Individualization of People from Images

Richard W. Vorder Bruegge
FBI Operational Technology Division
Forensic Audio, Video and
Image Analysis Unit (FAVIAU)
Quantico, VA 22135

703-632-6315

rvorderbruegge@fbiacademy.edu

Operational Technology Division

DIGITAL EVIDENCE SECTION

FORENSIC AUDIO, VIDEO AND IMAGE ANALYSIS UNIT

IMAGE ANALYSIS

FACIAL & CLOTHING COMPARISIONS
HEIGHT DETERMINATION
IMAGE AUTHENTICTY
IMAGE ENHACEMENT

VIDEO

VIDEO ENHANCEMENT
AUTHENTICITY
VIDEO RESTORATION
AUDIO ENHANCEMENT ON VIDEO
SPECIAL EFFECTS

AUDIO

AUDIO ENHANCEMENT
SIGNAL ANALYSIS
AUTHENTICITY
VOICE COMPARISON
MISCELLANEOUS REPAIRS

CASES SUBMITTED

- Terrorism
- Homicide
- Armed Robbery
- Financial Fraud
- Public Corruption
- Health Care Fraud
- Money Laundering

EVIDENCE EXAMINED

- Film
- Photographs
- Video tapes
- Digital Images
- Digital videos

Forensic Photographic Examinations

- Comparisons of Questioned Images with Known Objects, Places, or Images
  - Facial Comparisons/Personal Identification
  - Identification of camera as source of image
  - Clothing, vehicles, rooms, etc. (Anything that can be photographed can be compared…)
- Detection of Image Manipulation Artifacts / Image Authentication
- Photogrammetric Examinations
- Information Extraction (Enhancements)

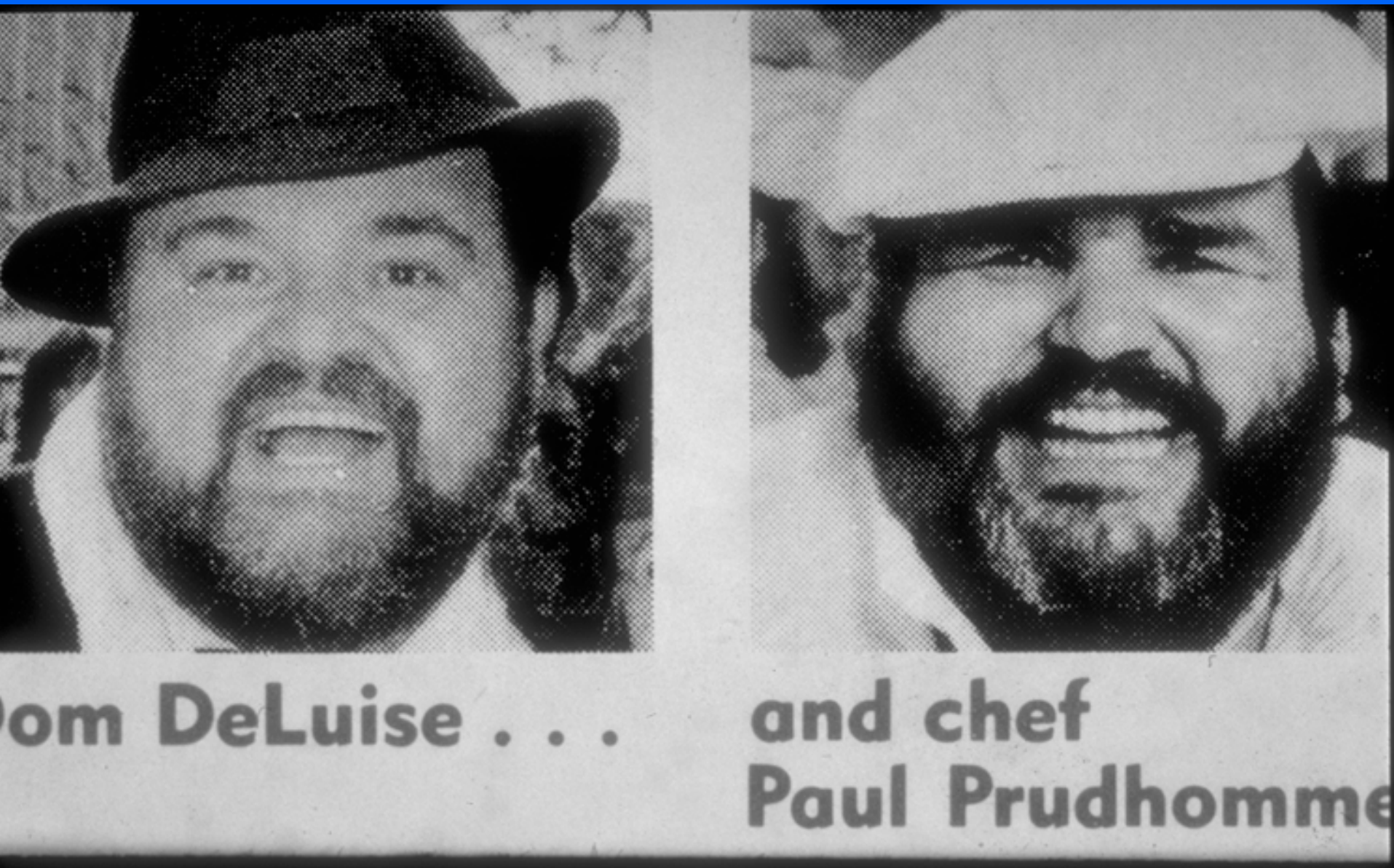
Forensic Photographic Examinations

- FBI Laboratory has conducted this work since the 1930's.
- Bank Protection Act of 1967
- Expert Witness Testimony
- Open Court
- Daubert & Kumho Tire Standards
  - Accepted field, peer-reviewed, known error rate, testable.
  - Facial ID Statistics?

Personal Identification from Photos / Facial Identification

- Lack of statistics means:
- Conclusions are ultimately opinion-based.
  - 100% certainty (ID or Elimination) based on knowledge, training, and experience.
  - Same as fingerprint testimony!
  - Error rates calculated for practitioners, not technique.
- Forensic science needs more data.

Recognition vs. Identification?



Personal Identification through Photographic Analysis

- Positive Identification of Individuals depends upon presence and visibility of individual identifying characteristics
  - Ear patterns
  - Moles, Skin Tags, Birthmarks
  - Freckle Patterns
  - Scars
  - Tattoos
  - Knuckle Crease Patterns

Techniques of Photographic Facial Comparisons

- Morphological Analysis
  - Point-by-point analysis
  - Measurements secondary/approximate
- Photo-Anthropometric Technique
  - Dimensional analysis
  - Measurements primary, points secondary
- Photographic Video Superimposition
  - “Real-time” combination of other two
  - Inherently dimensional, but not “measured”

Photographic Comparisons: Principle of Individualization

- The individualization of an item of evidence is established by finding agreement of corresponding individual characteristics of such number and significance as to preclude the possibility (or probability) of their having occurred by mere coincidence, and establishing that there are no inexplicable differences. *(Adapted from Tuthill, 1994)*

Class Characteristics in Photographic Facial Comparisons

- Characteristics shared by persons in a group
  - Overall shape of face, chin, mouth, nose, eyes, ears …
  - General shape and characteristics of the hairline, facial hair, eyebrows, glasses...

Individual Identifying Characteristics ("Minutiae")

- Individual Identifying Characteristics differentiate persons from others in a group and can make a person "unique" either alone or in combination
- Moles, freckles, ear patterns, birthmarks, chipped teeth, tattoos …
- Irregularities of hairline, eyebrows, facial hair...

Critical Factors in Photographic Facial Comparisons

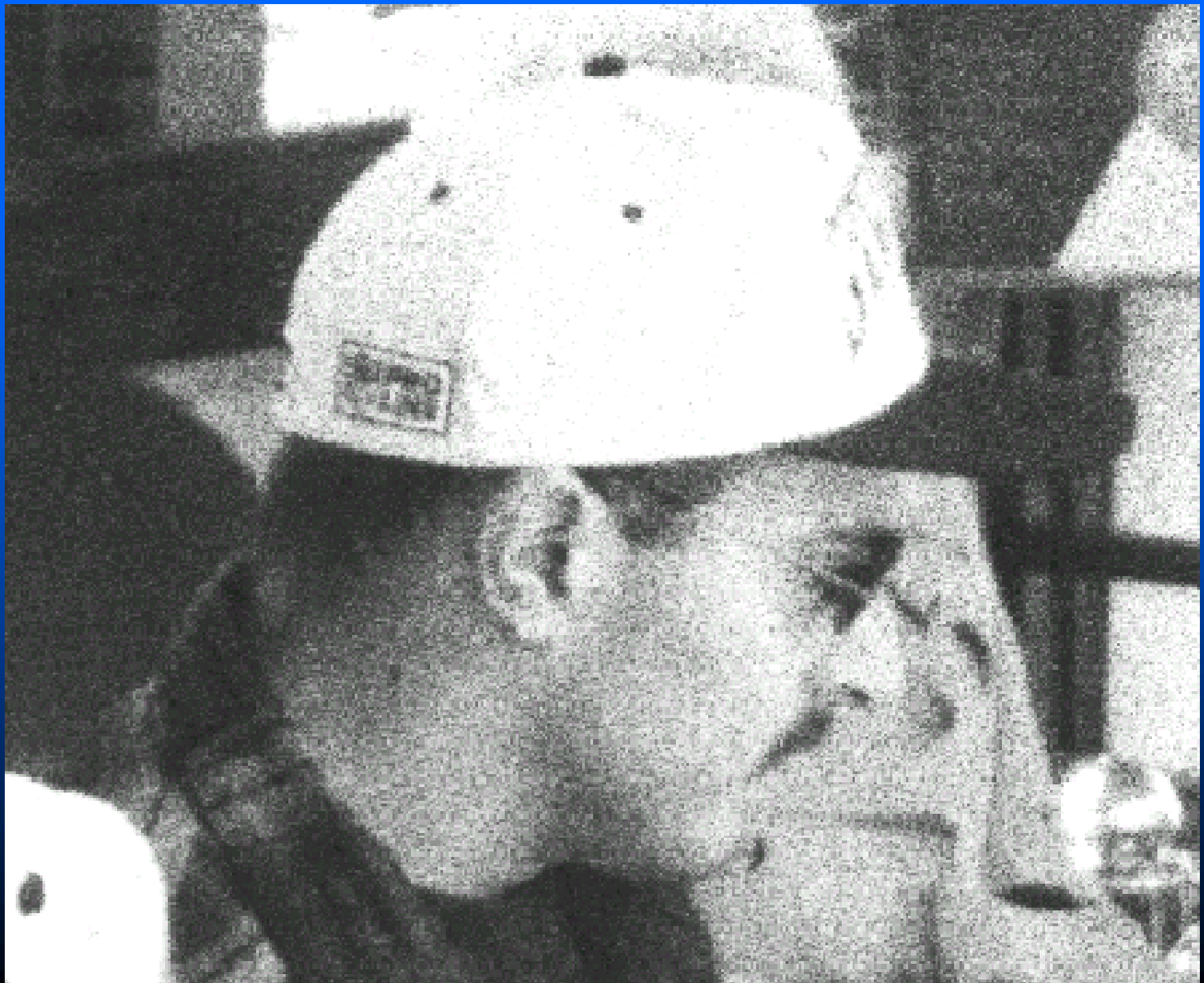
- Comparable views of Questioned and Known individuals is crucial
  - Camera-subject geometry
    - » Angle
    - » Distance/Perspective
  - Lighting/shadows
  - Image resolution (feature visibility)
- SAME AS FACIAL RECOGNITION

Critical Factors in Photographic Facial Comparisons

- Transient nature of human face can affect analysis:
  - Facial expression
  - Changes in weight or age
  - Addition/removal of facial hair
  - Transience of blemishes (acne, freckles, moles…)
- Intentional alteration:
  - Make-up
  - Surgery

