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A CROSS-SECTIONAL STUDY ON TECHNIQUE FOR REMOVAL OF EAR OSSICLES: A DIAGONAL CORONAL SECTION METHOD.

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ABSTRACT

Background
The retrieval of intact ear ossicles (malleus, incus, and stapes) from the temporal bone is crucial for anatomical studies, implant design, and educational purposes. Previous techniques have been laborious, destructive, and required advanced equipment, making the process challenging, especially for the fragile stapes. The present study is undertaken to retrieve the ossicles intact from the temporal bone to measure the various parameters of these ossicles in the North Indian population for designing and constructing the implants.

Methods
A cross-sectional study was conducted on 50 male and 50 female cadavers from North India. A diagonal coronal section technique was employed to retrieve 200 ear ossicles from temporal bones, aiming for a minimally destructive approach. This technique allowed precise extraction with less damage than traditional methods, particularly beneficial for preserving the delicate structure of the stapes.

Results
The diagonal coronal section method successfully extracted complete ossicle sets with minimal damage. The study verified that this technique is effective and reliable for intact ossicle retrieval, enhancing anatomical understanding and aiding in implant development for the North Indian population.

Conclusion
This approach is less destructive and allows for easy retrieval of ear ossicles. The technique is highly reliable and preserves the anatomical integrity of these bones, especially the fragile stapes, making it suitable for educational and research applications.

Recommendation
The diagonal coronal section method is recommended as a standard procedure for extracting ear ossicles. It is instrumental in both educational settings for medical students and in research for developing otological implants.

Keywords: *Ear ossicles, Diagonal coronal section, Ossicle retrieval, Temporal bone, Stapes, Implant design, Anatomical Education*
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INTRODUCTION

The tympanic cavity contains a chain of auditory ossicles in humans -malleus, incus, and stapes, which are well protected in this cavity. However, retrieval of these tiny bones has always been challenging without disturbing the normal anatomy of the tympanic cavity, a part of the temporal bone. So, human temporal bones provide an irreplaceable source for the study of ossicles and related structures. Harvesting intact temporal bone specimens from human cadavers is a technically challenging process that is invaluable in the education of medical students, otolaryngology& neurosurgery residents, and fellows (1).

There are various methods of middle ear dissection and removal of temporal bone specimens from cadavers. The few most common methods are described in the textbooks of Anatomy (2). To reveal the middle ear, one of the most popular techniques is the Piecemeal Removal of the Bone, which entails breaking the bone into fragments. However, all of the previous approaches were laborious, time-consuming, and required highly advanced equipment, such as an electric autopsy saw (3).

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The current study aimed to remove the intact ossicles from the temporal bone to measure the different ossicle properties in the North Indian population for implant design and construction. This study's approach to retrieving the ossicles—particularly the stapes, the most delicate bone—is simple and dependable.

MATERIAL & METHOD

Study Design

This study was a cross-sectional analysis.

Study Setting

The study was conducted across multiple medical colleges in North India. The colleges included Guru Gobind Singh Medical College, Faridkot; Government Medical College, Patiala; Government Medical College, Amritsar; Punjab Institute of Medical Sciences, Jalandhar; Government Medical College, Chandigarh PGI, Chandigarh. Cadavers were sourced from the anatomy departments of these institutions, providing a diverse set of temporal bones for ossicle retrieval.

Participants

The study involved 50 male and 50 female cadavers, with no specific exclusion criteria related to age or health conditions at the time of death. The inclusion criterion was the availability of intact temporal bones, suitable for dissection and ossicle retrieval. Only cadavers from the North Indian population were included to ensure consistency in anatomical measurements for regional implant design.

Data Sources/Measurement

Data collection involved the extraction and preservation of ear ossicles (malleus, incus, and stapes) from cadavers. Each temporal bone was dissected using a diagonal coronal section technique, which divided the skull into medial and lateral halves. Ossicles were measured and stored in labeled plastic pouches with identifiers for cadaver number, side, and gender. The technique was documented with visual aids, including labeled diagrams and photographs, to capture procedural steps and landmarks. The method of retrieval of tiny bones involved the following steps.

