

FLEXIBILITY RESTORATION OF ARTICULATIO METACARPOPHALANGEAL 1 IN CADAVER PRESERVED BY FORMALIN WITH ACETIC ACID EXPOSURE

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Abstract:

Cadaver rigidity due to formalin preservation often intricates students' understanding in anatomical learning. Various solutions have been trial, but there were no satisfactory results. In this study, acetic acid solution was used to restore the motion flexibility motion of small joint in the hand. Investigated the difference in motion angle of articulatio metacarpophalangeal 1 after being given acetic acid in cadaver post formalin preservation. A pair of cadaver hands conserved by formalin from the same body, were exposed to 5% acetic acid for 4 months. Angular measurements performed on flexion and extension before and after exposure. The flexibility of metacarpophalangeal joints 1 increased in the form of angular reduction in flexion movement (22.8° reduced, $p < 0.05$) and the addition of angle to the extension movement (9.85° increased, $p < 0.05$). Administration of acetic acid for 4 months may increase the motion flexibility of small joint like articulatio metacarpophalangeal 1 in cadaver post-formalin preservation. This result may help students to have better anatomical understanding in cadaver at anatomy laboratory.

Keywords: Acetic acid; Articulatio metacarpophalangeal 1; Cadaver; Flexibility; Restoration

Introduction

Dissection using cadaver in anatomy learning still irreplaceable to gain three-dimensional experience and students' long-term understanding of human anatomy. In addition, dissection with cadaver reported can foster cooperation between students and professional attitudes when facing lifeless bodies.¹ The combination of formalin and methanol has long been used as a fixative liquid in preservation used in various medical educational institutions hence cadavers can last a long time. However, rigid cadaver due to the use of formalin often intricates students' understanding of a structure in the body, especially when studying the musculoskeletal system. Ethylene glycol (glycerol), since decades ago has been combined with formalin in preservative liquids to retain moisture and reduce the rigid effects on cadaver due to formalin. Unfortunately, it promotes growth of fungi if given in high concentrations.² Therefore, it is necessary to think about the right restoration formula to increase the flexibility of post-preservation cadavers with formalin.

Interestingly, glacial acetic acid has been reported to be beneficial in restoring the flexibility of cadaver extremity post formalin preservation.³ In addition, there is a recent publication stating that acetic acid can be used as a preservation fluid in fresh brain so it is suitable for use in surgical skills training.⁴ However, there is no data stating that glacial acetic acid can restore flexibility and extremity of cadaver post formalin preservation in high humidity country, like in Indonesia. Therefore, further investigation about the use of glacial acetic acid in the flexibility restoration of post-preservation cadaver with formalin is needed to help anatomical learning especially in musculoskeletal systems without stimulating fungal growth on cadavers, and also less toxic for others. This research investigates the changes in flexibility of small joint, articulation

metacarpophalangeal 1 (MCP 1), preserved by formalin with acetic acid exposure in certain period of time.

Research Method

Sample

The sample was a pair of cadaver hands that came from the same male body from Anatomy Laboratory of YARSI University. They have been preserved by formalin bath in a humid with no sun light circumstance. The samples were intact and never been dissected. The samples were obtained in the same day of experiment.

Exposure

Glacial acetic acid diluted into 10 liters of 5% acetic acid solutions. The solution poured into each glass container, then covered with its glass lid. The samples soaked in this solution for 4 months. In the first couple months, the solutions were replaced into the new one with the same amount and concentration, every couple week. Every month, the articulation MCP 1 of each sample were injected with this solution by subcutis and intra-articular routes.

Observation and Measurement

The physical features of samples were observed before and after exposure includes skin color, rigidity, fungal growth macroscopically on the samples. In addition, the scent changes of samples and surrounding also noted.

The bending test was performed before and after exposure. The angular measurement of flexion and extension movements of articulation MCP 1, as further as it could, gently without breaking it, were committed with digital goniometer. The mean changes of angle measurements then statistically analyzed with T-test paired.

Results

Physical features

Before exposure, the samples were brown, wrinkled, rigid and limited in movement. It was nearly hard to perform flexion and extension movements in articulation MCP 1. There was no obvious fungal colonization in the samples. In addition, a strong scent of formalin from samples were smelled.

