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Original Article

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3D Anatomage™ as a Supplement in Learning Tracheostomy among Otorhinolaryngology and Head Neck Residents

Anil Kumar Harugop[1], Rajesh Radhakrishna Havaldar[2], Rahul Gulaganji[3] Mansi A R Venkatramanan[4], Abhijit S Gogate[5]

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Abstract

Tracheostomy is a tricky procedure but very crucial for ENT surgeons to master. Medical colleges use innovative tools to implement the teaching of anatomy to students and one such tool is the 3D Anatomage™ table which is a fully segmented touch interactive real human 3D anatomy platform that helps to visualize human anatomy just as it can be seen on a fresh cadaver. This study is based on advanced clinical skills program that was conducted for 26 ENT residents whose knowledge was assessed before and after the training and a feedback was taken to assess the usefulness of 3D Anatomage™. After the Module, an average of 23 students found it useful and superior to the old fashioned mannequin method of demonstration; 22 students showed significant improvement in knowledge and skills.

Keywords: 3D Anatomage™; Virtual Dissection; Tracheostomy.

INTRODUCTION

In recent years, technology has driven its way into almost all areas making the quality of life easier. It has also become a major tool in teaching students from kindergarten till university. One such use of technology is 3D Anatomage™ which has made its way in making the concepts of anatomy easier in medical colleges particularly in teaching complicated anatomy of the human body to medical students.[1] Cadaveric dissection helps the students to touch and feel the organs to understand the anatomy and also the related nearby structures.[2,3] In resource poor settings where availability of cadavers is less due to lesser donated bodies and higher costs, the virtual anatomy learning table 3D Anatomage™ is a valuable tool.[1] 3D Anatomage™ is envisioned by a firm in California in collaboration with the Stanford Clinical Anatomy Department. It involves 3-dimensional reconstruction of stereoscopic images of different body parts. Different body parts can be displayed layer by layer to study muscles, bones, organs, nerves and blood vessels. Also, different parts can be studied in all planes, thus understanding the relationship between various structures. With an integrated imaging technology, students are able to understand imaging of the structures side by side with the gross description of the body parts. Since it's a digital platform, the structures can be seen repeatedly any number of times unlike conventional dissection wherein each dissected can be carried out only once.[4-6]

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MATERIALS AND METHODS

This study was conducted to assess the knowledge of Post Graduate students pursuing Otorhinolaryngology course. The site was advanced Clinical Skills Lab attached to a medical college in North Karnataka. 26 students were selected. A pre-test Google form questionnaire (https://forms.gle/mkdV48Ss8bgWic2G8) was designed to assess their knowledge regarding tracheostomy and this was followed by a brief training module educating them regarding tracheostomy by demonstration of the relevant anatomy using 3D Anatomage™ table by a senior faculty who also stressed upon the clinical applications of the same. After this, a post-test Google form questionnaire (https://forms.gle/U7QXYBAaoMGv4a3a9) was given to the students and the results were compared.

The study was exempt from Institutional Ethics Committee clearance; however, a prior permission was taken from Academic Director, Advanced Skills Lab dated 13/04/2022. All students who participated in the study gave consent for the same.

A total of 12 questions were used to assess the knowledge of the students before and after the training module. (Appendix 1)

RESULTS

Figure 1 shows the question wise analysis of responses wherein it is clear that the candidates benefitted by the training module. The average correct answers scored by each candidate improved by 11%. Using paired t-test, the results were found to be statistically significant p-value. Some candidates showed an improvement by almost 35%.

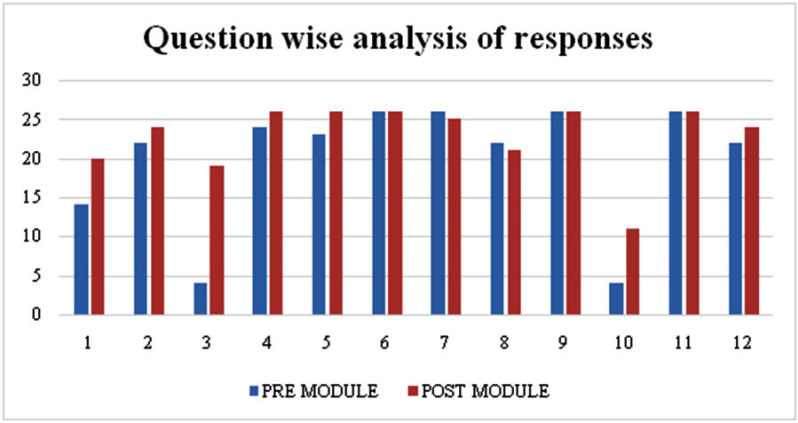

Fig. 1: Question wise analysis of responses

Table 1 shows the feedback received by the candidates with respect to their experience with the 3D Anatomage™ table. It is clear that 3D Anatomage™ table is a valuable tool to supplement their learning.