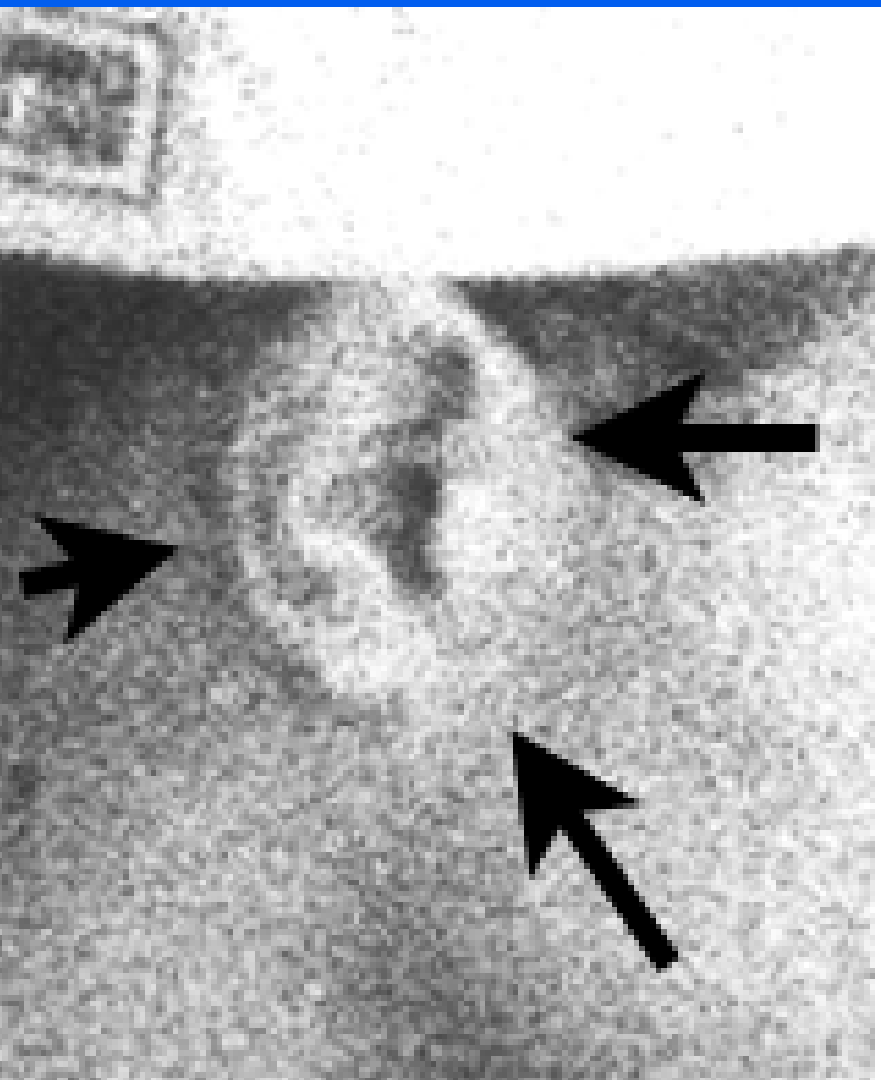
Visibility of Features in Questioned Images

- Must be able to see features to identify people and object.
- Visibility is Dependent upon:
  - Size of characteristic
  - Shape of characteristic
  - Contrast of characteristic and background
    - » Dark marks on light skin vs dark marks on dark skin

