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Anatomy Section

Burial, Excavation and Chemical Cleaning - An Economical Approach for Extraction of Human Bones from Embalmed Dissected Cadavers in India

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ABSTRACT

Introduction: The human bones are an integral tool in the study of anatomy. Bones are necessary not only for teaching anatomy but also for planning of various surgeries and assessing the efficacy of orthopaedic devices.

Aim: The present study was undertaken to develop the most suitable technique for extraction of human bones from embalmed dissected cadavers.

Materials and Methods: The study was conducted on the embalmed dissected cadavers in Department of Anatomy, GSVM Medical College, Kanpur, UP, India. The cadavers were buried in the soil for a period of two years at the depth of 1 foot, 2 feet, 3 feet and 4 feet. The bones so extracted were cleaned with a solution of normal water, detergent, bleaching powder and hydrogen peroxide. The result was compared with the bones extracted with other techniques.

Result: The bones extracted after this procedure were clean, intact and their quality was absolutely at par with the bones extracted with other techniques. It was found that the bones of the most superficial level i.e. 1 foot from surface had some decomposition at the ends. The bones at the 2 feet were of best quality - quite clean and intact. The bones at the 3 feet were also intact but some soft tissue was still adhered around these bones while there was a minimal decomposition of the cadavers buried at the depth of 4 feet due to which bones could not be procured from this depth.

Conclusion: The burial method for extraction of bones and the subsequent cleaning with a solution of normal water, detergent, bleaching powder and hydrogen peroxide is a very comfortable, cost effective, ecofriendly and suitable method for obtaining the human bone specimens from embalmed cadavers. The cadaver should be buried in superficial layer preferably 1 foot to 2 feet depth.

Keywords: Anatomy , Body donation, Decomposition, Osteology, Skeleton, Soil

INTRODUCTION

Osteology is fundamental for the understanding of anatomy and its application in the surgical and orthopaedic practices. The human bones are a mandatory tool for study and research in the department of anatomy and comprise an integral part of curriculum for medical graduates and postgraduates. The precise knowledge is also essential for practice in orthopaedics, surgery, otolaryngology and plastic surgery.The availability of human bones is a bottle-neck in the whole issue. The shortage of human cadavers is the most important underlying cause for it. In a study from Maharashtra, India, a gross insufficiency of cadavers was found in 90.90% of medical colleges [1]. The availability of unclaimed bodies after police verification has various medico legal procedures which cause much delay and is practically very difficult to follow. Donation of body is also not a common practice therefore causing scarcity of cadavers. Some institutions have turned to plastic replicas [2] but artificial substitutes aren't ideal because plastic models are usually reproductions of a single specimen and don't include the range of variations found in real bones [3]. Human body is very complex but it conforms to a general pattern. Patterns described as normal in Anatomy textbooks are not found in every bone but it does not mean that the rest are "abnormal. They are variants which are present in many individuals [4]. Students trained on facsimiles never see these differences

among individuals. Moreover, the models aren't entirely accurate since the molding process doesn't capture the detail of a real specimen which is especially critical in the skull.

In present times with few available, it is difficult to spare a fresh cadaver for extraction of bones only since it is much needed for the dissection purpose for medical students. Hence, the present study was undertaken to evaluate the most comfortable, cheap and suitable method for extraction of bones and their cleaning with readily available chemical solution from the embalmed cadavers.

MATERIALS AND METHODS

The study was prospective, performed on 32 embalmed cadavers in Department of Anatomy, GSVM Medical College, Kanpur, UP, India for a period of twenty seven months (October 2013- December 2015). The cadavers were buried in soil at different depths : 1-4 feet for the extraction of bones and the outcome was observed in comparison to the stock of bones already available in the department. All the cadavers were received in the department as a kind donation for academic purposes. Out of 32 cadavers 30 cadavers were fully dissected and 2 cadavers were undissected. Due approval of ethical committee for extraction of bones from these cadavers was taken. The burial method for extraction of bones was adopted. A burial ground of 10 x 8 x 4 feet was made. The soil of the area was loamy in nature. The cadavers were buried in four stratas at four levels of depth- 1 foot, 2 feet, 3 feet and 4 feet from the surface with a pack of loose soil between two stratas. The undissected cadavers were buried at the deepest 4 feet depth from the surface. Common salt (5 Kg) was loosely spread on the cadavers. The area was demarcated and outlined for future access. The cadavers were buried in the soil for a period of two years. After two years the bones were excavated.