First of all, the calvaria were removed at about 6m above the external auditory canal with the help of a hand saw, hammer, and chisel (fig 1). This exposed the brain and then the brain was removed carefully, after incising the tentorium which elevated the cerebellum along the cerebrum. All the cranial nerves were amputated using a scalpel and the brainstem was cut. This subsequently exposed the cranial skull cavity.

Fig 1: Head and neck specimen after removing calvaria

The skull was then cut sagittally into two halves for easy handling of the specimen (fig 2).

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Fig 2: The skull sectioned sagittally

The following bony landmarks were marked and recognized; (fig 3)
As a petrous part of the temporal bone
As arcuate eminence
As tegmen tympani

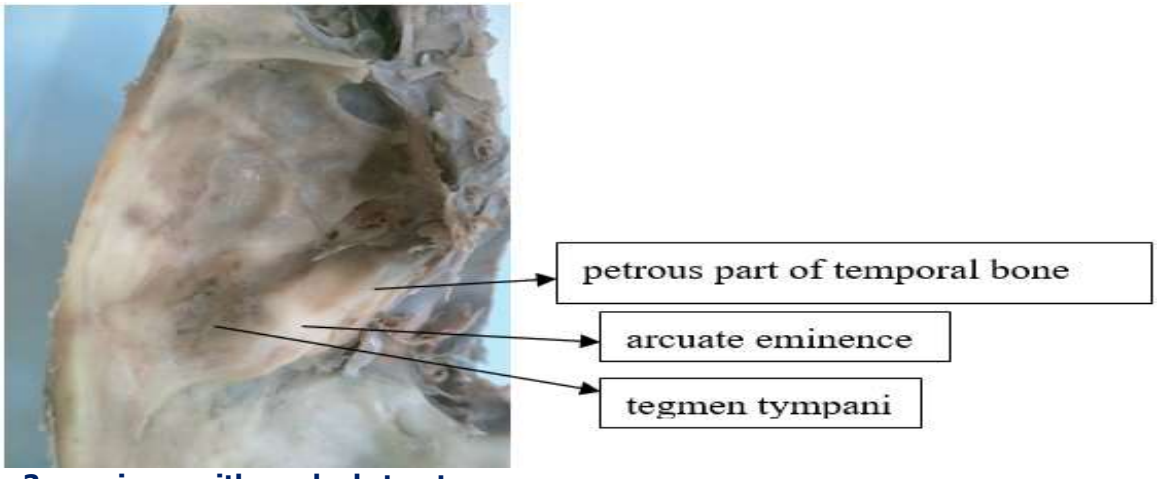

Fig 3: specimen with marked structures

The chisel was placed between the arcuate eminence and tegmen tympani, which cracked out the small chip of bone by a gentle hit. The chip of bone was removed, under which lay the malleoincus joint (fig 4). Tegmen tympani was removed with the help of toothed forceps to make a wider view (fig 5). The first bone to be extracted was the incus; the easiest one to be moved with the help of forceps by disarticulating incudomalleal and incudostapedial joints. Next was the malleus, after chipping it off from the tympanic membrane as its handle is attached to the tympanic membrane and cutting off the chorda tympani.

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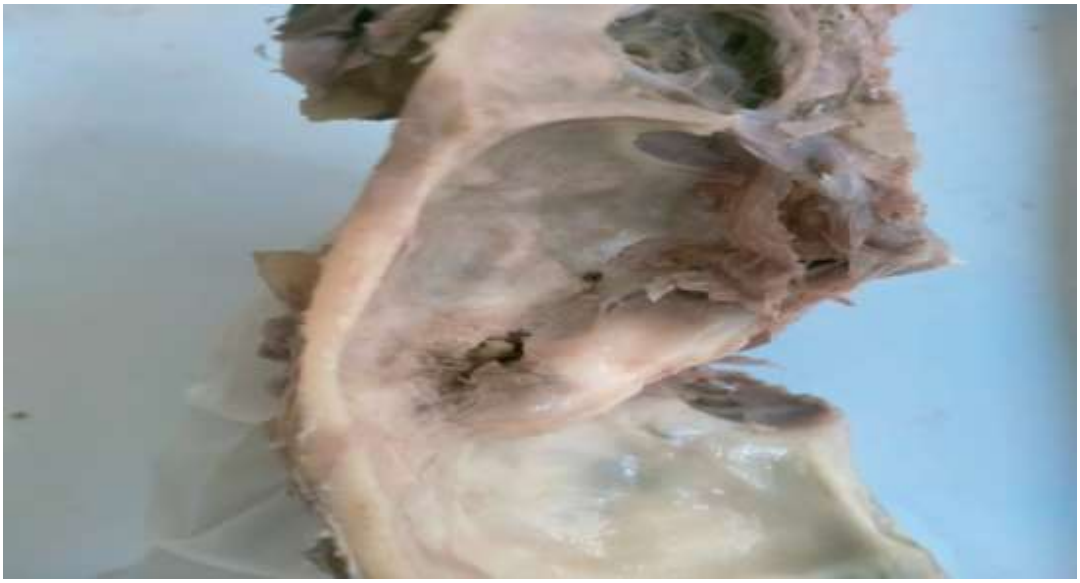