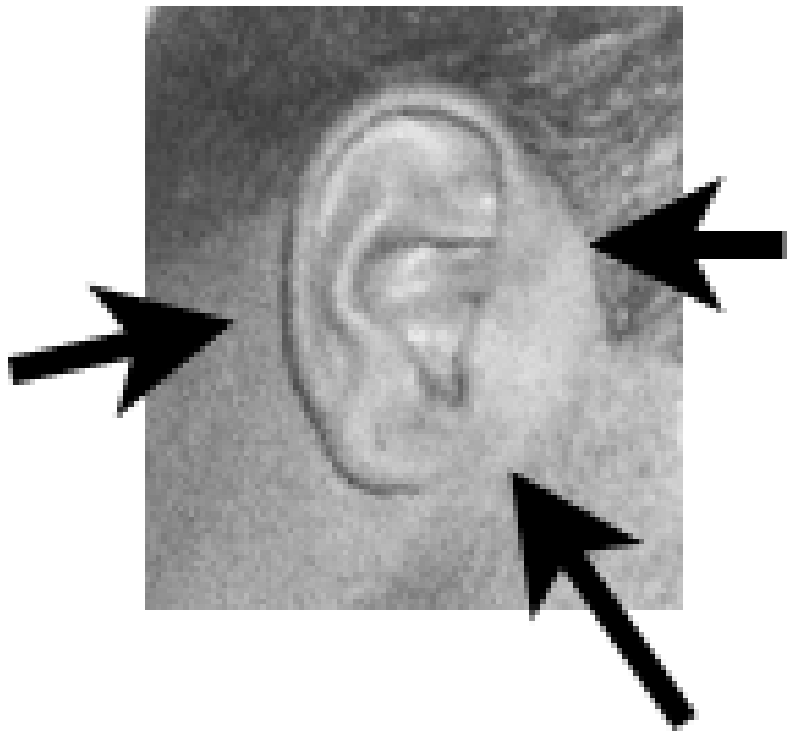


Side-by-side comparison of ear

Questioned



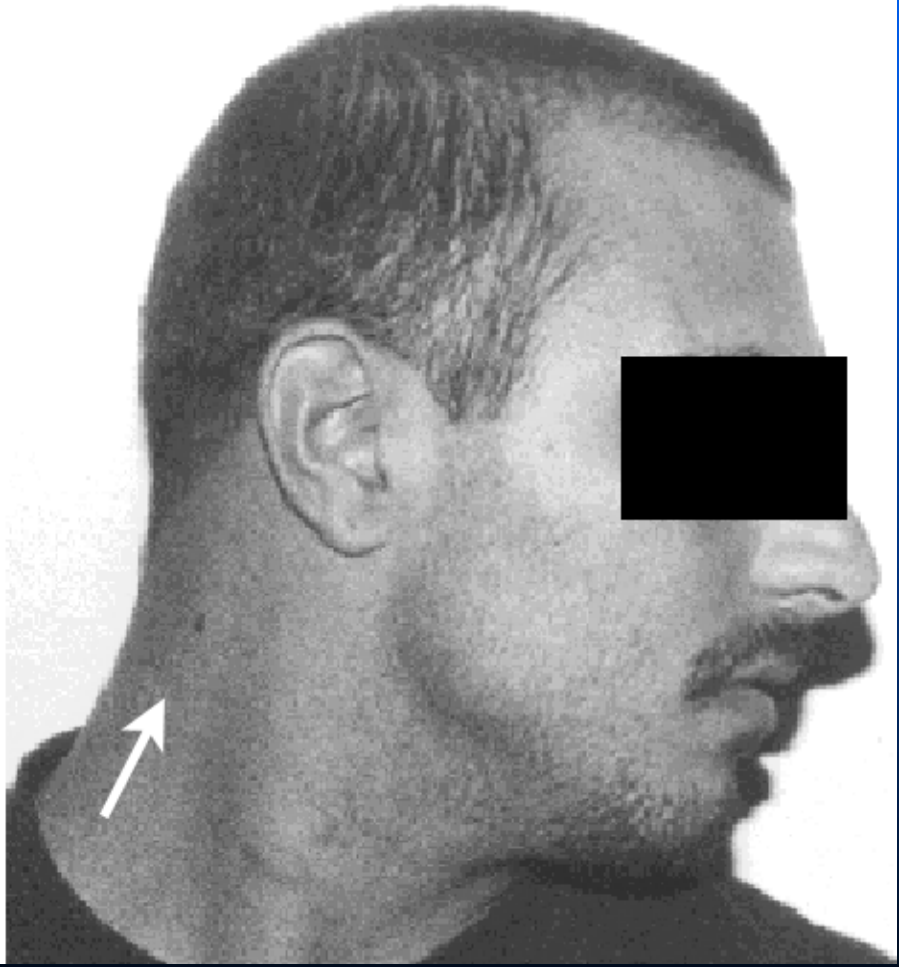
Known



Facial Comparison - Mole on Neck

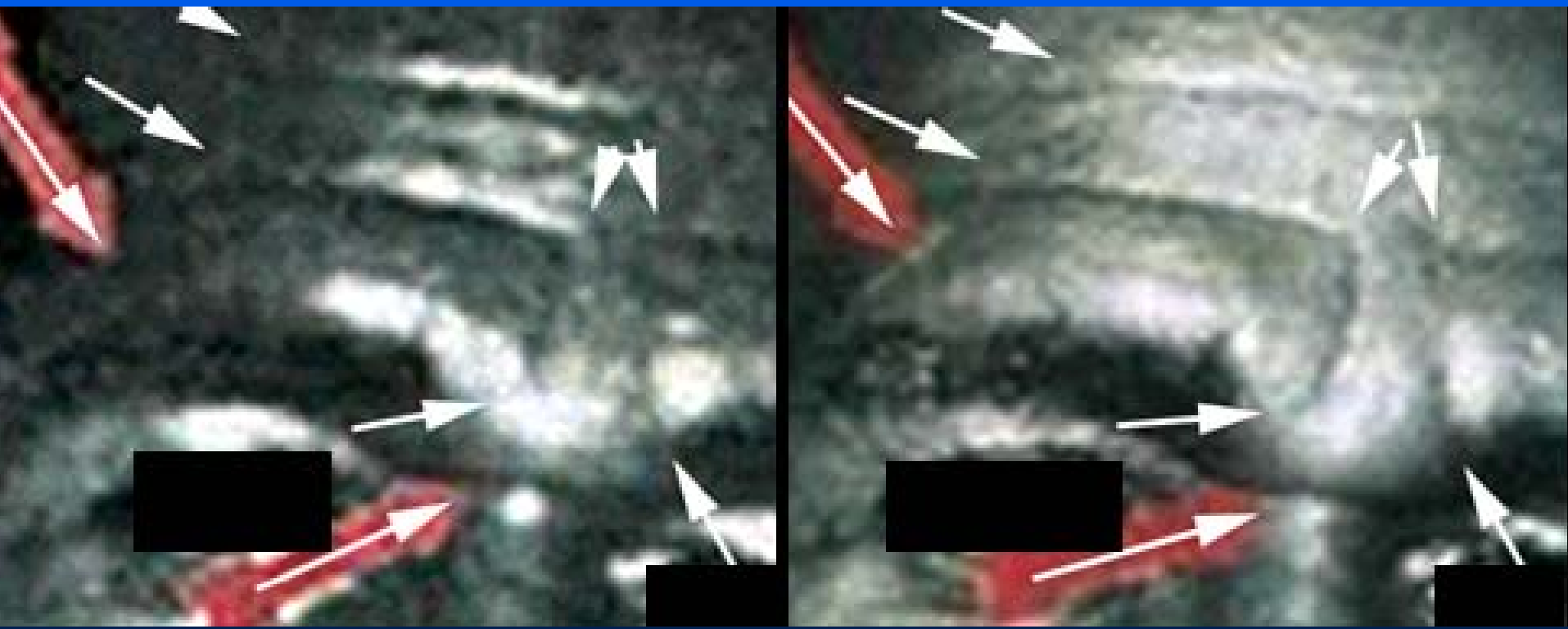
Questioned

Known

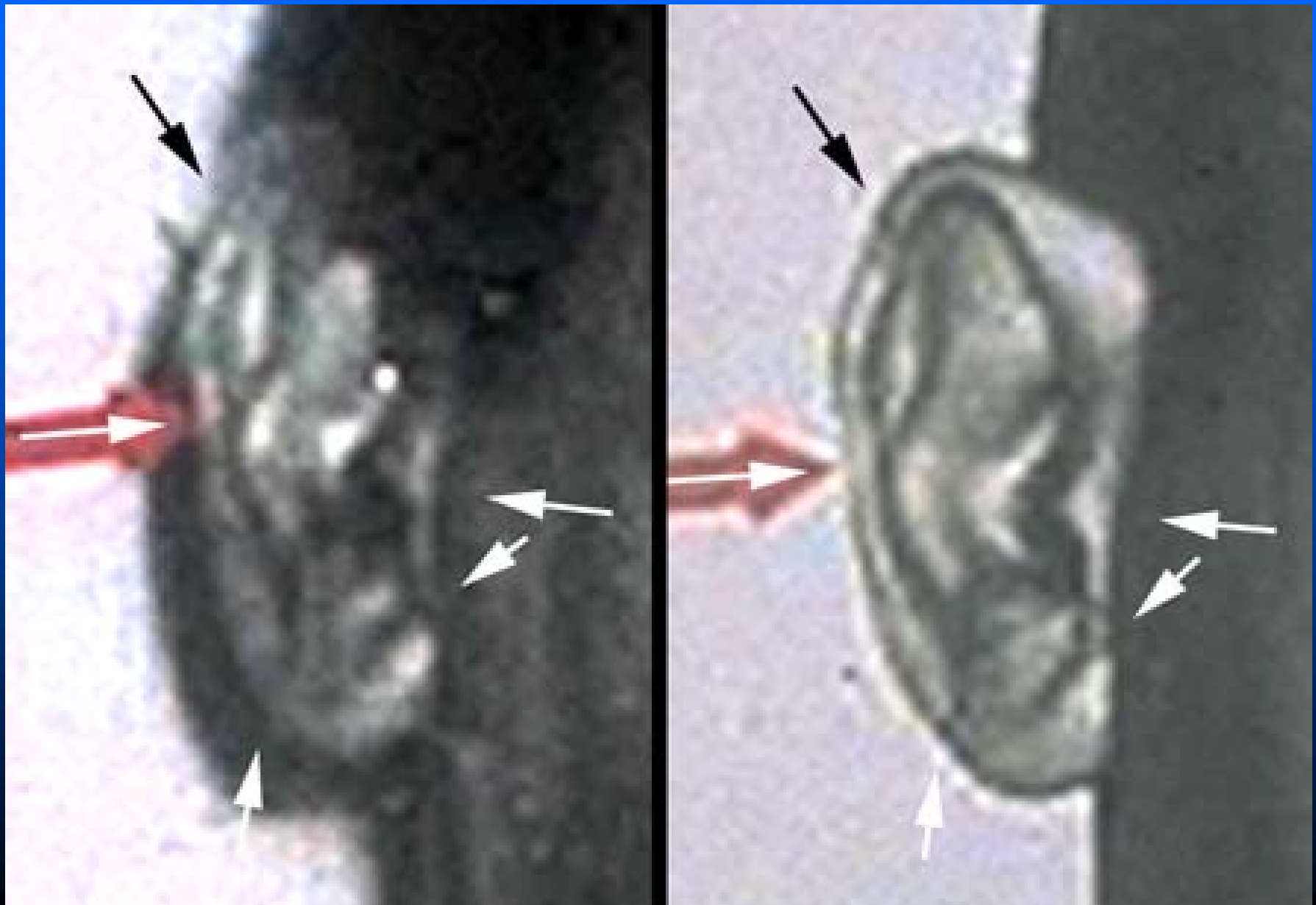


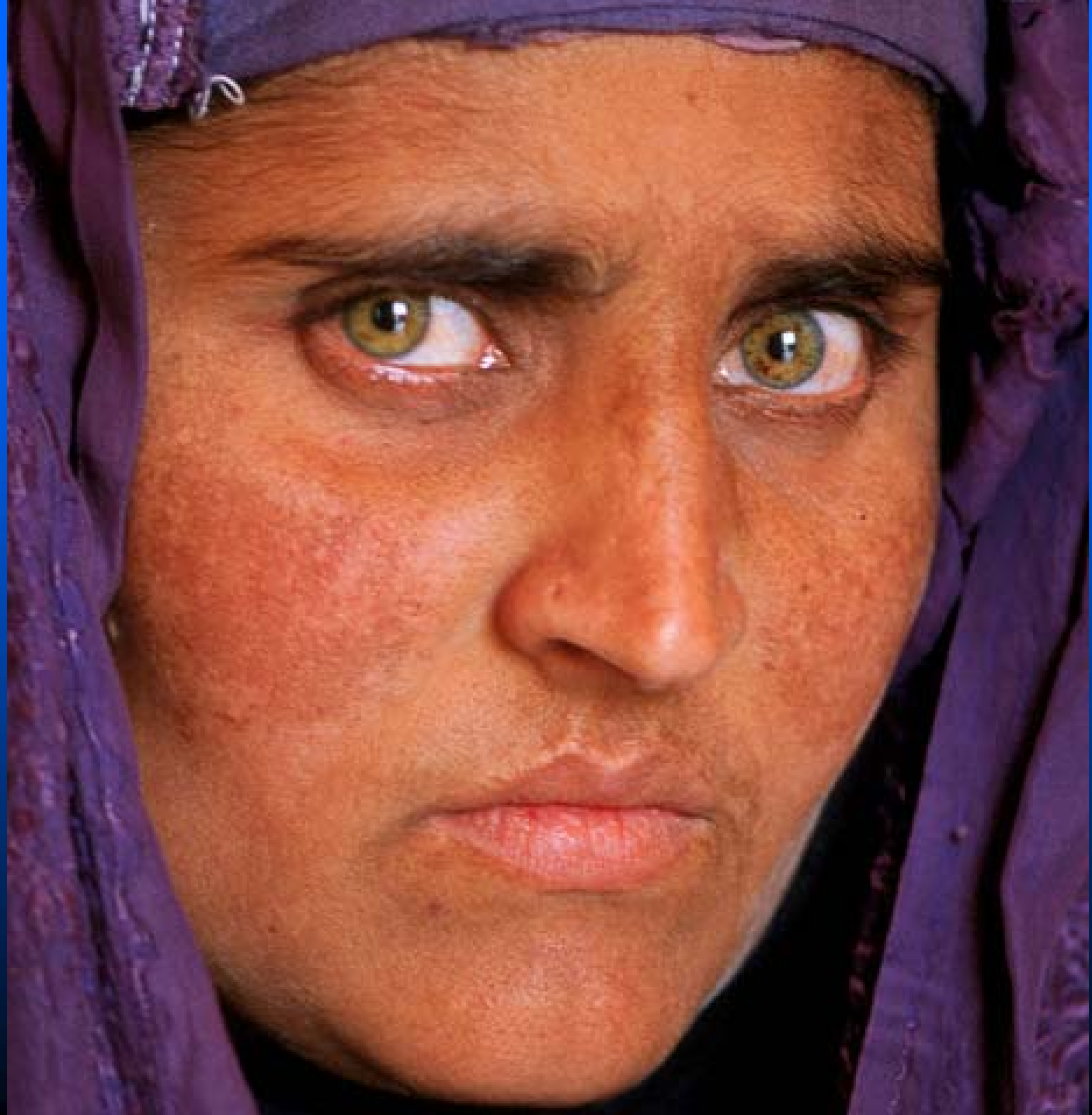
Questioned vs. Known Individual

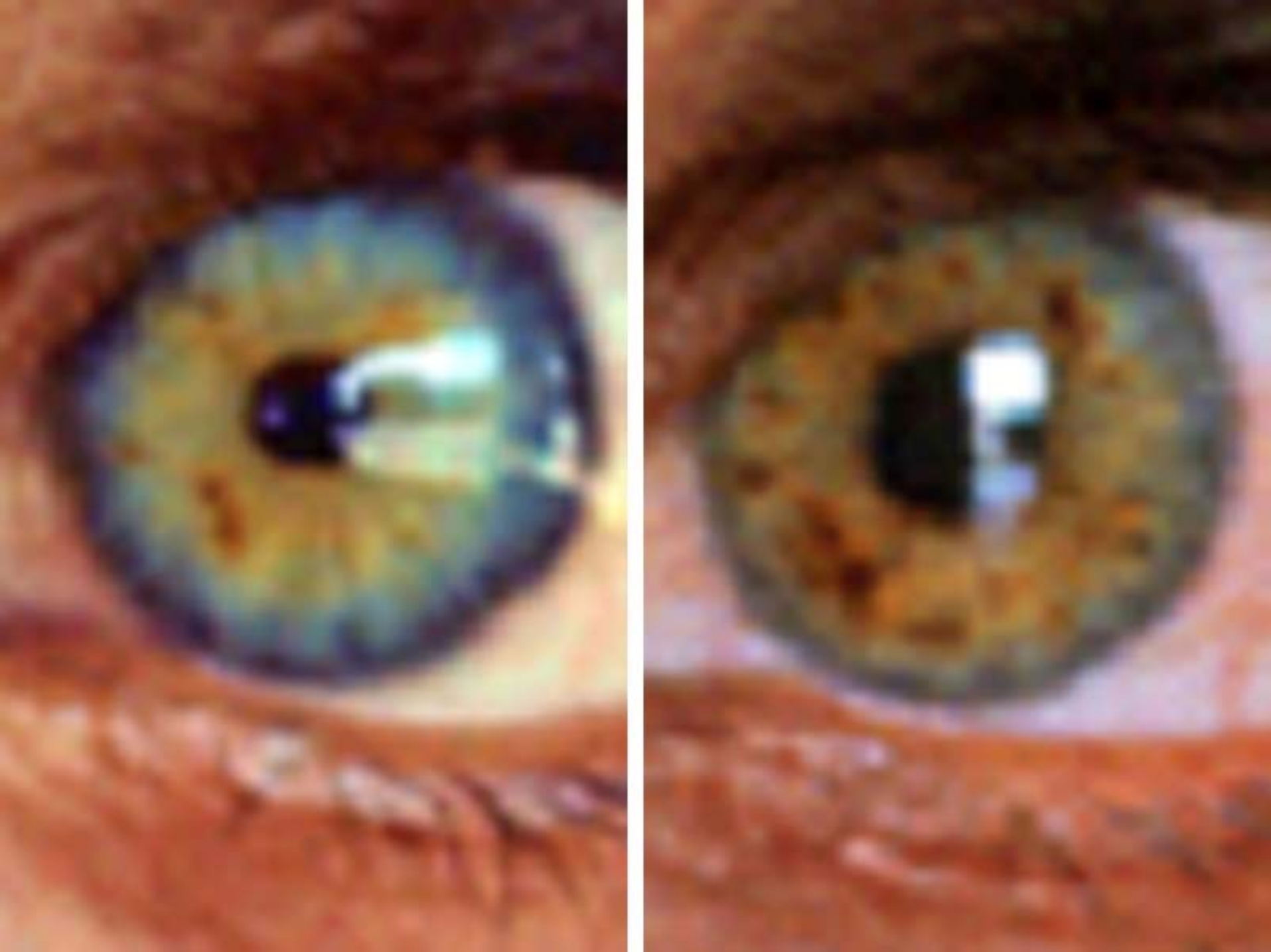
Points of Comparison - Forehead

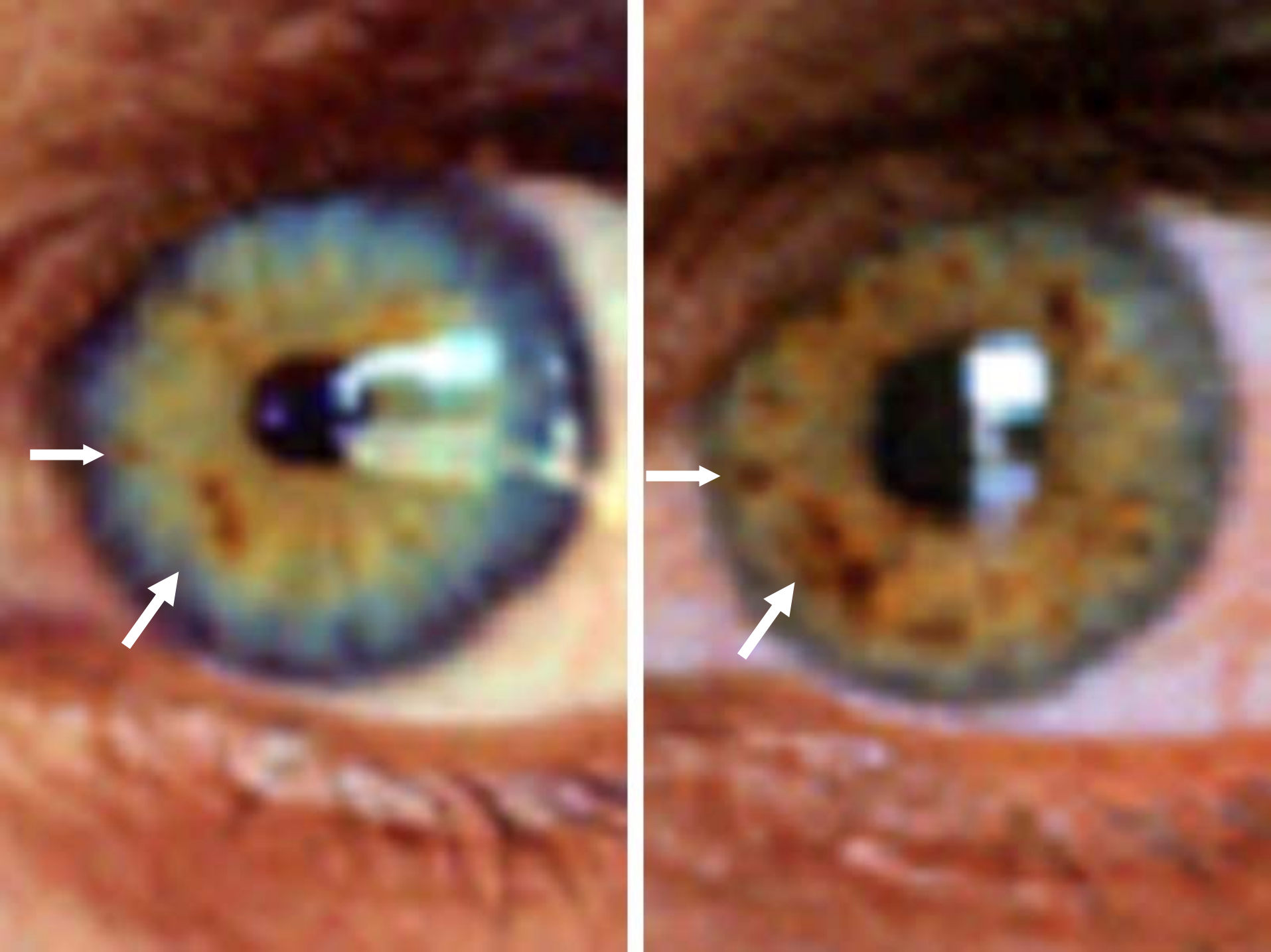


Points of Comparison - Ear









FBI Facial Comparisons General Procedure (1/2)

- Review questioned & known images
- Ensure quality is best available
  - ask for more if needed
- Matching views selected for best 1:1
- Consider following for potential overlay:
  - Nostrils' visibility (tilt of face)
  - Eyes' & Ears' visibility (rotation of head)
  - If similar in Q & K, then
- Attempt image rotation and resizing for overlay

FBI Facial Comparisons General Procedure (2/2)

- Select similar points for rotation of image
  - Center of pupils or outer corners of eyes for rotation
- Once rotated, resize one (or both) images to scale
  - Center of pupils, typically, but others sometimes
- Create overlay in Photoshop and compare characteristics:
  - Relative spacing and size of features
  - Class and Individual Identifying characteristics
  - One-page checklist utilized.