Fig. 2 shows that each of the candidates benefitted from the training module. Among the 26 candidates, 22 candidates showed improvement in the test scores after the module, 1 candidate who performed the same and 3 candidates who did not show any improvement. Using paired t-test, the results were found to be statistically significant p-value.

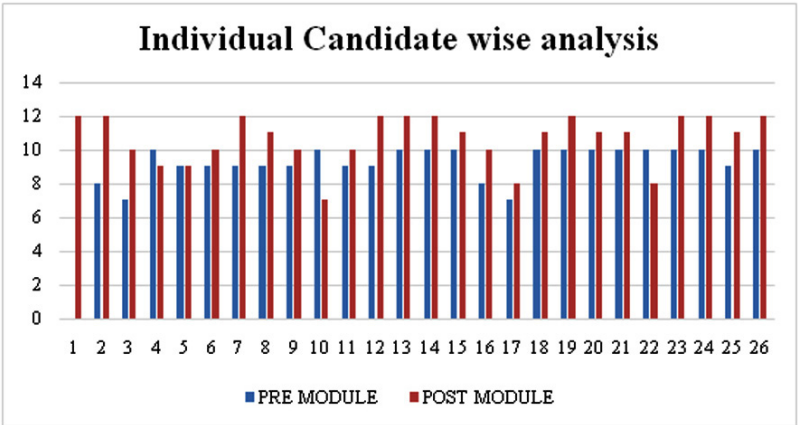

Fig. 2: Individual candidate wise analysis of responses

Table 1: Feedback received from the candidates

Using paired t-test, the results were found to be statistically significant with a p-value of	1. Do you find 3D Anatomage as an addition to simulation mannequin is helpful in learning for surgical anatomy of trachea for tracheostomy.	2. Did you benefit from applying 3D Anatomage in learning the anatomy of trachea?	3. Do you feel that simulation mannequin is more superior to 3D Anatomage	4. Do you feel using 3D Anatomage helps in learning surgical anatomy of trachea and its related structures in all possible planes?	5. For future simulation simulation studies, do you feel using 3D Anatomage as a supplement is useful to enhance gross learning of the subject?
Yes	25	25	17	24	24
No	1	0	2	0	1
Maybe	0	1	7	2	1

DISCUSSION

In today's world of technological advancement, students prefer to learn concepts when it is supplemented by good use of technology.[7-8] The use of novel ideas to teach explain the greater understanding of the students of the complicated anatomy and also the clarity in appreciating three-dimensional visualization of structures over two-dimensional images in books.[9] Due to the unlimited use, the cost of procuring cadavers and embalming them is completely negated using Anatomage™. Also, there is no issue regarding the disposal of cadavers using this technology. The in-depth understanding is supplemented by the fact that each structure can be visualised in all planes by the student thus understanding relations to other structures easier. Also, the integration of radiology with the gross images side by side makes application of knowledge gained in the advanced skills lab into clinical practice easier.[1] A few disadvantages that could be appreciated by the students is that variations in normal anatomy cannot be learnt using Anatomage™. Also, the normal feel of the tissues is not possible using this technology.[10,11] The present study was aimed to evaluate how well students understandinmg of concepts related to tracheostomy was better understood by using 3D Anatomage™ as a supplementary tool in their understanding of the surgical anatomy. We are also of the opinion that since this is an interactive device, it would encourage self-dependent study and foster team work and inter personal skills development amongst students.

CONCLUSION

3D Anatomage™ virtual dissection table is useful to learn anatomy and its use as a supplement to cadaveric dissection is beneficial to students. The wider use of its repeatability, accessibility, ease and interactive nature of use, integrative radiology, multi-planar understanding of structures and its relations is beyond doubt a boon to the students. We need to conduct further studies to evaluate if the knowledge gained through the usage of 3D Anatomage™ can be retained for a longer time as against the knowledge gained by cadaveric dissection. Also, we need to conduct similar studies across undergraduate and super specialty course students to assess its applicability across all student populations in a medical college.

APPENDIX- 1

A total of 12 questions were used to assess the knowledge of the students before and after the training module. The questions were as follows:

1. Which type of incision is taken in case of emergency tracheostomy?
   - Vertical Incision below the Cricoid
   - Vertical Incision above the Cricoid
   - Horizontal Incision below the Cricoid
   - Horizontal Incision above the Cricoid
2. Which of the following is not a Strap muscle?
   - Sternohyoid
   - Sternothyroid
   - Omohyoid
   - Thyrohyoid
   - Cricothyroid
3. Which of the following is not a part of tracheostomy set?
   - Trousseau dilator
   - Allis forceps
   - Langenbeck retractors
   - Skin hooks