Fig 4: Malleoincus joint visible after the removal of the chip of bone

Fig 5: Malleoincus joint visible after the removal of the chip of bone (closer view)

For the removal of stapes, a diagonal coronal section is taken across the skull to divide the skull into medial& lateral parts with the help of a band saw machine (fig 6). The medial portion of the bone contained the third ossicle, the stapes (fig.7)

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Fig.6: Diagonal coronal section taken after removal of two tiny bones

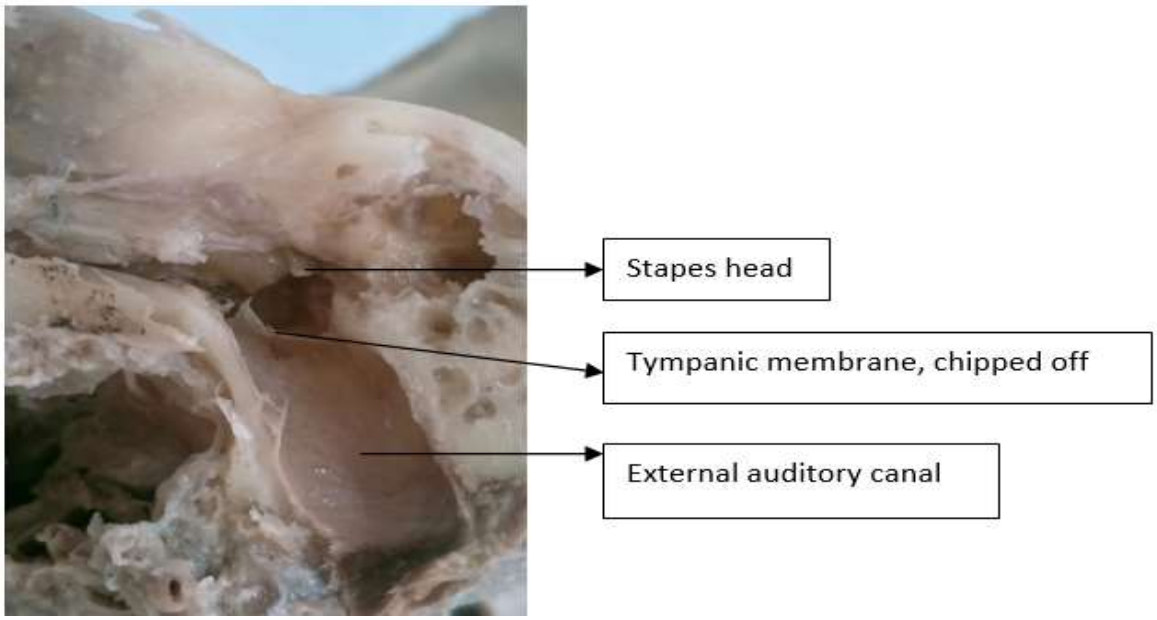

Fig 7: Stapes visible in the medial part of the skull after taking the section

It was taken out with great caution as it is attached to an oval window. It was retrieved by gentle manipulation with the help of sharp forceps, lifting from one side, after breaking the tendon of the stapedius muscle that is attached to the neck of the stapes. Care was exercised while removing stapes as its footplate and cruras were thin & delicate. The three bones were cleaned & dried. All the ossicles thus obtained were put into plastic sachet bags with a zip-locking mechanism. These pouches were assigned serial numbers, sides, and gender.