FBI Facial Comparisons
Best Case Scenario

- High Quality Images (Q & K)
  - Passport-quality photos
  - Passport-quality lighting (no shadows)
- Same Camera-Subject Geometry
- Potential to photograph subject repeatedly
  - Multiple photos, multiple angles

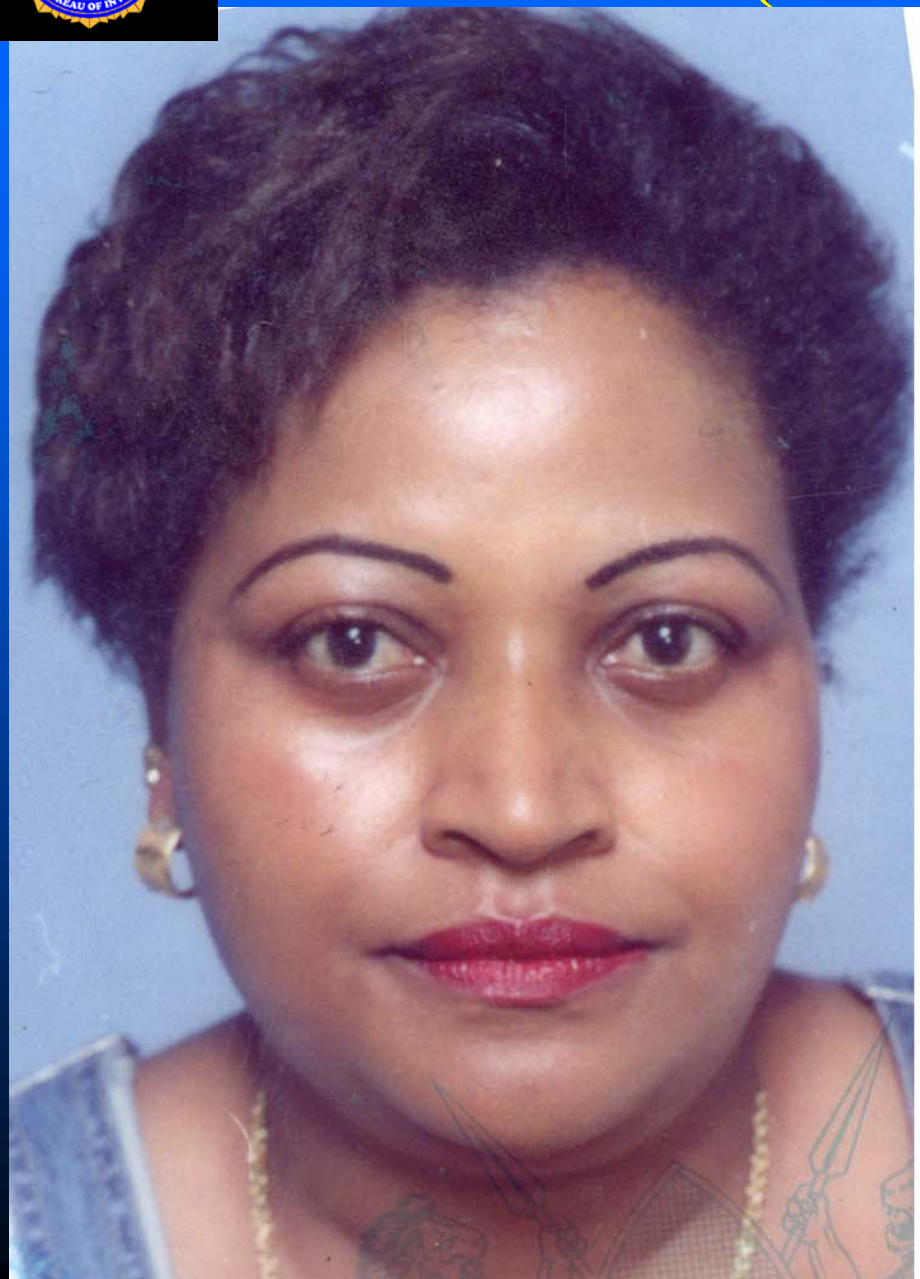
FBI Facial Comparisons
Best Case Scenario

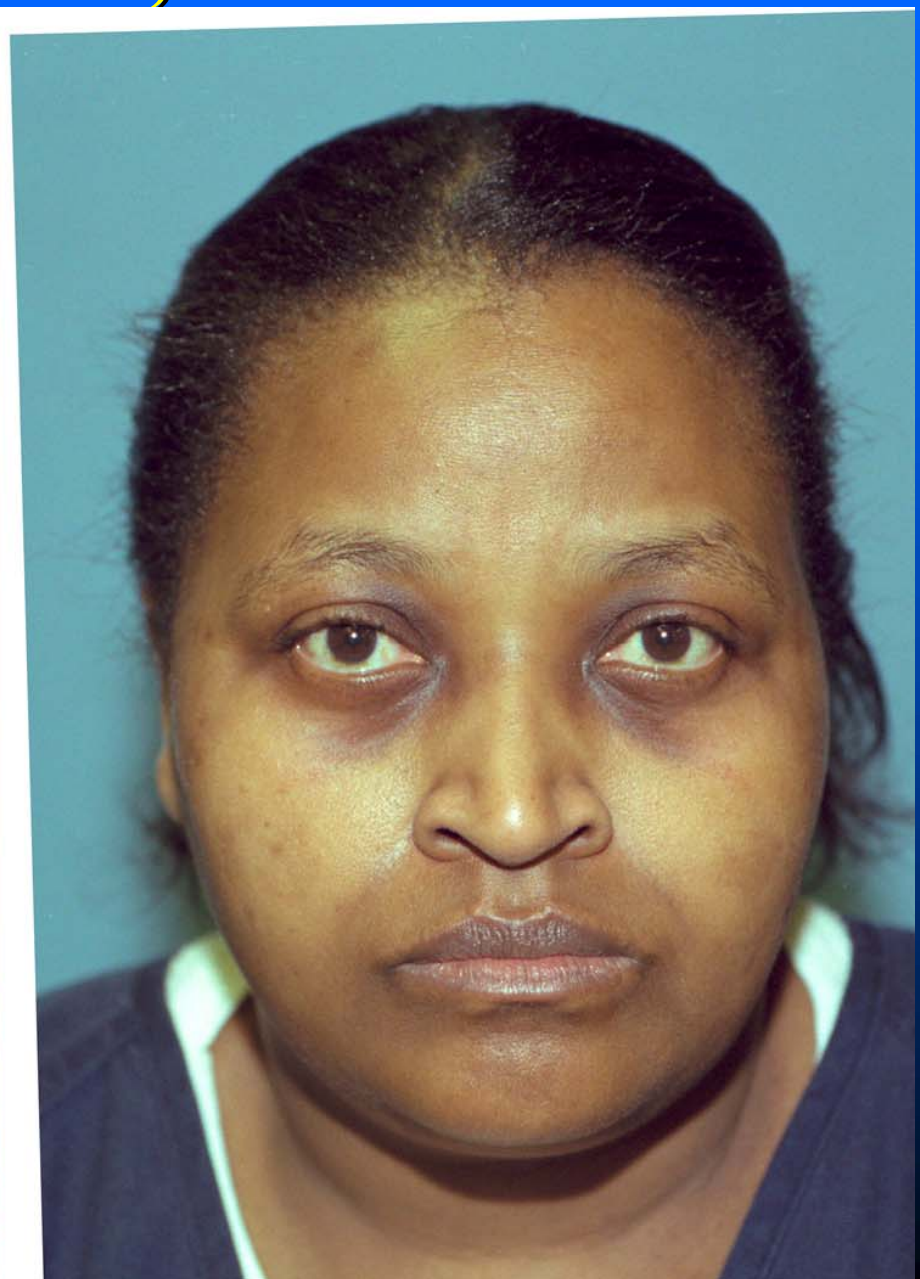
- Recent Case in Washington, D.C.
- Questioned Passport Photo
- Subject in custody thought to be one in passport.
- Differences, however, in skin coloration, hair style and other characteristics led to defense position “Not the same person”

Questioned Individual (photograph from Q1 passport)

Known Individual
photograph (frame 14) from K10 film negatives

Side-by-side comparison of X (from Q1) and Y (from K10)





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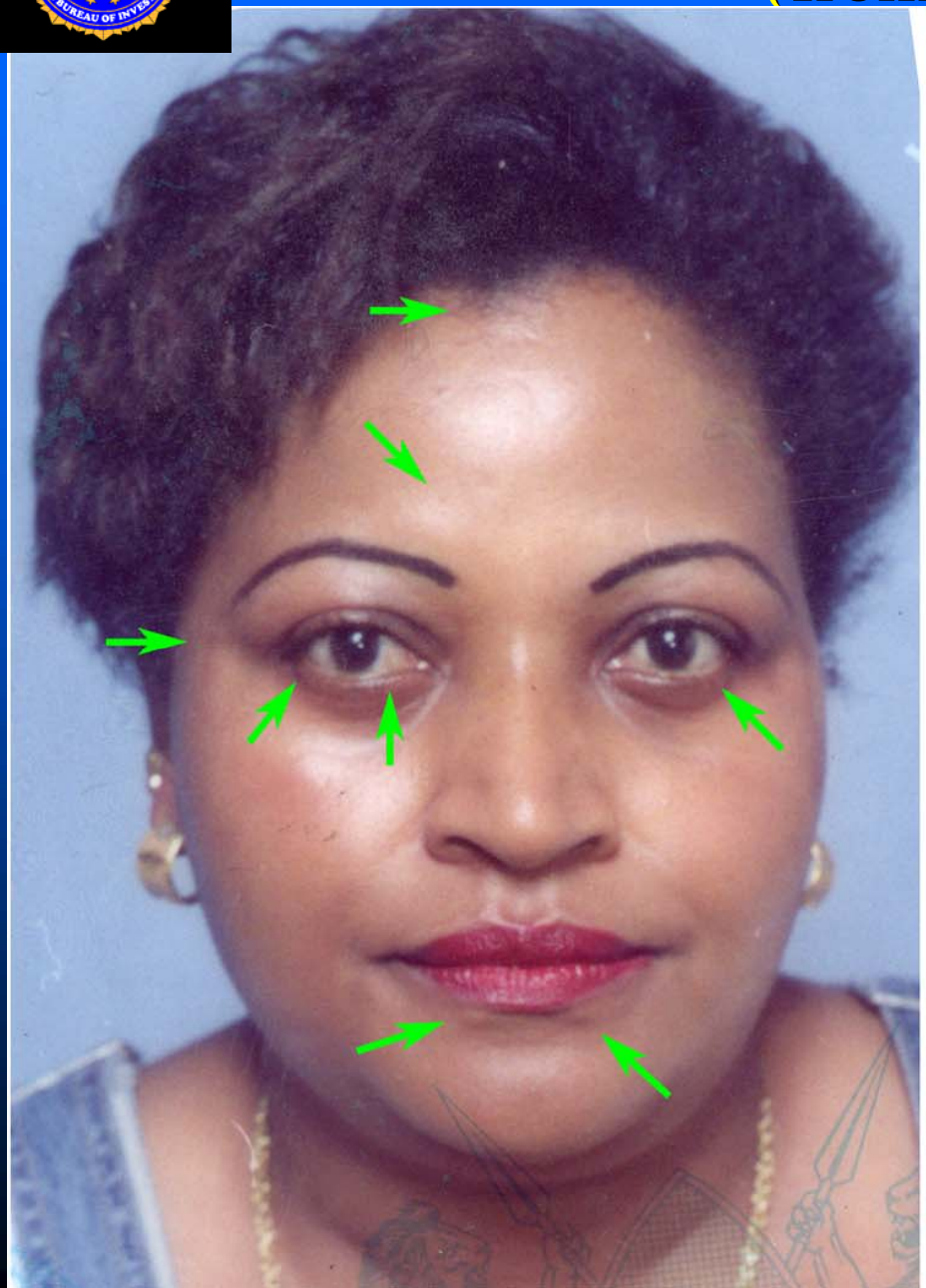