4. Which number blade is used for creating Tracheal window?

- No. 11
- No. 12
- No. 13
- No. 15

5. Tracheal window is created at what level?

- At 1st tracheal ring
- Between 1st and 2nd tracheal rings
- Between 2nd & 3rd tracheal ring
- At 2nd tracheal ring

6. Which of the following is not an Immediate Complication?

- Primary Hemorrhage
- Aspiration of blood
- Air embolism
- Tracheo-oesophageal fistula

7. Which among the following tubes come with an inflatable cuff

- Portex Tracheostomy Tube
- Jackson tracheostomy tube
- Fuller bivalved tracheostomy tube
- Negus tracheostomy tube

8. A high tracheostomy is done at

- Above thyroid isthmus
- Behind thyroid isthmus
- Below thyroid isthmus
- At the level of thyroid isthmus

9. At what position is the patient kept while performing a tracheostomy?

- Neck extended with a shoulder roll.
- Hyperextend neck
- Rose position
- 30 degree head end elevation

10. Which of the following is not an indication for tracheostomy?

- Retained secretion
- Respiratory obstruction
- Respiratory Insufficiency
- All of the above

11. Which of the following is not a late complication of tracheostomy

- Subglottic stenosis
- Tracheal stenosis
- Persistent tracheo-cutaneous fistula
- None of the above

12. Functions of Tracheostomy include

- Relieves upper airway obstruction
- Improves alveolar ventilation by decreasing dead space
- Administration of anesthesia
- All of the Above

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Original Article

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Comparison of Frequency Specific Hearing Thresholds Between Pure Tone Audiometry and Auditory Steady State Response

Ripal Barot [1], Swathi A[2], Neeta Sharma[3], Prachi Mene[4], Ashwin Ashok Jaiswal[5], Adarsh A S[6]

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Abstract

Hearing is one of the fundamental senses. It connects individual to the outside world, through communicate in a way that none of the other senses can achieve. Pure tone audiometry and auditory steady state response are audiological tests to evaluate hearing thresholds on an individual enabling in determination of the degree, type and configuration of hearing loss. At present, Pure tone audiometry (PTA) is the gold standard for the evaluation of hearing levels. Audiometers are used to make quantitative measurements of pure-tone air and bone conduction thresholds. However, it is not possible to obtain reliable thresholds with PTA in all patients. [1,2]

Auditory steady state response (ASSR) testing is a newly developed measurement of auditory evoked potentials it can be used to objectively for predicting frequency specific hearing thresholds. ASSR measurements also detects automatic response and that feature is attractive in that it avoids problems associated with the experience and expertise of the observer[3]

Result: Among the 51 patients we found out very strong correlation between PTA and ASSR measurements at all the four frequencies were found between Normal and SNHL groups. However, in CHL group, there was no correlation between PTA and ASSR measurements at 500 Hz and 1000 Hz.

Conclusion: ASSR was able to detect thresholds at about 5 dB higher than that of PTA in both the ears in normal hearing patients at all frequencies.We conclude that ASSR testing can be an excellent complement to other diagnostic methods to serve as a valuable tool in the determination of hearing thresholds

Keywords: PTA; ASSR; Audiological Test; Hearing Loss; SNHL; CHL.

INTRODUCTION

Communication is vital for effective execution of everyday activities and significant interaction in lack of which, it might be very tough for the human beings to share thoughts and express themselves. Being one of the five special senses, it is particularly special as it is the sense that allows the people to communicate with other.[2] Therefore, injury to hearing can disrupt communication and substantially affect a person's ability to carry out the daily activities. Hearing loss affects over 466 million individuals, causing some level of impairment. This amount equates to more than 6% of the world's population. In India, approximately 63 million people everyone has significant auditory impairment, 3 with ear wax (15.9%), chronic suppurative otitis media (5.2%), otitis media with effusion (3%), dry perforation (0.5%), congenital deafness (0.2%), and other non-infectious unknown causes (10.3%) such as presbycusis. Audiologic testing is performed for assessing the hearing thresholds throughout the spectrum of frequencies that are important for human communication.

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Auditory thresholds are usually measured for air as well as bone conducted pure tone stimuli in order to differentiate the conductive hearing loss from sensorineural hearing loss, so as to characterize the pattern of hearing impairment at various frequencies. Pure tone audiometry (PTA) is regarded the gold standard approach for evaluating hearing frequencies among the several audiometric procedures used for determining hearing thresholds.[3] On the other hand, auditory steady state response (ASSR) testing is a recently established assessment of auditory evoked potentials that may be used objectively to estimate frequency specific hearing thresholds. In ASSR, pure tone sounds are used as the stimulus. wherein it is modulated, both with respect to its amplitude and frequency. Modulation of a pure tone sound stimulus decreases the spectral splatter, thus stimulating specific, restricted and narrow area of the basilar membrane. If the rate of modulation is higher than 60 Hz, the neural activity is recorded from the brain stem. The response detection in the frequency domain assures us that the ASSRs are detected objectively. Detection is not based on subjective visual examinations of the waveforms or response patterns as in case with PTA.