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Fig 8: Band saw

Fig 9: Instruments used in the study

Statistical Methods

The study primarily utilized descriptive statistics to analyze the success rate of intact ossicle retrieval and the relative ease of extraction for each ossicle type. Data were analyzed to determine the effectiveness and reliability of the diagonal coronal section method compared to more traditional techniques, with specific attention to any cases of bone fragmentation, particularly of the stapes.

Ethical Considerations

The study received ethical clearance from the institutional review board of each participating medical college. Ethical guidelines were adhered to throughout the study, including anonymizing cadaver details and obtaining prior ethical approval for human tissue handling.

RESULTS

The study successfully retrieved 200 complete sets of ear ossicles from 100 cadavers (50 male and 50 female) using the diagonal coronal section technique. The retrieval process preserved the structural integrity of the ossicles, particularly the stapes, which are typically vulnerable to damage during extraction.

Ossicle Retrieval Success Rate

The diagonal coronal section technique proved effective, with an almost 100% success rate in retrieving intact ossicles across both male and female cadavers. The method enabled the preservation of all three ossicles — malleus, incus, and stapes — in each set, making it feasible for anatomical and implant design applications.

Reliability and Ease of Extraction

The diagonal coronal section technique provided a straightforward approach to ossicle extraction, with minimal bone fragmentation observed. The method was particularly advantageous for extracting the stapes, which remained intact in nearly all cases due to the reduced risk of breakage afforded by this technique.

Storage and Labeling

Each ossicle set was securely stored in labeled plastic pouches, providing a well-organized system for future anatomical study or implant design research. The labeling system documented the cadaver number, side, and gender, which will assist in comparative anatomical studies across different demographic groups.

DISCUSSION

The study results demonstrate that the diagonal coronal section technique is a highly effective and less invasive method for retrieving intact ear ossicles, specifically designed to minimize damage to these delicate structures. By preserving the integrity of the malleus, incus, and especially the fragile stapes, the technique achieved a near 100% success rate in extracting complete ossicle sets from both male and female cadavers. This high success rate addresses a major challenge in anatomical studies of the temporal bone, where traditional methods often lead to fragmentation or damage, particularly of the stapes. These

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results indicate that the diagonal coronal section technique not only meets the primary objective of retrieving complete ossicles but also does so in a manner that maintains their anatomical integrity, making them suitable for further study.

The reliable preservation of the stapes is a notable finding, as this bone is prone to damage due to its thin and fragile structure. Previous methods often compromised the stapes, limiting their usefulness in anatomical education and research. In contrast, the diagonal coronal section technique offers a safer alternative, allowing the stapes to be extracted intact in almost every case. This success underscores the technique's suitability for preserving even the most delicate structures in the middle ear, providing valuable specimens for teaching medical students, as well as for designing ear implants that require precise measurements of ossicle dimensions. The reduced risk of damage enhances the potential for accurate anatomical analysis and implant construction, supporting the study's goal of contributing to otological research and education.

Additionally, the systematic storage and labeling of each ossicle set in identified plastic pouches allows for organized data collection, critical for conducting demographic or comparative studies on ossicle characteristics in the North Indian population. By documenting the cadaver number, side, and gender, this approach also ensures that future research can readily identify and analyze ossicle sets. This level of organization adds value to the study's findings, facilitating comparative research that could help refine implant designs to better suit anatomical variations within specific populations.
Overall, the study's findings suggest that the diagonal coronal section method is a reliable and minimally destructive approach to ossicle extraction. This technique aligns well with the study's objectives by enabling efficient retrieval of ossicles with minimal fragmentation, meeting both anatomical and clinical needs. It represents a practical advancement over traditional methods, as it allows for the safe extraction of intact ossicles, which are essential for otological research, educational purposes, and implant development.

The anatomical knowledge of temporal bone and middle ear ossicles is very important for medical students, ENT trainees, and various research purposes. An essential way of learning temporal bone anatomy & surgical technique is through repeated dissections (4). The combination of surgical experience and laboratory cadaveric dissection has resulted the excellent quality in otologists (5). Keigl et al(6)claimed that practice improves outcomes. Repetitive cadaveric dissection is needed for a successful outcome. There are various methods described in the textbooks of Anatomy (2). The most common is the traditional block method as described in ENT books.

