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The Effects of Environmental Factors on the Preservation of Plastinated Anatomical Specimens: Observational Study in Iraqi Medical College

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Abstract

Background: Plastination is the method of choice for preserving biological specimens for teaching anatomy. Plastinated tissues are durable, but exposure to the environment and handling conditions, especially in harsh climates such as anatomical labs in the Middle East, may be a factor in the long-term effects on structural and aesthetic integrity. **Objective:** The aim of this research is to recognize the physical and environmental durability of plastinated anatomical specimens in Iraqi medical labs to identify the most common types of deterioration and the variables that endanger these specimens and lead to its deterioration. **Method:** 24-month quantitative observational research in the College of Medicine at Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences using 32 anatomical specimens plastinated with silicone. The specimens were examined by standard anatomical evaluation techniques for evidence of biological contamination, surface changes, color inconsistencies, or structural instability. **Results:** The vast majority of specimens (75.0%, n = 24) showed no major structural stability flaws. By comparison, 3.1% of the samples showed surface silicone weeping/softening ("silicone melting"), 3.1% showed localized fungus growth, 3.1% showed color change, 9.4% showed dust accumulation, 6.3% showed mechanical wear, and 25.0% showed mild to moderate localized deterioration (n = 8). The results suggest that Plastination is quite robust even in extreme microclimates. But the most important damage vectors are high ambient temperatures, exposure to particles, variation in relative humidity, and frequent handling by students. Stringent environmental controls and preventive maintenance measures must be implemented to maximize the lifetime of the specimen.

Keywords: medical education, environmental degradation, plastination, silicone, anatomical specimens, Iraq.

Introduction

Dr. Gunther von Hagens' 1977 invention of plastination, which substituted inert polymers for volatile and dangerous fixatives like formaldehyde, radically altered the field of anatomy education [1]. Step one of the conventional silicone process is fixation, Step two is dehydration in cold acetone, Step three is forced impregnation under vacuum, finally, and step four is gas/heat curing. Under ideal storage circumstances, the produced specimens remain dry, odor-free, non-toxic, and resistant to environmental deterioration [2].

Plastinated specimens may nevertheless degrade, even if silicone polymers are structurally stable. Specimens experience unique microclimatic stresses in contexts that are unique to their regions, such as medical schools in Iraq. Specimens are strained in big undergraduate anatomy classrooms due to

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factors such as strong student contact, seasonal dust storms carrying particulate matter, and high summer ambient temperatures (>40ºC) [3].

Although there is a lot of literature on the methods for preparing plastinated tissues [4,5], there is a lack of information on how well they hold up in dry, hot, and particle-filled environments over the long term. The purpose of this research is to assess the effects of physical handling and environmental exposure on 32 plastinated specimens from the College of Medicine at Jabir Ibn Hayyan Medical University.

Materials and Methods

Study Design and Sample Selection

The cross-sectional observational research study was performed at Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences College of Medicine Department of Anatomy. A total of 32 human anatomical specimens, all of which had been silicone-plastinated, were methodically chosen for the cohort.

This group of specimens consisted of:

Neuroanatomy: brains, including whole brains and coronal portions (n=8)

Internal Organs: hearts, lungs, and kidneys (n=12)

Musculoskeletal: Joint preparations and prosections of the upper and lower extremities (n = 12)

Prior to review, all specimens had been actively used in undergraduate medical education for 2 to 5 years and were created using normal silicone impregnation processes.

The most significant environmental measures used at each site were:

Temperature Range: (22- 36 °C) (Unconditioned Indoor Storage vs. Off-Peak Periods)

Relative Humidity (RH): 20 % to 65 %

Handling Frequency: Heavy undergraduate use (~15-25 student interactions/specimen/week)

Evaluation Criteria and Diagnostic Parameters

Five main deterioration modes were monitored for each specimen throughout the multi-point visual examination:

Biological sulci, fascial planes, or surface porosities may collect airborne particles, a process known as dust accumulation.

Frictional erosion, microtears caused by handling, and fraying of fragile systems (such as peripheral nerves and vascular branches) are all examples of mechanical wear.

"Melting" or "weeping" silicone refers to the release of unpolymerized silicone oligomers or the breakdown of surfaces caused by high temperatures.

When organic residue and sudden increases in humidity cause visible fungal development or sporangia production, we say that there is microbial contamination.

When compared to baseline photographic records, surface yellowing, blanching, or hyperpigmentation might be described as color alteration.