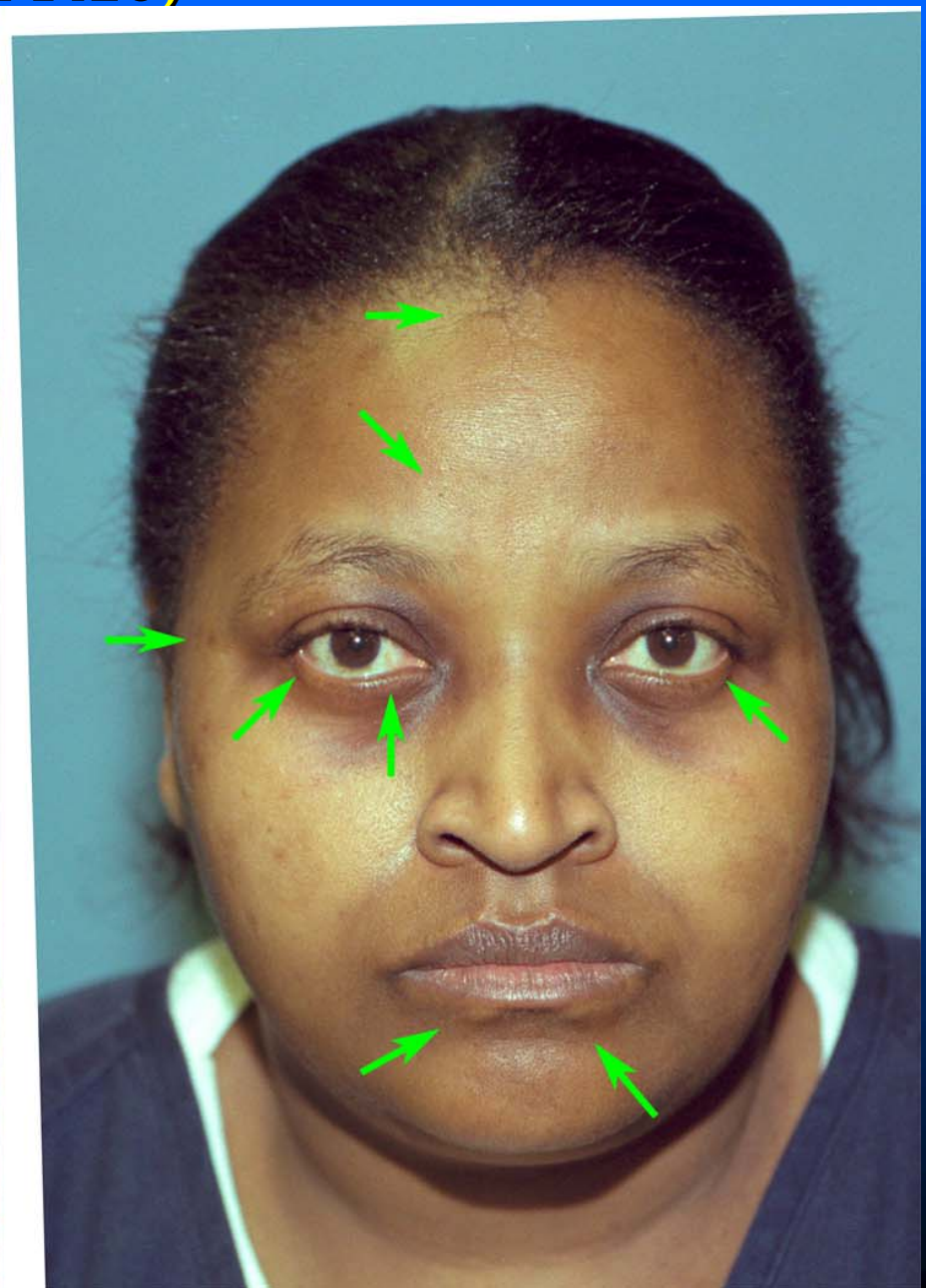

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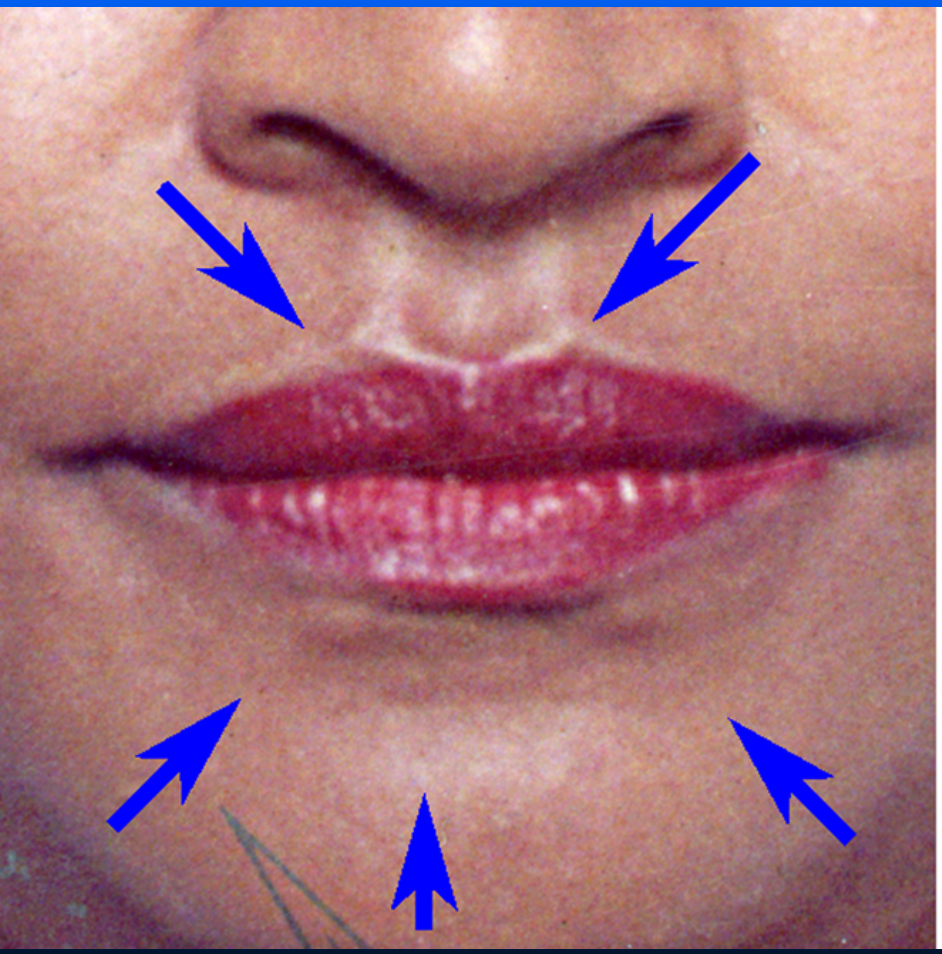

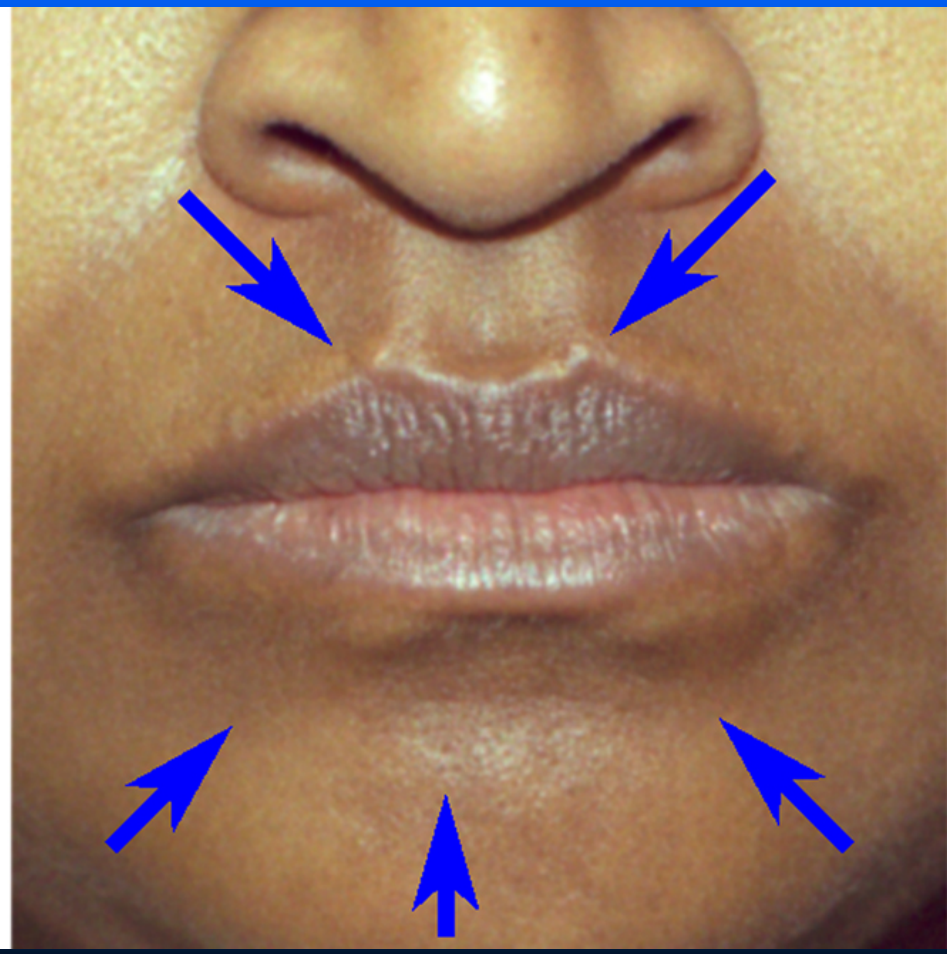

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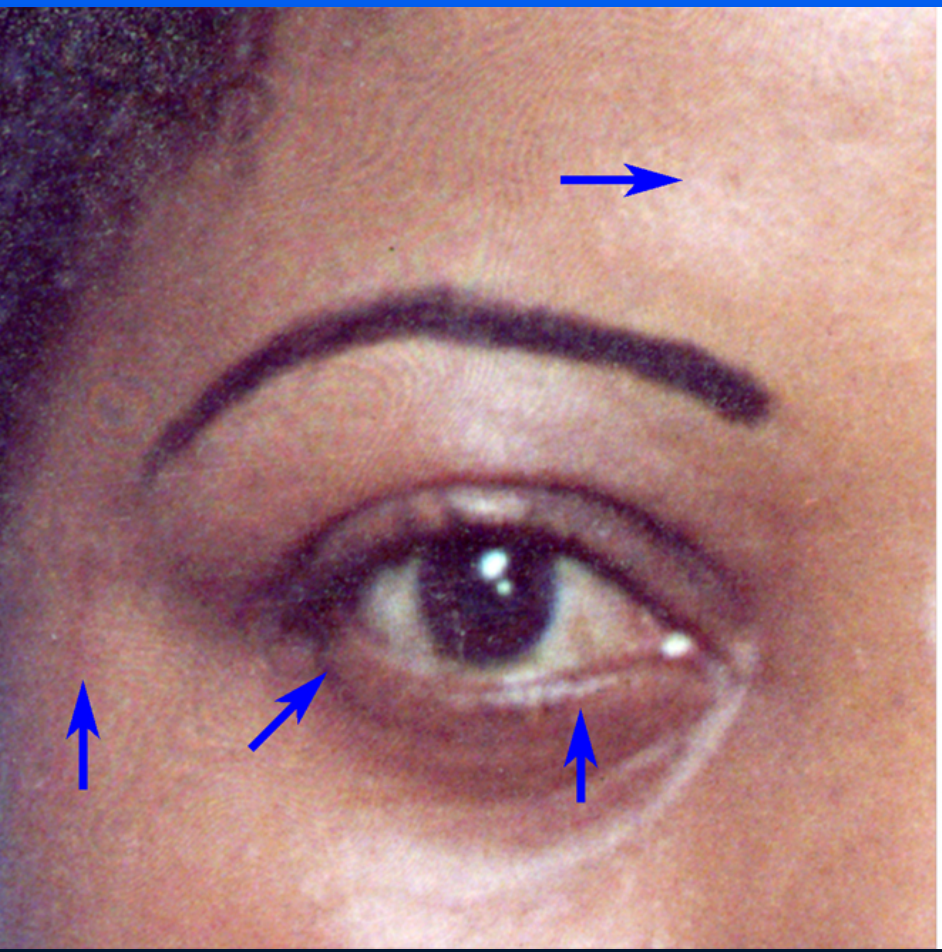


