Nowadays, although there have been several new improvements and innovations in surgical approaches to the aging face, little is known about the aging rate of facial structures. The following questions

**Figure 1.** Brow position measurements: Brow ptosis index = brow height/interpupillary distance (IPD)

**Figure 2.** Cheek mass migration measurements: Cheek Mass Index = maximal cheek mass distance (MCMD)/ interpupillary distance (IPD); α = angle from maximal cheek mass (MCM) to midline


**Figure 3.** Lateral brow descent, both subjects

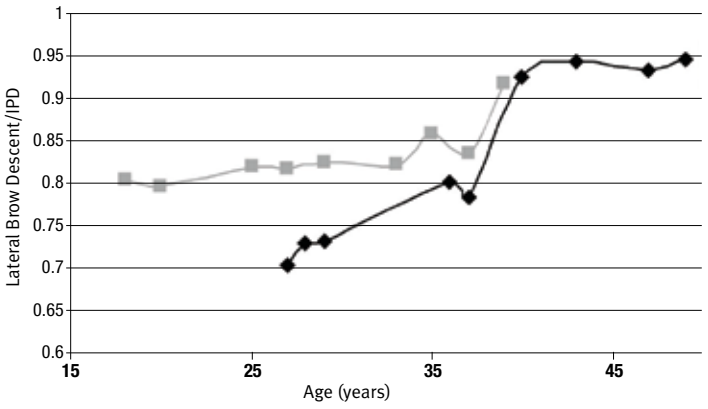
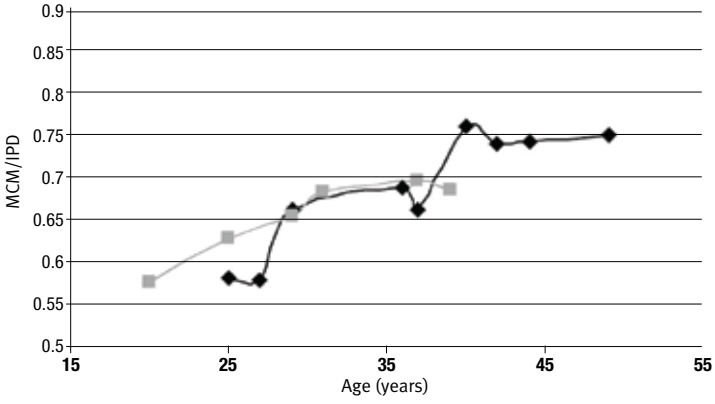



**Figure 4.** Changes of maximal cheek mass, both subjects



are still unanswered: a) at what age do the first signs of deep soft tissue aging appear? b) is the rate of change consistent throughout the years? c) are there any factors influencing the changes in a specific patient? We do know that aging is a multifactorial process, and that the rate of aging is probably an individualized process.

In this study, we looked for a constant and reliable photographic distance between two fixed facial elements (the interpupillary distance) that would enable us to compare the changing facial physiognomy of the same person in a series of different-sized photographs. Estimating changes in anatomic facial landmarks through time necessitates the use of photographs, which are not usually uniformly taken. Moreover, photographic technique has changed over the years and, therefore, technical factors might also influence the results. The only fixed length in the face is probably the interpupillary distance, which is constant in any single adult and does not change with age. Other parameters, for example eye width and position of the lateral canthus or anterior hair line, do change with age.

We know that midfacial ptosis is aggravated by significant weight loss, the absence of malar or maxillary bony support, and inherent collagen diseases. Nevertheless, there is a paucity of information, since most observations regarding the aging process have been empirical or subjective and have not studied the same individual's facial change through aging [5].

A high priority in midfacial rejuvenation surgery is recreation of the youthful, oval fullness or ogee at the uppermost part of the midface [6,7]. In the opinion of most plastic surgeons, it is the cheek mass descent that gives the aging face its empty, aged look [6-8].

Yousif and colleagues [1,2] were the first to study the relationship between the nasolabial crease and the maximal projection point of the cheek mass. They tried to subjectively analyze midface changes in chronological personal photographs by studying the facial photographs of 19 individuals over the age of 60, taken approximately every 10 years from the age of 20. Nevertheless, they found very early in the study that because of variations in positions, expressions, and external lighting of the non-professional pictures, it was impossible to analyze these personal photos objectively. They further analyzed midface soft tissue parameters comparing two different age groups, 20 to 30 versus the 60 years and older group. They then compared these two groups by using photogrammetric analysis of the nasolabial angle, alar rim and lateral commissure, and also measuring the maximal cheek projection point in the sagittal plane. They used the interpupillary distance to normalize all x-axis measurements; they also chose to normalize the y-axis distances by dividing the intercanthal to menton distance into all other y-axis distances.