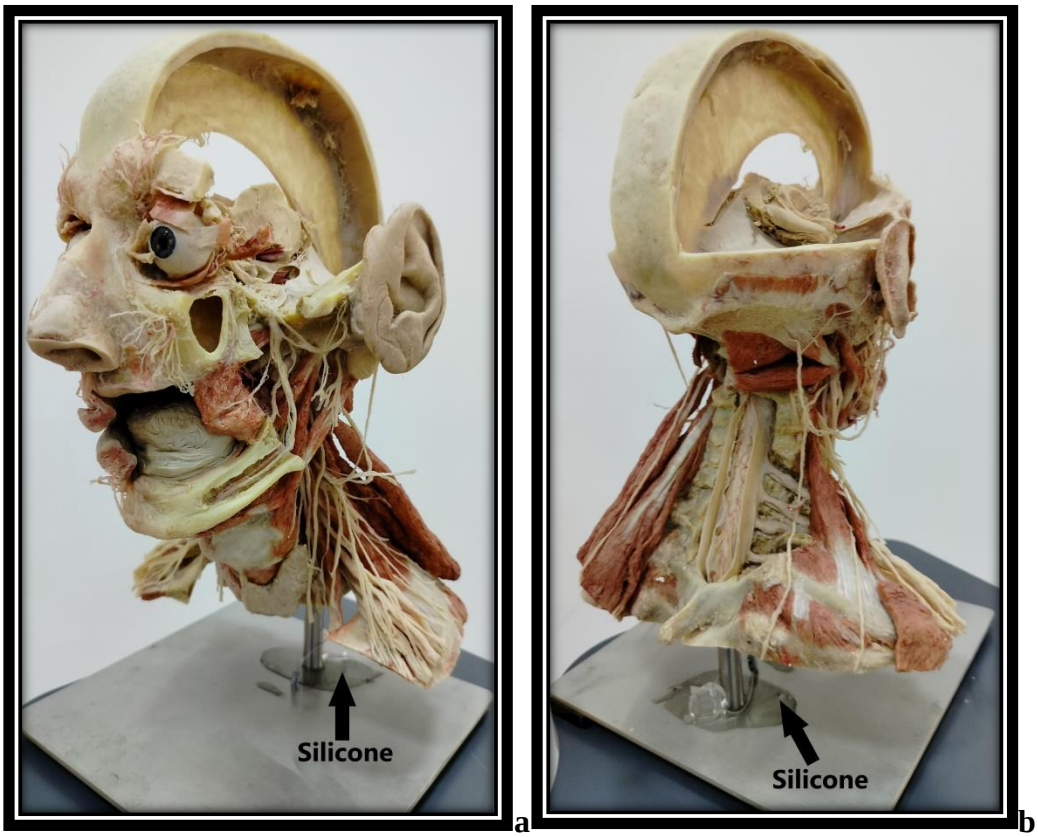
Results

The preservation rate of the 32 plastinated specimens was evaluated; **24 specimens (75.0%) remained completely unchanged**, demonstrating no visible or tactile degradation defects. 8 specimens (or 25.0% of the total) showed signs of localized mechanical or environmental changes.

Overall Condition Breakdown of the Specimens (N = 32)

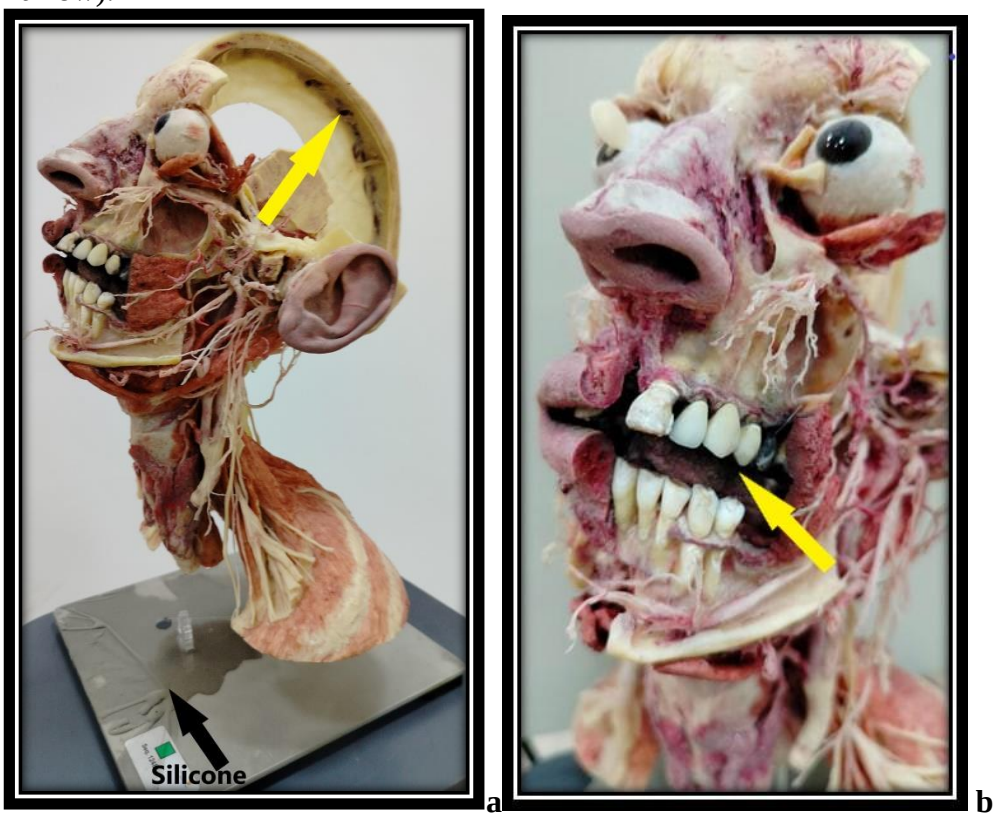
75 percent unchanged (n=24)

25% showed changes (n=8)



a b

Fig. 1(a&b): Head & neck plastinated specimen showing melting of silicone on the base of the stand (black arrow).



a b

Fig. 2(a & b): Head & neck plastinated specimen showing melting of silicone on the base of the stand (pointed by the black arrow) and the growth of fungi (black areas pointed by the yellow arrows).