Reasons for Poor Quality Imagery

-Multi-generational copies

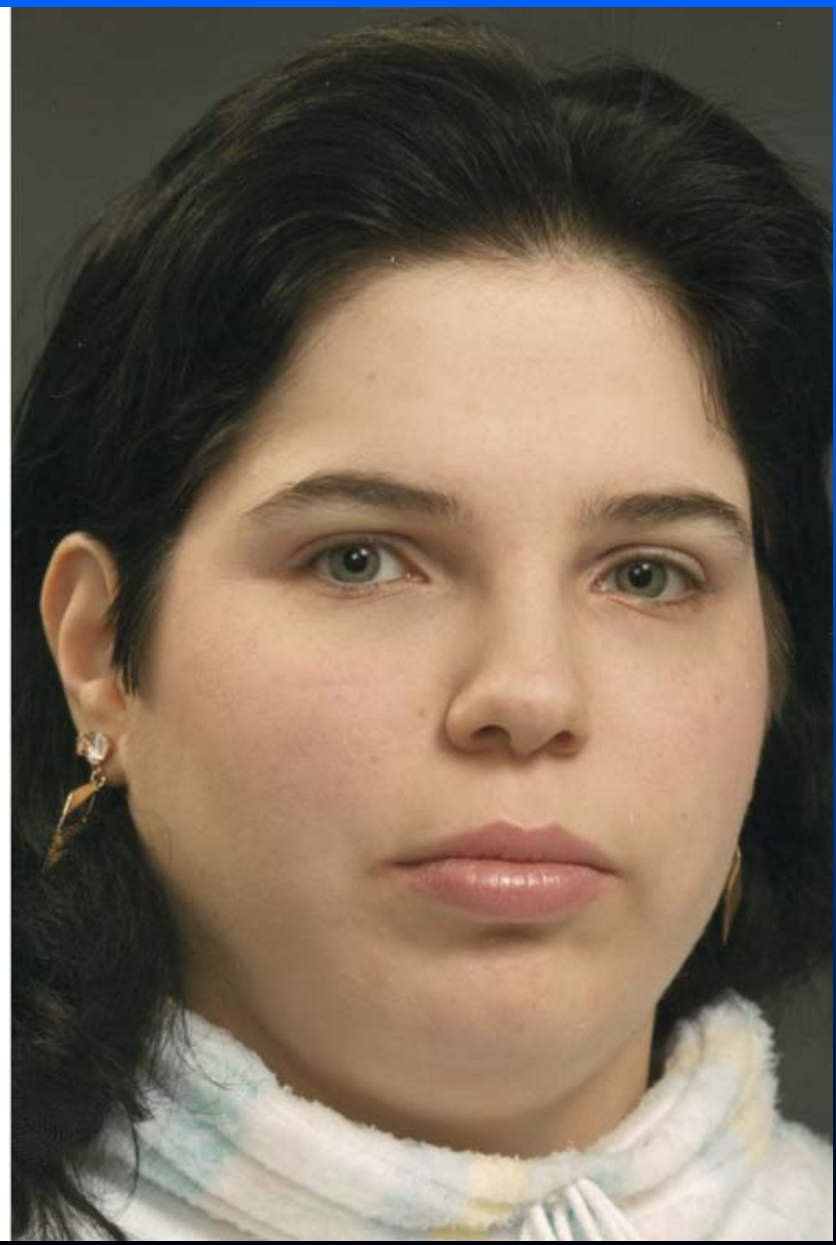
-Digital image compression

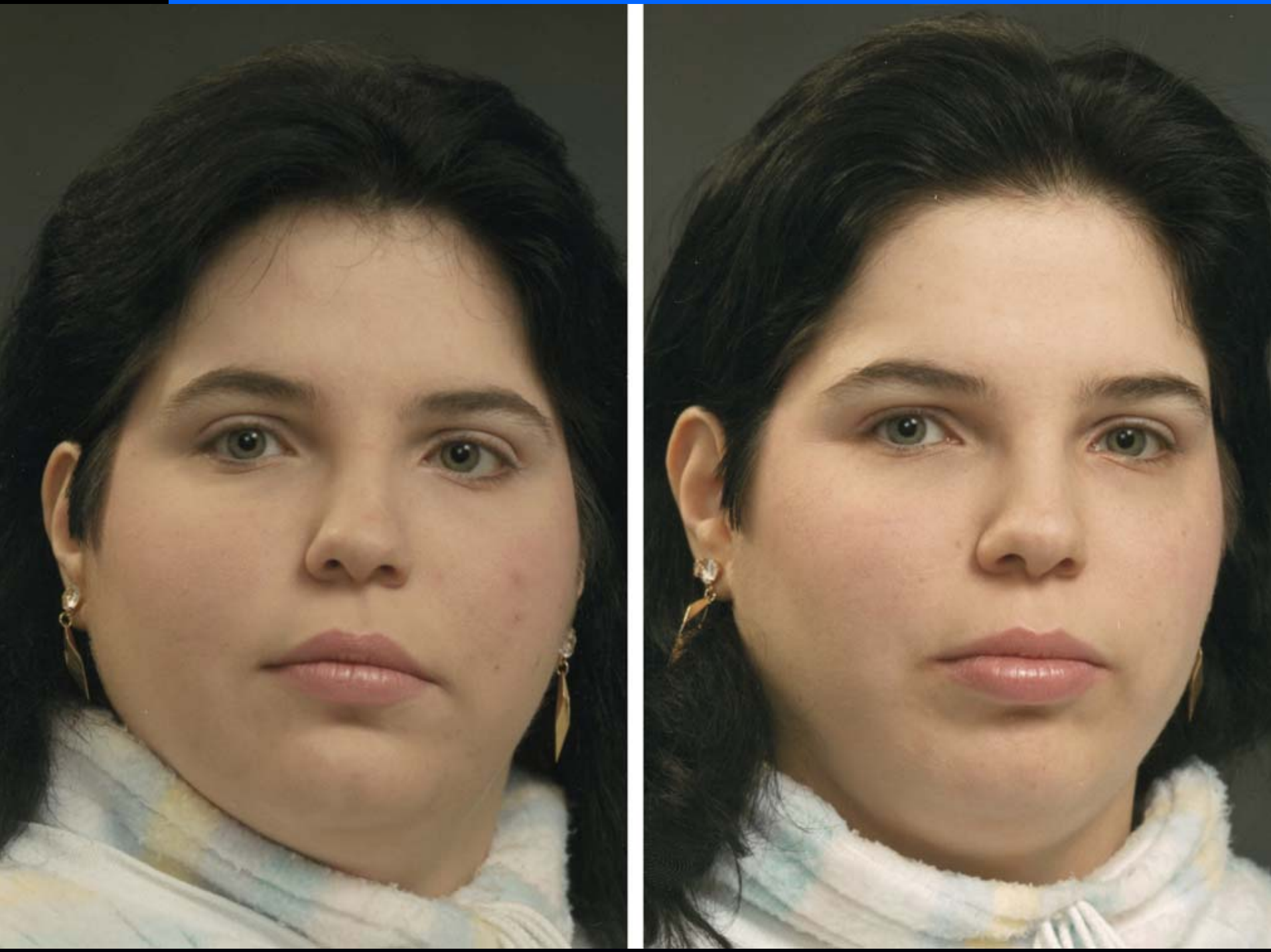
-Improperly photographed originals

-All of the above

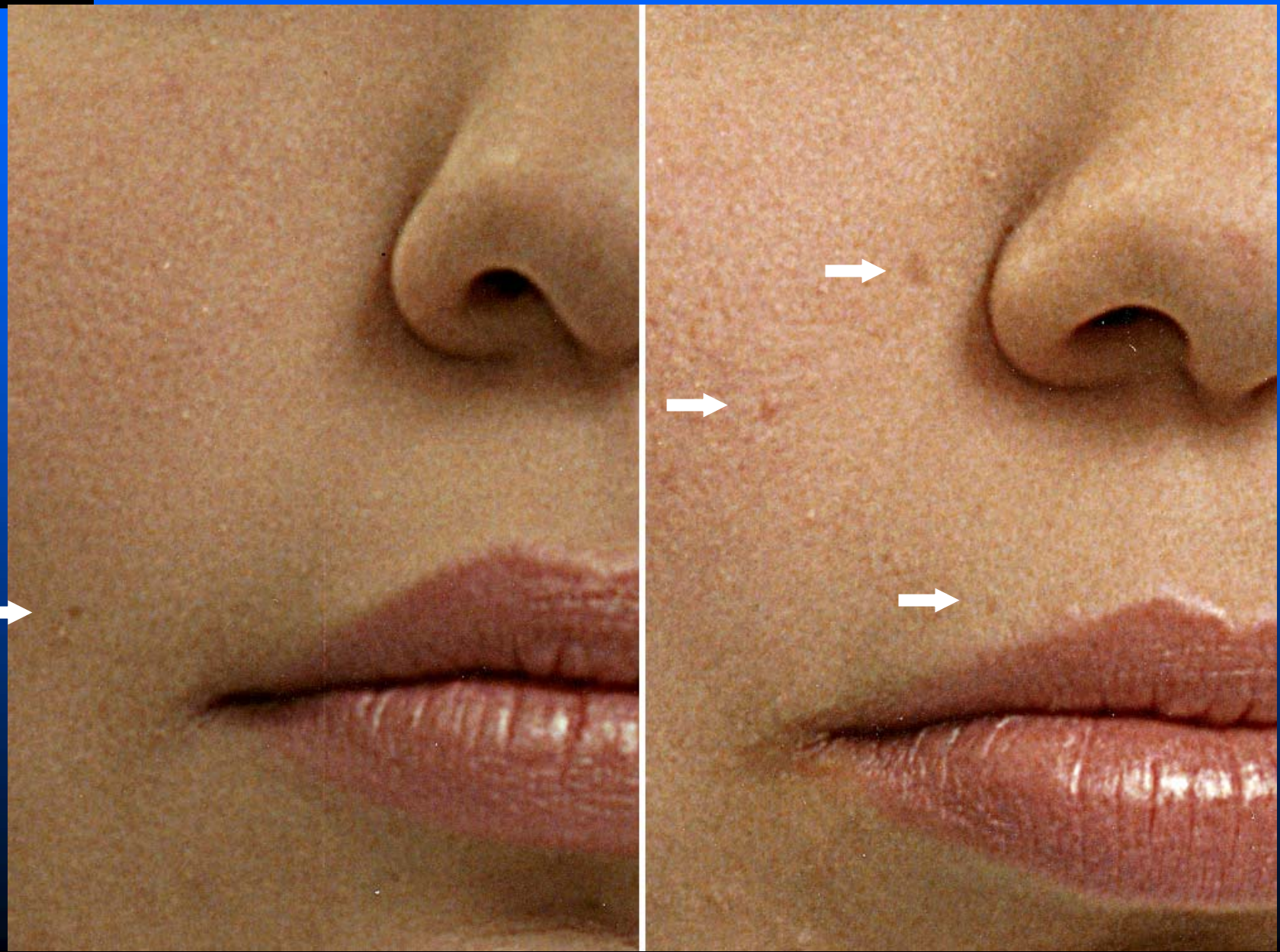
-Intentional alterations of images

Comparison of Twins





Points of Comparison/Differentiation
Freckles on order of 1mm or less



Automated Facial Identification - Challenges/Problems/Issues

- Target-Camera geometry
  - Changes in perspective affect measurements
    - » Great promise in 3D-morphable models
    - » But where will we get 3D images of the bad guys?
- Changes in facial expression
- Differences in imaging system (cameras and recording devices).
  - Resolution affects ability to identify landmarks
  - Imperfect optics and other system calibrations...