Analyzing many pictures of our patients and the studied "Brown Sisters" made us understand that even the menton point is not a reliable fixed point, due to its photographic diversity, and depending on light and posture. We also asked for old photographs of our patients, but found them unreliable for any objective study. In contrast, the exceptional photographic atlas of the "Brown Sisters" seems uniquely appropriate for this kind of study.

We devised a tool for the objective photographic measurement of brow ptosis and cheek mass migration, and found some similarities with the study by Yousif et al., where measurements of the interpupillary distance were used as a standardized technique to compare distances between facial structures (x-axis), among different subject groups [1]. In contrast to their study, we used the constant interpapillary distance to overcome the lack of uniform photographic techniques and different picture sizes in serial photographs (in a similar posture) of the same person and analyzed the brow descent in subsequent photos. This tool can be used to study patients' facial aging, and to record and evaluate surgical results and follow-up. We realized, as did Yousif and team, that the most reliable measurable cheek soft tissue point was the most prominent point of the cheek. Yousif's group was able to measure this point in live patients, using a special instrument designed to measure this point in relation to the nasolabial crease in the sagittal plane [1,2]. We checked the validity of analyzing the maximal reflective cheek mass (most prominent point of the cheek) from a two-dimensional picture and realized that it could be reliably determined by the change in shadow gradation of the photographic cheek, in similar conditions of external lightening. In our study, the cheek migration had two periods of descent – the first in the second half of the third decade and the second a decade later. A possible explanation for this stepped descent is the complex dynamic relations between the cheek-retaining ligaments and the cheek mass. This finding, though limited because of the small number of subjects, might be the possible cause of "bad results" in young face-lift patients.

Based on our clinical observation that brow descent starts in the third decade and that the lateral brow descent is probably more significant than the medial, we were interested in finding the earliest age of change in brow position, and the rate of change.

Though many of the photographs had to be excluded from the study due to technical bias, mainly head rotation, we were left with consecutive, high quality pictures of similar facial positions of the oldest and the youngest sisters. We were able to demonstrate in the study of the "Brown Sisters" that the dynamic changes of the brow started at around the age of 25. Nevertheless, in contrast to medial brow descent, which was found to be restricted and minimal in amount and length of descent, the lateral brow continued to gradually descend over the years.

Our findings demonstrate clinically what David Knize showed back in 1996 [9]. In his meticulous anatomic studies on 40 half-head cadaver specimens, Knize thoroughly

described the elevator and depressor mechanisms of the brow. He showed that the lateral brow has less support from deeper structures than the medial brow, and that the balance of forces acting on the eyebrow selectively depresses the lateral brow [9]. Structures that may promote mobility of the lateral brow are the preseptal fat pad, the galea fat pad, and the subgaleal fat pad glide plane space. On the other hand, the depressor forces of the lateral brow are gravity and the corrugator supercilii and lateral orbicularis oculi muscles, which cause the soft tissues lateral to the fixed temporal line to slide over the temporalis fascia plane.

To date, there is no information on the descent rate of aging facial soft tissues. This is mainly due to the technical difficulties in comparing soft tissue landmarks on consequential photographs, sometimes taken with variable expressions, facial position, and lighting. Knowing more about the rate of descent would provide surgeons with better tools to optimize surgical treatment, especially if a common pattern characterizing different areas can be demonstrated.

### STUDY LIMITATIONS

The pictures in this study were not taken using strict clinical parameters or under strict conditions of uniform lighting and facial position. However, most of these problems are overcome by the study methodology. The study only analyzed two of the four subjects. We also know that photographic facial analysis without physical examination might miss some important information. Furthermore, we do not know if any of the subjects underwent any cosmetic treatments to the eyebrows, such as hair plucking or cosmetic surgery, which might have influenced our result.

## CONCLUSIONS

Although only two women were analyzed, and despite the study limitations mentioned, we were able to analyze 25 years of facial aging in two sisters and discover that there was a similar change in both. Medial brow descent was mild and short in duration, occurring at about the age of 30, followed by apparent stabilization until the fifth decade. On the other hand, lateral brow descent started at the beginning of the third decade and continued gradually. Cheek migration had two periods of descent – the first from age 25 to 30 and the second a decade later.

Obviously, more studies of this nature with a large number of subjects are needed before any conclusions can be drawn. The identification of certain descent patterns of the human aging physiognomy could have a profound effect on the timing and scope of rejuvenation surgeries. Moreover, the tool we developed could be used to follow aging changes and postoperative results, thereby helping the surgeon achieve true rejuvenation surgery.

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