After 4 months of exposure, the skin color became a bit lighter, still wrinkled but softer in palpation. There was no fungal growth found in both samples. The scent of formalin disappeared from samples and surrounding. The smell of acetic acid replaced the old scent. When bending test performed, the joint was less rigid, and it was easier to commit

articulation MCP 1 flexion and extension movements.

Angular measurements

The result of angular measurements of the samples shown in Table 1. Although it was obtained from the same cadaver, the angle measurement of each movement in each sample were different before exposure. In result, there were different angle measured after exposure in each movement.

After 4 months of exposure, there was 22.8° ($p=0.036$) reduction in angle measurement of articulation MCP 1 flexion movement. In addition, there was 9.85° ($p=0.016$) enhancement in angle measurement of articulation MCP 1 extension movement.

Table 1. Angular measurements of articulation MCP 1 in flexion and extension movement before and after acetic acid exposure

Angle measurement in movement	Hand 1	Hand 2	Mean	Difference	P value
Flexion					
Before	135.1°	144°	139.55°	22.8°	0.036
After	113.6°	119.9°	116.75°		
Extension					
Before	177.6°	172.5°	175.05°	9.85°	0.016
After	187.7°	182.1°	184.9°		

Discussion

Formalin is the main ingredient in cadaveric preservation fluids to date. This liquid is easy to obtain, inexpensive and can preserve cadaver in the long term. Formalin quickly penetrates into tissues, including muscles, thus quickly hardening the muscles, causing the cadaver become rigid and its flexibility of joint limited.² However, it has carcinogenic and genotoxic effects. In several recent studies were reported that cadaver soaked in a combination of formalin also had irritating effects on students, such as smelly scent, eyes sore, and excessive lacrimation. In addition, chronic toxic effects on laboratory team have also been reported, such as dry

skin, eczema, allergic contact dermatitis, eye irritation, respiratory tract irritation, work-related bronchial asthma and other disorders.⁵⁻⁷

Acetic acid is potential as preservation fluid for fresh cadaver, accessible and cheap. In recent study, other forms of acetic acid have been investigated to preserve post mortem fresh blood for investigating the cause of death without freezing the sample, so that post mortem conditions that can cause bias in certain substance measurement could be avoided.⁸ Furthermore, 60% acetic acid or more has reported beneficial as a fresh cadaveric brain preservation fluid assessed by

color change, consistency of cortex and pia mater texture parameters.⁴

Acetic acid also had been used to softening plant material embedded in paraffin since several decades ago.⁹ Acetic acid has given satisfactory results in its use as a human restorative fluid for almost 4 decades in formalin preserved cadaveric arm.³ The result of our present research is continuing above studies.

There are changes in physical features of small joint in hands, articulation MCP 1, after soaked and injected by 5% acetic acid solution. It was assessed with some parameters includes color change and rigidity. It took 4 months to restore its flexibility. Previously in Japan, acetic acid solution was already used to softening fish bone inspired by their traditional way to soak a fish like sardine in vinegar.^{10,11} Altered bone structure and hardness of the bone causing its weight decreased and water content increased. Elution of mineral constituting the bone was shown to be the main reasons for physical properties changes of fish bone cured in 4% acetic acid solution.¹² These could be considered also as reasons for physical features changes in cadaver's small joint, articulation MCP 1 in this research, hence it needs further researches to validate it.

In addition, the disappearance of a strong formalin scent may be beneficial to laboratory team and students in anatomy laboratory. Furthermore, harmful effects of formalin explained above could be reduced. Although the joint flexibility slowly restored, there were no obvious fungal growth in both samples, thus it needs further study to find optimal concentration needed combined with toxicologist advice.

Conclusions

Acetic acid solution is potential to restore the physical features include joint's flexibility of small joint in hands, articulation MCP 1. These results could help given consideration and encourage anatomists who are facing the same difficulties in teaching anatomy using rigid cadaver because of formalin preservation, especially in humid circumstance as such as Indonesia.

However, further investigation with larger sample related to microscopical and biochemical changes are required to validate the physical features and flexibility changes in cadaver preserved by formalin. The optimal concentration based on weight of cadaver body parts is necessary to find to avoid undesirable fungal growth and toxic effect in restoration process.

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