Long Range Challenge (for Law Enforcement and Intel Communities)

- LINKABLE/SEARCHABLE DATABASES:
  - Multiple agencies, states, and jurisdictions have, or are building, known offender databases, but systems not necessarily compatible or shareable.
  - Quality of images usually poor
    - » 640 x 480 is NOT GOOD ENOUGH FOR ID!
    - » JPEG damages images
  - ANSI/NIST STANDARD WILL IMPROVE QUALITY AND HELP DATA SHARING

GOAL FOR ANSI/NIST STANDARD:

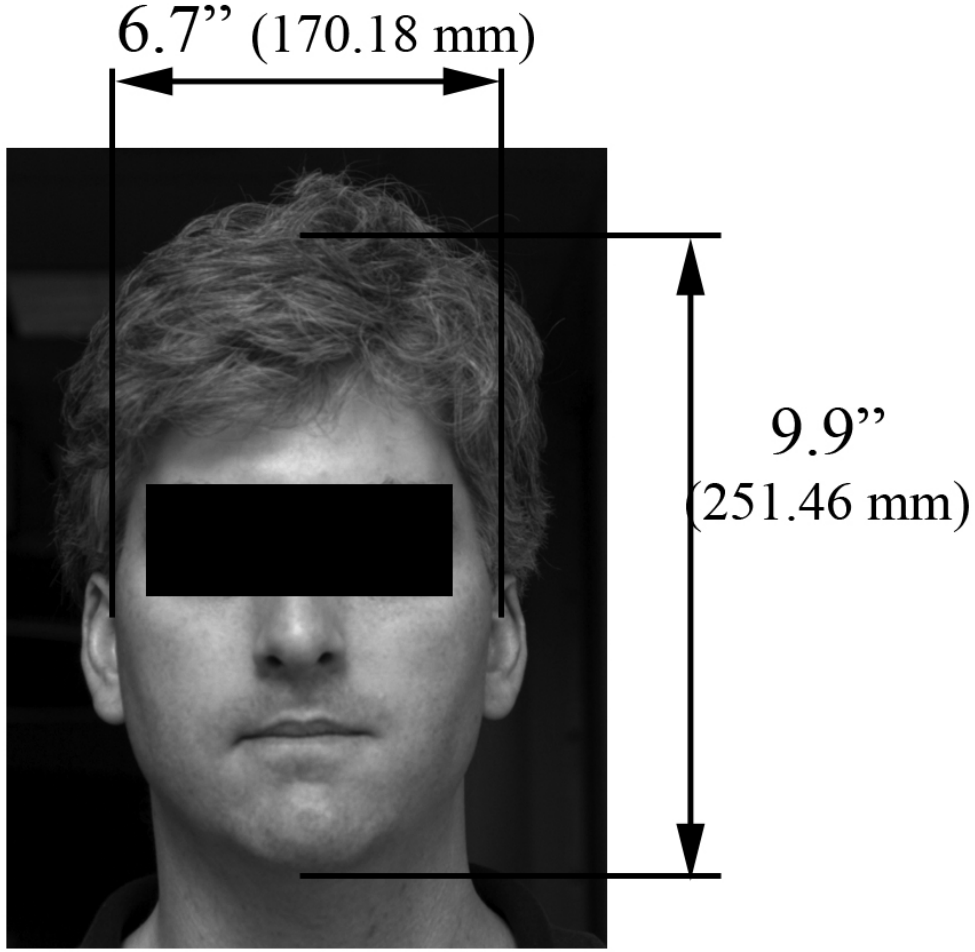
FACIAL EQUIVALENT OF THE 10-PRINT CARD

“FORENSIC QUALITY”

Can new ANSI/NIST Standard Addresses our Requirement?

GOAL:
Resolution
on Face
= 0.1 mm
(Requires
~ 1700 x 2515
pixels on face)

Adult Males in U.S.
99th percentile height & width



Proposed Level 50/51 Requirements

- 0.1 mm resolution on face requires approximately 1700 x 2515 pixels ON face.
  - 3300 x 4400 pixels will meet for head & shoulder (50)
  - 2400 x 3200 pixels will meet for head only photo (51)

- 5-views needed for comparison purposes:
  - Full Frontal (1)
  - Full Profiles (2)
  - 3/4 Profiles (2)

Proposed Level 50/51 Requirements

- Full scope of effect of compression remains to be determined. Therefore, for full frontal images, lossless compression is requested for now.
  - (Further research remains to be done)
  - 15:1 for profile views is acceptable

- Ears MUST be visible in all photos (if possible).
  - Ear provides strong potential for individualization and is prominent visible feature in questioned images.

Proposed Level 50/51 Requirements

- Acquisition of all images at level 50 should meet or exceed requirements for all other levels.
- In other words, if Level 50 is met, all potential users and applications should have their requirements met as well.
- Note that the 5-photo requirement would also allow for 3-D facial models to be constructed with better quality than with fewer images.

Other means of Personal Identification

- Positive Identification of Individuals depends upon presence and visibility of individual identifying characteristics
  - Ear patterns
  - Moles, Skin Tags, Birthmarks
  - Freckle Patterns
  - Scars
  - Tattoos
  - Knuckle Crease Patterns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1:26:17PM
136A

Known Photo of Suspect

Left arm detail

Questioned

Known

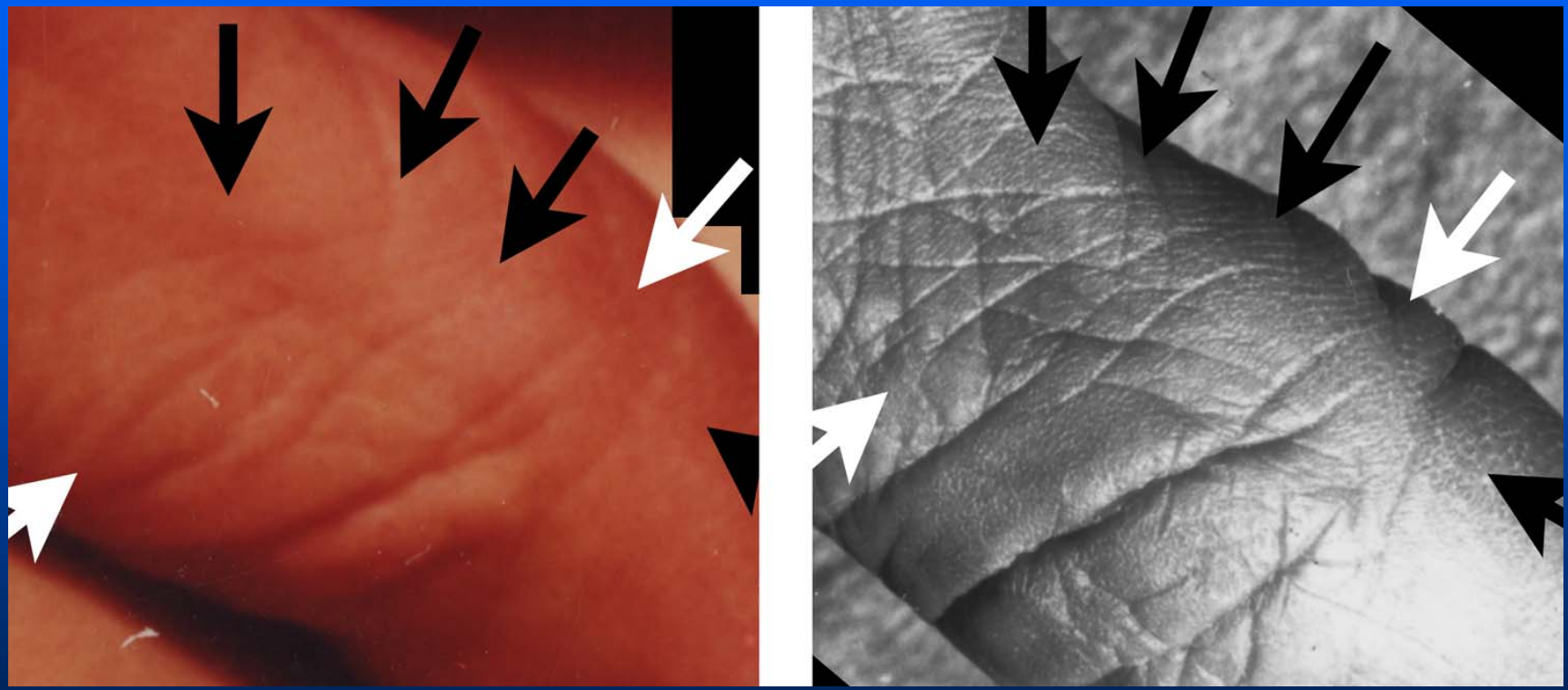
Photographic Comparisons and Knuckle and Freckle Patterns

- Some images do not depict questioned individual's face but do depict their hands
- Case examples have included:
  - Child abuse
  - Kidnapping
  - Murder
- Possible to positively identify suspects if other identifying characteristics are present