The bones so extracted were cleaned with a solution of normal water, detergent, bleaching powder and hydrogen peroxide. The most suitable technique for extraction and cleaning of the bones in the Indian set-up was concluded.

RESULTS

After two years the burial ground was inspected. On inspection the soil of the demarcated area was visibly depressed about 6 inches deep from the surface. The area was excavated. It was found that the bones of the most superficial level i.e. 1 foot from surface were clean and accompanied with some signs of resorption or decomposition especially at ends [Table/Fig-1]. The bones at the 2 feet were quite clean and intact. The soft tissue around these bones was almost completely removed [Table/Fig-2a,2b]. The bones at the 3 feet were also intact but some soft tissue around these bones was still adhered [Table/Fig-3].

[Table/Fig-1]: Bones extracted after burial at 1 foot depth (after cleaning)- showing decomposition at ends.

[Table/Fig-2]: Bones extracted after burial at 2ft depth - a)- Before cleaning b) After cleaning.

The poorest result was seen with the cadavers buried at the deepest level of 4 feet. The two undissected cadavers were still completely undecomposed [Table/Fig-4]. None of the bone could be obtained from these cadavers besides other cadavers too at this level were only partially decomposed. The bones obtained had lot of macerated muscles and soft tissue adhered to surface. Two intact livers were also found at this depth though shrunken.

[Table/Fig-3]: Bones extracted after burial at 3 feet depth with muscles and soft tissue adhered.

[Table/Fig-4]: Intact embalmed cadaver at depth of 4 feet after 2 years of burial.

The bones obtained till depth of 3 feet, which were relatively clean with scanty muscles attached, were taken for further cleaning. While the bones with bulk of muscles still attached, obtained at 4 feet depth and the two undissected cadavers which failed to decompose were again buried at the depth of 1 feet from surface, to be excavated after 1 year.

Now the bones were taken and soaked in a container with a solution of 20 liters plain water, 500gm detergent powder, 500gm bleaching powder and 500ml hydrogen peroxide. The solution was used for cleaning of two full set of bones (two cadavers). Four such containers were used at a time. The container was covered with a lid and left in the room for a week, at room temperature. On 8th day bones were taken out, rubbed with a rough scrub and washed with plain water and left for drying in open air [Table/Fig-1,2b]. Finally, bones were polished with Varnish. The process was repeated till the stock was over.

The bones so obtained were very good, intact and clean. These were compared with the bones already available in the stock in the department obtained by boiling and maceration method. The results were absolutely at par as was obvious with inspection [Table/Fig-5].

[Table/Fig-5]: Sample of final outcome: Bones after cleaning and varnish.

DISCUSSION

Dry human bones are important material not only for teaching anatomy but also for surgical practice. Various methods causing soft tissue decomposition include:- a) Boiling b) Use of chemicals c) Use of insects d) water decomposition and e) Decomposition by burying in the soil. All these methods lead to complete skeletonization, and except boiling all other methods are effective for medium sized and large animals [5]. Yet another method used in ancient time was hanging of dead to free the cadaver of most of its flesh and to cut out the inner organs without taking apart any joint of the body [6]. Traditional methods of getting bones are very tedious, inconvenient and are not able to meet the requirement of bones if only fresh cadavers are used for this purpose. In one study boiling of embalmed specimen followed by burying under soil gave best results for procuring good quality bones. Standard reported methods for procurement of bones are either boiling or burial.

Some authors have also mentioned the embalmed cadaver not suitable for extraction of bones [7]. On the contrary, few workers have used the embalmed cadavers as well for procurement of bones [5]. It is agreed that decomposition of soft tissue is delayed in embalmed bodies due to presence of formalin but boiling before burial of such specimens leads to enhancement of soft tissue decomposition due to decrease in formalin after boiling [5]. Boiling of the whole embalmed cadaver is a very tedious process and requires manpower. The boiling of the body also causes obnoxious and bad odour all around the medical college campus thus contributing to heavy and hazardous air pollution. So this study did not use boiling of cadavers or bones at any stage. We used normal tap water in the study. The use of boiling water for soaking of bones could have resulted in speedy results in 3-4 days as compared to one week in the present study.

