IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 5 Ser. 2 (May. 2025), PP 48-51
www.iosrjournals.org

Efficient, Ethical, And Affordable Cadaveric Bone Procurement Technique For Advancing Research Initiatives.

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Abstract:
Background: *Increasing number of medical colleges has led to a persistent shortage of bones for educational and research purposes, prompting reliance on artificial substitute. Despite their utility, artificial bones lack the diversity inherent in actual human bones, posing a significant impediment to effective learning.*
Aims and objectives: *This present study aims to address the bone shortage by presenting an ethical and practical technique for the comprehensive utilization of bones from dissected cadavers.*
Materials and methods: *A previously dissected formalin-fixed cadaver underwent a process involving removal of soft tissue, joint disarticulation, immersion in bleaching powder solution, and treatment with Dranex™. Subsequent steps included immersion in washing powder and hydrogen peroxide solutions, sun drying, and a final application of wood polish.*
Results: *The findings of this study demonstrate the effectiveness of the proposed technique in facilitating bone procurement within 10-30 days. Importantly, this method minimizes defects to the integrity of the bone, preserving its essential properties for optimal utilization for learning and research purposes.*
Conclusion: *By providing a feasible, ethical, and cost-effective method, this study enhances the availability and authenticity of bones for anatomical education and research, contributing to the advancement of medical knowledge.*
Keyword: *osteology, bone procurement, cadaver, anatomy.*

Date of Submission: 01-05-2025 Date of Acceptance: 10-05-2025

I. Introduction

Learning anatomy is a fundamental step in understanding medical sciences, as it forms the very foundation upon which all other medical knowledge is built. Among the various aspects of anatomy, osteology—the study of bones—is particularly crucial. To gain a comprehensive understanding of human osteology, access to a human skeleton is essential. Traditionally, one of the most commonly used methods to procure human skeletons has been the burial method.[1] However, with the growing number of medical colleges and the limited availability of cadavers, it is increasingly impractical to dedicate a cadaver solely for the purpose of obtaining its skeleton.

In recent years, artificial bones have been introduced in many medical colleges as an alternative to real skeletal systems. While these synthetic models serve as useful educational tools, they often lack the authenticity, texture, and variability inherent in natural bones. These limitations significantly reduce their effectiveness, especially when teaching the finer details of osteology. Furthermore, the Indian judiciary system has imposed restrictions on the buying and selling of human bones, further complicating efforts to procure skeletons.[2] For newly established medical colleges, this creates an even greater challenge, as they cannot easily source bones from institutions with surplus supplies.

Another integral component of anatomy education is cadaveric dissection, which allows students to gain hands-on experience with human anatomy. This practice typically involves the use of cadavers preserved in formalin. While this method is invaluable for teaching, the cadavers, once used, are generally disposed of by incineration as biological waste. This is primarily because burial of formalin-fixed cadavers does not facilitate natural decomposition, rendering the recovery of bones from such cadavers impractical.[3]

Given this scenario, it becomes both ethical and efficient to explore alternative ways to utilize these cadavers that would otherwise be discarded as waste. Repurposing them for osteological studies could address the growing need for authentic teaching materials in medical education. Such an approach not only maximizes the use of available resources but also aligns with sustainable and ethical practices in medical science. This would ensure that cadavers, which play a vital role in shaping future medical professionals, continue to serve their purpose to the fullest extent, even after initial dissection exercises are completed.

By embracing innovative methods to address these challenges, the medical education system can ensure that the quality of teaching remains uncompromised, while also respecting the ethical considerations associated with the use of human remains.

II. Materials And Method

A formalin fixed dissected cadaver, basic dissection tools, bleaching powder, washing detergent, a drain cleaner Dranex™ and hydrogen peroxide was used for the study.

a) The cadaver was washed with tap water, and using scissors, scalpel and forceps, soft tissues were removed to the greatest extent possible.

b) Larger joints, including the shoulder joint, elbow, wrist, ankle, temporomandibular joint, and atlanto-occipital joint, were disarticulated.

c) For maceration, these bones was immersed in 20 liters of tap water for a duration of 24 hours. Following this, any remaining soft tissue were removed, and the bones were immersed once again, this time in a 20-liter solution containing 3% chlorine.

To achieve the desired chlorine concentration, 3030 grams of bleaching powder was added to 20 liters of tap water, considering the available chlorine in the bleaching powder as 33%.