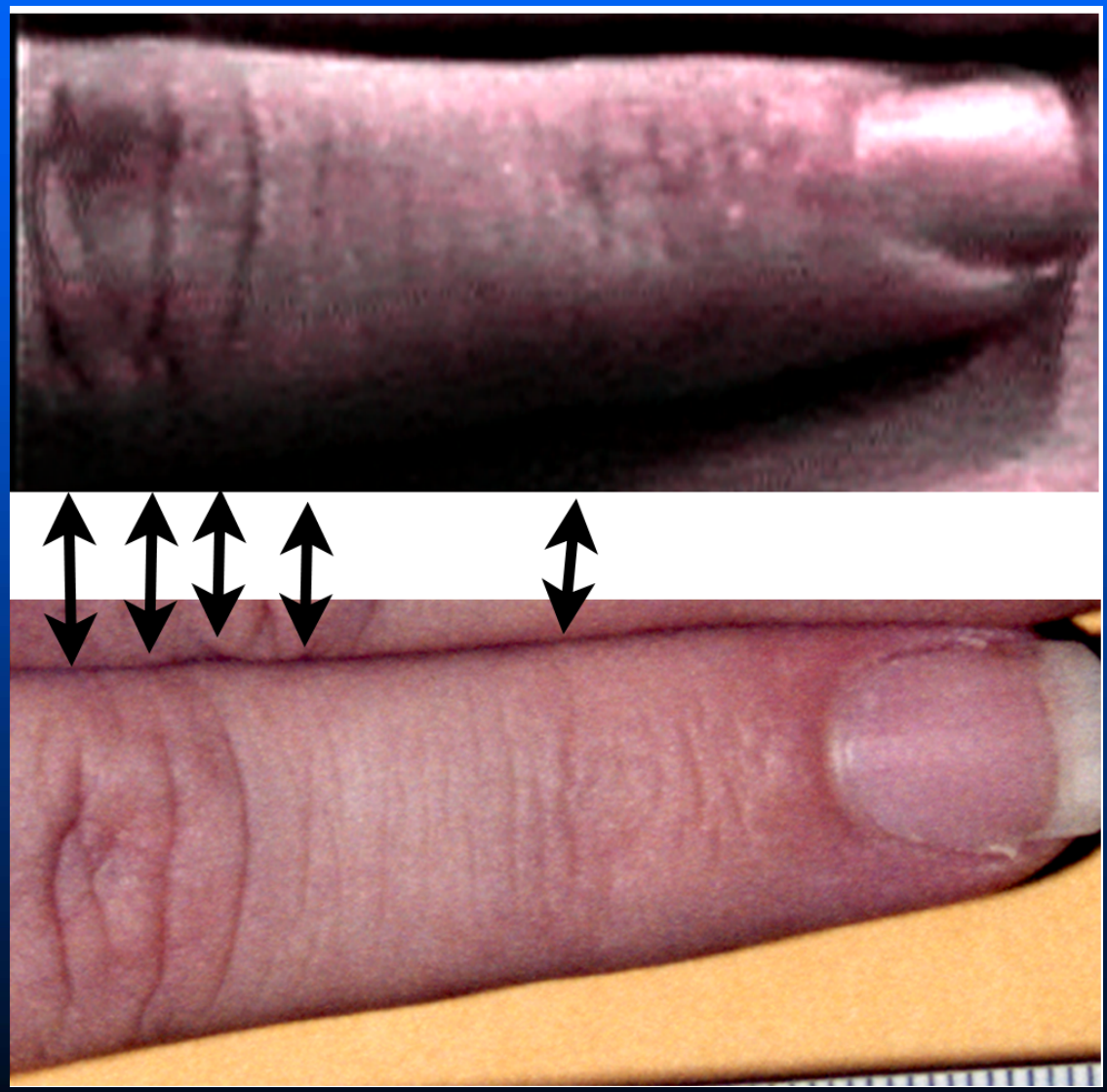
Questioned Thumb

Known Thumb

Side-by-side Comparison
Questioned and Known Thumbs



Side-by-side Comparison
Questioned and Known Index Fingers



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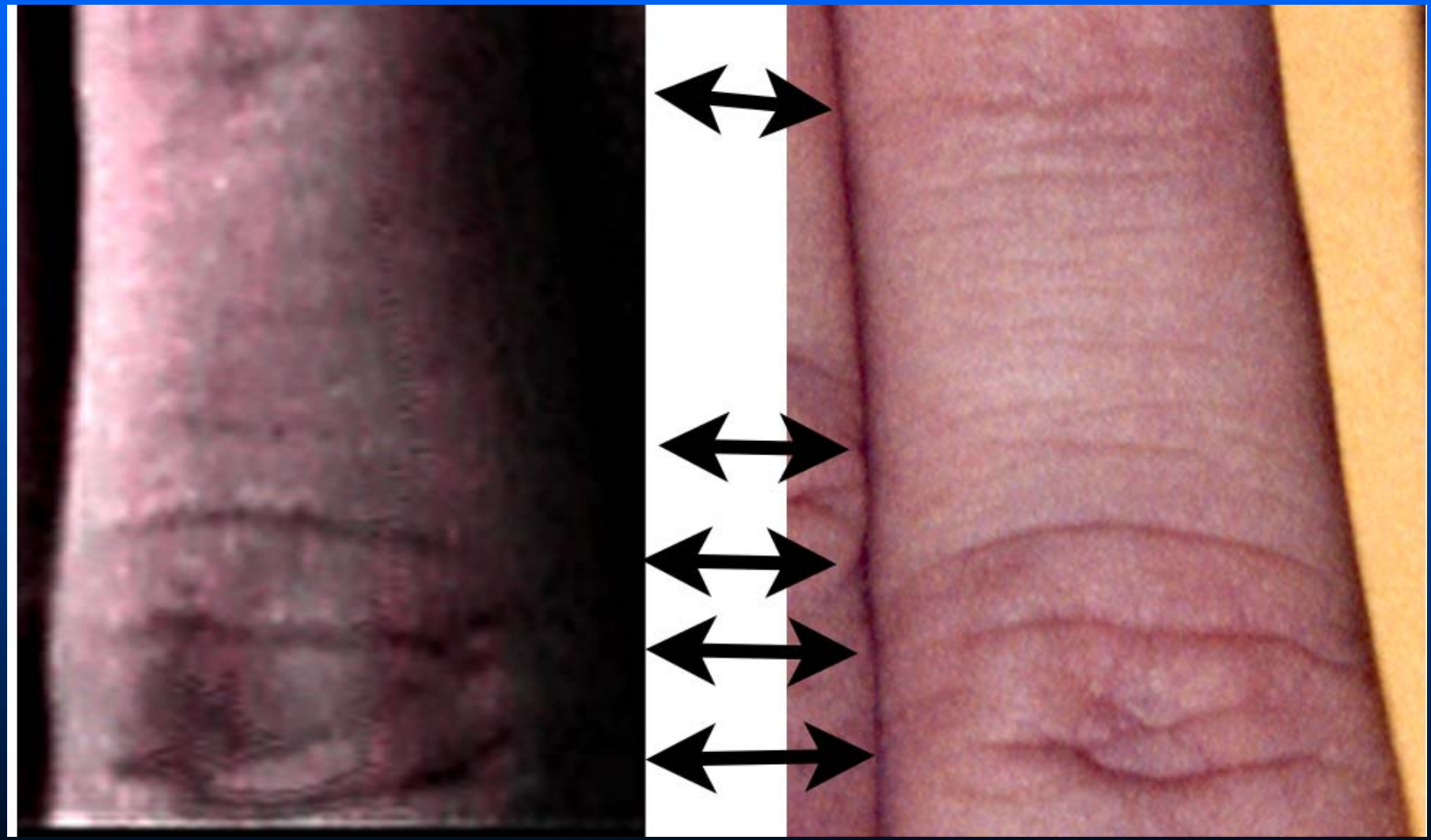
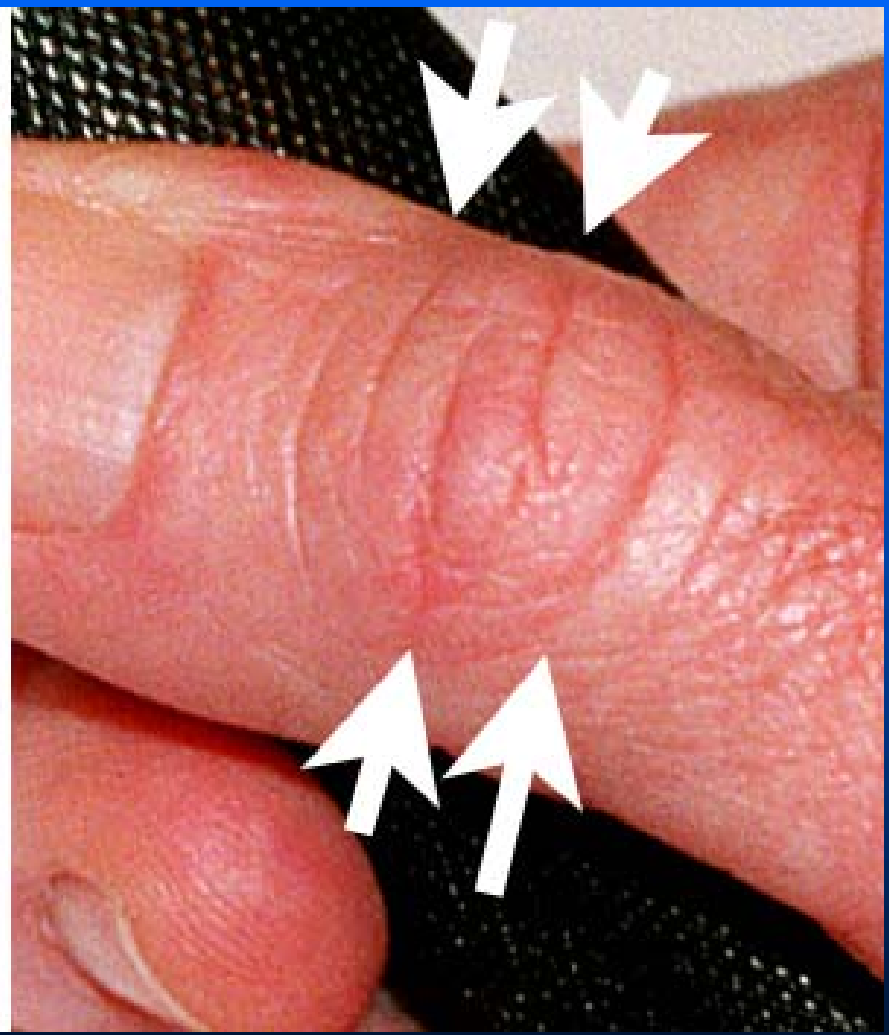


Side-by-side comparison
Questioned and Known Thumbs



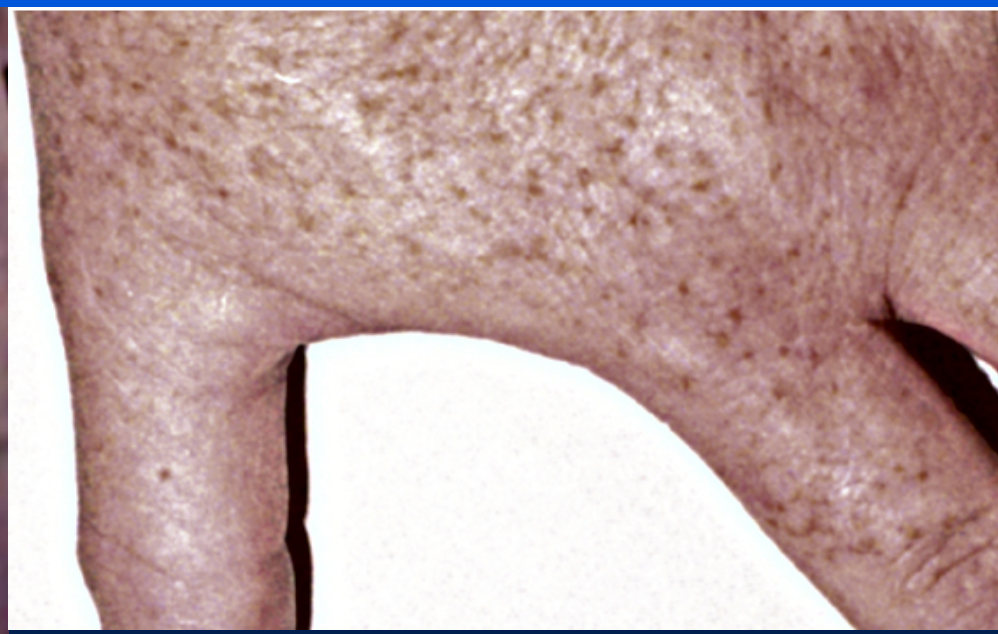
Raw Image

Cropped & Processed version of “DSC00008.jpg”

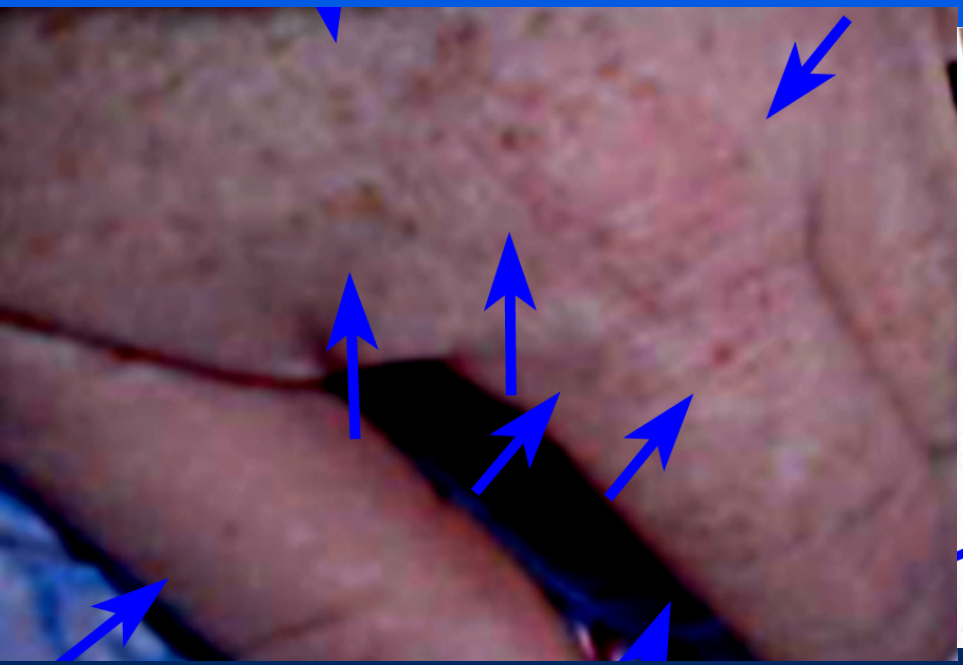
Left Hand of Suspect

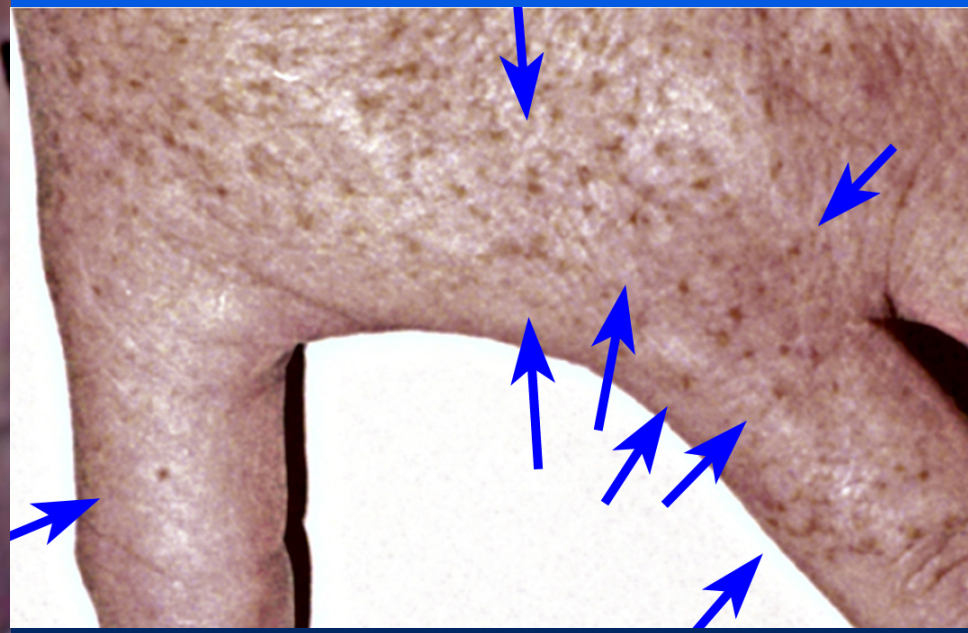
Cropped version of Left Hand of Suspect

Comparison of Questioned Hand (left) [from “DSC00008.jpg”] with Known Hand (right)



Comparison of Questioned Hand (left) [from “DSC00008.jpg”] with Known Hand (right)





QUESTIONS?

Richard W. Vorder Bruegge
FBI - FAVIAU - ERF
Building 27958-A
Quantico, VA 22135
703-632-6315
rvorderbruegge@fbiacademy.edu