Fig. 3: (a) showing a plastinated specimen of trunk wall with normal color of muscles, (b) showing plastinated muscles of shoulder region with change in the color, (c) showing a plastinated upper limb specimen with change in the color (faint)**.**



Fig. 4: A posterior view of trunk wall muscles showing the dust accumulation on the upper part of the trunk muscles pointed to by the red arrow, while the normal muscles of the trunk that are not affected by dust are pointed to by the blue arrow**.**

Incidence of Specific Degradation Modalities

The following are the specific types of defects found in the 8 specimens:

Structural and Anatomical Risk Distribution

Dust trapping inside deep sulci and crevices was more common in visceral organs (n = 12), such as lung fissures and heart sulci.

Neuroanatomy (n = 8): Color change caused by exposure of the lipid-rich white matter and mechanical wear at delicate edges (e.g., cranial nerve roots) makes them very prone to damage.

In the musculoskeletal system specimens (n=12), there was little mechanical wear at tendinous insertions and otherwise good durability.

Discussion

Without active intervention, 75% of the specimens had excellent structural integrity, showing the reliable durability of silicone plastination for anatomical preservation in difficult climatic conditions. But this 25% failure rate also reveals the idiosyncratic environmental vulnerabilities of lab settings in the Middle East.

Degradation modes analysis:

1. Dust accumulation (9.4%)

In most of the cases the dust had built up. Airborne particle events occur frequently in Iraqi laboratories due to the topography of the country. Complex anatomical recesses (such as cerebral sulci or renal sinuses) and the micro-porosities of cured silicone surfaces are potential entry points for microfine dust particles. Dust cannot directly damage structural tissues, but it does make it harder to see fine anatomical details and may even support the development of living organisms.

2. Mechanical wear (6.3%)

Plastinated tissues are mechanically stressed since they are intended for inspection by hand. When there are a lot of students compared to specimens, mechanical deterioration (such as nerve root avulsion and vascular bundle fraying) becomes more apparent [4, 5]. Frictional abrasion delicately removes surface features in the absence of supervised handling guidelines.

3. "Melting" or Softening Silicone (3.1%)

In chemical terms, "silicone melting" refers to the release of uncrosslinked silicone polymer fluid or the breakdown of the silicone matrix. The remaining unreacted oligomers rise to the surface under hot summer conditions (>35°C) inside unconditioned rooms, resulting in a sticky, wet consistency. Therefore, the curing time or gas promoter exposure during manufacturing must be carefully controlled in hot areas.

4. Fungal growth (3.1%)

Although cured silicone polymer is biologically inert [1], organic contamination on the surface can support fungal spores (e.g., *Aspergillus spp.*, *Penicillium spp.*). Organic contamination can originate from skin lipids and epithelial cells shed from the hands of students and increased ambient moisture (e.g., water from a spray bottle). In damp, poorly ventilated storage areas, fungus colonies can grow on surfaces.

5. Changes in color (3.1%)

One specimen was noted to have color loss or yellowing. The change usually occurs because the lipids were not completely extracted when the acetone was cold enough to dehydrate [2, 6], or because they were exposed to light and UV rays for too long in the display cabinet, which results in slow lipid photo-oxidation.

Recommendations

The following is a list of care and management recommendations, based on these research findings:

1. Environmental Control:

Anatomical storage rooms should be maintained at 20 to 24 degrees Celsius and relative humidity below 50%. Use HEPA-filtered air cleaners in the dissecting rooms to reduce airborne dust.

2. Storage and Housing:

When not in use, specimens should be stored in airtight polypropylene containers or sealed, dustproof acrylic glass cases; UV-filtering films on display cabinets and laboratory windows help stop light-induced discoloration.

3. Cleaning and Maintenance Procedures:

Use a gentle solution of ethyl alcohol (70%), compressed air, or a soft-bristled brush to clean the specimens at regular intervals to remove dust.

For fungal contamination, use a single application of 70% ethanol or diluted ethanol-glycerin in infected areas. Avoid strong organic solvents, such as pure acetone, as these can damage the silicone matrix.

4. Handling Instructions

All students must wear powder-free nitrile gloves to prevent the spread of skin lipids and fungal spores. Avoid allowing students unsupervised by faculty members to access delicate specimens (such as brain stems and cranial nerves).

Conflict of interest: NIL

Funding: NIL

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