The formulation is determined using the formula: [% chlorine desired / % chlorine in bleaching powder] × 1000 = Grams of bleach powder per liter of water.[4]

The bones are left in this solution and check and clean everyday until the soft tissue can be easily separated from the bones.

d) For degreasing process, the bones, now free of as much soft tissue as possible, were submerged in a 20-liter water solution containing 500 grams of washing detergent for 24 hours.

e) With proper precautions a drain cleaner, Dranex™, which contains highly concentrated sulphuric acid along with other chemicals, was applied to those portions of the bone where soft tissues were still present.

By pouring small drops of water over the powder, a chemical reaction is induced that reacts with the soft tissue, causing the tissues to dissolve.

f) The bones will be cleaned with tap water and left to air dry overnight, followed by sun drying until properly dried.

g) Finally, varnish paint was applied over each bone using a brush to give a more polished look and prevent any infestation. The bones were then left to air dried.

Fig 1: showing a formalin fixed dissected cadaver and detached skull before immersing in water.

**Fig 2: showing flat bone and long bone after removal from 3% chlorine solution.
and a skull bone being treated with Dranex.**

III. Results

The bone such obtained are clean and odour free without any greasiness and can be used for teaching proposes.

Scapula: being a flat and thin bone, it was kept in the chlorine solution for 8 hours only, keeping for 12 hours causes perforation of the subscapular fossa. The borders and processes of the scapula with several muscles attachment need to be cleaned with Dranex for several time avoiding the fossa part. The bone processing was completed by 10 days.

Long bones: rather easy to clean, kept in the chlorine solution for 3 days with cleaning every 24 hours. Use of Dranex was mildly need only over some part of muscle attachment area. Completed the whole process by 15 days.

Small bones: difficult to disarticulate (carpals, metacarpals, phalanges, tarsals, metatarsals, vertebrae). Kept in chlorine solution for 7 days with regular soft tissue cleaning every 24 hours. Dranex was applied over the disarticulated bone which make it easier to disarticulate and after multiple application of around 4-5 times individual bones were collected. The whole process was complete in 20 days.

Skull: most complicated. Kept in chlorine solution for 10 days with daily cleaning. The vault and mandible were easy to clean. Dranex powder had to be used multiple times. The whole process took around 30 days.

Table 1: showing total times required to procured different categories of bone using the method.

Category	Bone	Chlorine solution	Dranex powder	Drying	Total no of days
1. Flat	Scapula	8 hours	multiple	3 days	7 days
2. Long	all	3 days	few	7 days	14 days
3. Small	all	7 days	multiple	3-5 days	14-17 days
4. Skull	Cranial base	10 days	multiple	8 days	21 days
	Calvarium	1 day	Not required	3 days	7 days
	Mandible	3 days	few	5 days	10 days

Fig 3: CATEGORY 1 (FLAT BONE)

Fig 4: CATEGORY 2 (LONG BONES)

Fig5: CATEGORY 3 (SMALL BONES)

Fig 6: CATEGORY 4 (SKULL BONE)

IV. DISCUSSION

This research explores the suitability of bones obtained from formalin-fixed cadavers for anatomy teaching and research.

Some authors[5,6] argue that such bones lack both external and internal integrities, while others[7,8,9] found no such deformities.

Our study found no observable external changes. However, the bone integrity appeared fragile, with a tendency for cortex breakaway during ligament detachment.

Existing research[10] often focuses on bones recovered from sand or soil pits, requiring prolonged maceration for soft tissue removal. However, Bones from our institute's sand pit exhibited a dark color and fragility.

Efforts to expedite the cleaning process have been explored, such as the use of higher concentrations of chlorine solutions (50%, 70%, and 90%)[11]. However, the increased quantity of bleaching powder required poses a cost challenge.

Aridam D and William PS[12] suggested the effective use of 3% chlorine solution for soft tissue removal, softening the tissues for easier manual extraction.

Leeper BJ[13] identified a commercially available sink cleaner, Clorox, as effective in soft tissue removal. Due to cost considerations, we combined the techniques aiming to reduce both cost and cleaning time.

V. Conclusion

This study proposes an efficient and economical method for obtaining clean and usable bones from dissected formalin-fixed cadavers, addressing the challenges faced by medical colleges in acquiring anatomical specimens for educational purposes. The results demonstrate the feasibility of this approach, offering a practical solution for institutions facing limitations in bone procurement.

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