In another technique, called as modified block method, four bony cuts were made through the dorsum sella, midsagittal plane & oblique planes in the right & left posterior cranial fossae; to extract temporal bone for further use (7), whereas in the skull base block method (8), the first bony cut was made in the midsagittal plane from the optic foramen to the occipital bone, proceeding inferiorly to the second cervical vertebra. The second bony cut was made in the coronal plane at the level of the optic foramen spanning the lateral aspects of left and right temporal bones. Here the bilateral temporal bone specimens were extracted using these bony cuts. The comparatively large specimens were extracted by this method which were claimed to be more suitable for studying the complexity, utility, and limitations of various approaches of lateral and posterolateral skull bases that are important for surgical planning.
The epitympatic diaphragm, Prussak's space & middle ear anatomy is best described by Marchoini et al(9) where the structures can be visualized by endoscopic dissection that allows good visualization of the epitympanic diaphragm but this technique requires very sophisticated instruments.-

Jewelers cut method (10) described by Baneswar et al, claimed to be the least destructive method of piecemeal dissection as compared to traditional methods of piecemeal removal of bone. First, the temporal bone was removed from the skull by cutting the zygomatico-temporal suture and parieto-temporal suture. Later, the bone was cut with a jeweler's saw in the vertical plane, dividing it into two halves to extract the ossicles.
Cobber's cut method (11), a cut is made between squamous & petrous parts of bone with the help of a chisel making a crack labeled as a cobbler's cut. Then precise and gentle manual force is applied between these two parts and is separated into two unequal halves, passing through the incudostapedial joint.

The technique used in the present study is a diagonal coronal section with the help of a band saw (fig 8), which proves to be very reliable for extracting the ossicles and even less destructive method than other methods. With this technique, the skull was cut into medial and lateral halves, after extracting out the tiny bones. The two halves were also used to study various other features like the facial canal, canal for tensor tympani, oval window, promontory, mastoid air cells, mastoid antrum, aditus, and pyramid.
So, this method is suggested as a routine procedure for extracting the tiny bones as this is the least destructive and can be used to learn the anatomy of the temporal bone which will enhance the knowledge of undergraduates as well as ENT aspirants.

GENERALIZABILITY

The findings of this study have promising implications for broader application in anatomical research and clinical practice, particularly in regions beyond North India. While the technique was tested on cadavers from this specific population, the diagonal coronal section method's simplicity, minimal destructiveness, and high success rate in preserving intact ossicles make it likely adaptable to other populations and settings. Its use could extend to various medical education and research contexts globally, as the anatomical structures involved are generally consistent across human populations. However, further validation in diverse populations would enhance the method's generalizability, ensuring its effectiveness and reliability across different demographic groups and anatomical variations.

CONCLUSION

The method proves to be the easiest; least destructive and most reliable method to retrieve the three ossicles intact; which can be used for further research purposes and learning material for medical students.

LIMITATIONS

A primary limitation of the study is its focus solely on cadavers from the North Indian population, which may limit the applicability of findings to other populations. Additionally, the technique's effectiveness in varied anatomical or pathological conditions was not assessed, warranting further validation.

RECOMMENDATIONS

Based on the findings of this study, the diagonal coronal section technique is recommended as a standard procedure for extracting intact ossicles. This method is advantageous due to its ease, reliability, and minimal destructiveness, making it suitable for both research and educational purposes. It allows the delicate structures of the ossicles, especially the stapes, to be preserved for measurement and implant design, enhancing anatomical understanding for medical students and ENT professionals. Adopting this technique can improve the quality of anatomical education and otological research.

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LIST OF ABBREVIATIONS

ENT: Ear, Nose, and Throat

Fig.: Figure

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No funding was received.

CONFLICT OF INTEREST

The authors have no conflicting interests to declare.

AUTHORS CONTRIBUTION

Dr. Bhavna, 2nd author helped in the measurement and retrieval of bones
Dr. Khayati, 3rd author, helped in writing and framing the article

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