In the present study the embalmed cadavers were buried at different depths in the soil for a period of two years with 2 rainy seasons, however it rained very little in one of

the seasons. Humid weather of rainy season is helpful in accelerating decomposition leading to early skeletonization of specimen/cadaver. Fluctuations in water activity in the soil is one of the most influential factors influencing microbial activity under field conditions [8] and produce a wet-dry cycle consistent with the increased turnover of microbial biomass [9]. Common Salt was sprinkled over the buried cadavers because of its hygroscopic property resulting in wet-dry strata in soil.

The nature of soil was loamy and fine textured in nature. It is reported that the soil texture affects the water content of soils and the oxygen dissolved in the groundwater affects the decomposition reactions [10]. Fine textured soils retain moisture better than sandy or silty soils [11] which results in uniform reducing condition so that anaerobic microorganisms dominate decomposition which are less efficient decomposers than aerobes [12]. Therefore fine textured soils inhibit cadaver breakdown [13]. The coarse texture soil has large pore content that allows gases and moisture to move relatively rapid through the soil matrix [14]. Therefore it is felt that addition of sand to the soil could make it coarse textured, facilitate easy digging and probably given better results.

Generally, decomposition for one week in the air is equivalent to two weeks in water and eight weeks in soil [15]. The time taken by method in present study was 2 years in comparison to one year by burying the cadaver without embalming [5]. It has been reported that cadavers buried in soil usually require one to two years to completely skeletonize [15].

The bones buried at one feet depth were clean though showed signs of resorption or decomposition at the ends while the bones at 2 feet were clean and intact. It has been reported that burying of human cadaver specimens in superficial surface of soil leads to early decomposition due to greater level of biological activity at the surface and in the upper soil layers because of the greater availability of oxygen and food [16]. Thus, the depth of burial will influence the decomposition of organic materials with greater depth impeding decay [17]. It seems that the period of 2 years at depth of 1foot was longer than required for decomposition, while it was sufficient for the depth of 2 feet and shorter for the cadavers buried at depth of 3 feet and much shorter for depth of 4 feet. It is reported that a deep burial below 1 meter (3 feet) will restrict insect and other invertebrate activity [11] and is protected from the temperature fluctuations usually experienced in an ambient environment [18]. Burial at depth may also result in the material being constantly or periodically below a water table, which can restrict oxygen availability and decrease decomposition. Therefore, two cadavers remained almost completely undecomposed at the depth of 4 feet. A working assumption of relationship between depth and duration can be derived i.e. 1 foot for one year, 2 feet for 2 years, 3 feet for 3 years. Deep burial below 3 feet is not advisable for the purpose of bone extraction.

In the study, common detergent was used for cleaning which being an alkali resulted in saponification of soft tissue without decalcification of bone [16,19]. Use of acid for removal of soft tissue makes them brittle because it removes calcium from bones [16]. The chemical nature of bleaching powder resulted in cleaning and whitening the bones. The hydrogen peroxide resulted in speedy decomposition of adhered soft tissues and also added to the bleaching action [20]. Painting with varnish results in shine and luster on the surface of bones. It has also been proved that there is no effect on mechanical properties of bone after storage even if it has been procured from an embalmed specimen. However, in another study [21], it was claimed that embalmment induces significant modifications of the molecular composition of bone and not suitable for Raman spectroscopy studies. Prepared bone specimens were having no decay or fracture and were intact with all normal features.

The approach used in the study is very simple, convenient and economical. However it also has few limitations like the duration required for keeping the bodies buried was two years. The cleaning with chemicals and tap water also took a week. The duration required is much more than the boiling method. So, the institutes, which already have a working stock of bones, can use it. Some of the bones in superficial layer also got broken while digging the soil. The method was useful for extraction of bones in a bulk for undergraduate teaching even with a small burial ground. The cadaver wise isolation and marking of bones could not be done however it could be made possible with due attention and efforts at the time of burying of only few cadavers at a time, and further segregating them at the time of excavation and cleaning. Such precise marking of bones would help in various anthropometric research works.

CONCLUSION

The method used in the study for procurement of bones from an embalmed cadaver was very simple, convenient, eco-friendly and economical. Therefore, preparation of bone specimen from embalmed cadaver can be of immense value for academic institutes to fulfill their demand for teaching anatomy with own limited resources and manpower.

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