It is crucial to assess both audiometric techniques in terms of their accuracy in identifying frequency thresholds in persons with hearing loss. This would improve the technique for examining a person who has complained of hearing loss in order to provide prompt assistance. With this background in mind, we want to see how pure tone audiometry and auditory steady state response compare in terms of frequency specific hearing thresholds.

SELECTION OF PATIENTS

INCLUSION CRITERIA: 1. Patients who will attend the OPD to Jawaharlal Nehru hospital and research centre, ENT & Head and Neck surgery department, with ear related complaints will be the probable subject of my study.[2] Patients who are in the age group of 12 to 60 years. (PTA & ASSR can be done in adolescents and adults, and there is increase in prevalence of hearing loss in those age group so we have included the above age group for our study.)[3] Patients who are willing to participate in the study.

EXCLUSION CRITERIA: 1. Chronic otitis media 2. Otitis media with effusion 3. Otitis externa 4. H/O operated ear 5. Patients less than 12 years and above 60 years. 6. Patients who do not give consent for study.

METHOLOGY

The 51 patients were subjected to thoroughly clinical examination and audiological examinations by PTA and ASSR. We divided the patients into 3 groups. Group 1 with normal hearing patient, group 2 with conductive hearing loss and group 3 with sensory neural hearing loss.

The PTA was done with Elkon 3N3 Multi pure tone Audiometer. For evaluation and statistical purposes, thresholds were measured at 500, 1000, 2000, and 4000 Hz. ASSR will be done with Neuro Audio (V.2010) Multi-ASSR and measurements was recorded. Participants were tested while they are awake and in a relaxed supine position. Registration electrodes were placed over both mastoid bones at the hairline and on the low forehead. Air-conducted stimuli were presented via inserted earphones. Test frequencies of 500, 1000, 2000, and 4000Hz were used as ASSR carrier stimuli. The four carrier frequencies were delivered simultaneously to both ears. These frequencies were modulated with respect to amplitude and frequency. A 100% amplitude modulation, 20% frequency modulation and 90Hz modulation rate was used. Analysis of data was done.

Criteria for hearing assessment: These patients are categorized as having conductive and Sensor ineural hearing impairment. The degree of hearing impairment is assessing by WHO classification of hearing loss.

Normal hearing–< or =25 Db

Mild = 26–40 dB

Moderate= 41– 55 dB

Moderatly Severe = 56 – 70 dB

Severe = 71–90 dB

Profund => 90 dB

RESULT

The data collection started from November 2020 till August 2021. 51 patients were analysed in our study.

- In our study, 2/3 rd patients 34 (66.6%) were from 41–60 yrs of age. 7 (13.7%) patients were less than 20 years of age and 5 patients each were from 21–30 and 31–40 years of age. The Sex distribution was 27 males and 24 females in the study. We observed that 30 (58.8%) patients were suffering from SNHL while only 4 were suffering from conductive hearing loss excluding COM, *i.e.* with intact TM. However

17 patients had Normal hearing.

- One Way Anova comparison between Types of Hearing Status on the basis of difference between ASSR and PTA at different levels frequencies in Right Ear amongst 51 patients. Mean threshold levels between both the tests were compared to each other with the same patients in their right ear at 500Hz, 1000Hz, 2000Hz, and 4000Hz (Table 14). The mean threshold levels amongst normal (n=17) individuals by PTA at 500, 1000, 2000, and 4000Hz were 4.7±2.8, 4.4±3, 3.5±4.9 and 3.8±3.3 respectively. The mean threshold levels amongst CHL (n=4) by PTA at 500, 1000, 2000, and 4000 Hz were 2.5±2.9, 5±0, 5±4.1 and 5±4.1 respectively. The mean threshold levels amongst SNHL (n=30) individuals by PTA at 500, 1000, 2000, and 4000Hz were 9±6.5, 10±6.7, 8±6.2 and 8±4.7 respectively. The three groups differ significantly in the one way anova comparison. Nevertheless, normal and CHL group were comparable to each other at all four frequencies on the basis of difference between PTA and ASSR. (p>0.05). Similarly, SNHL and CHL group were comparable to each other at all four frequencies on the basis of difference between PTA and ASSR (p>0.05). The SNHL group has higher threshold than patients with normal hearing at all the frequencies. (Table: 1)

Table 1: One Way Anova comparison between types of hearings tatuson the difference between PTA and ASSR at different levels frequencies righ tear

	Normal		CHL		SNHL		Total		F	p value	Mean difference			p value		
	Mean	S D	Mean	S D	Mean	S D	Mean	S D			A – B	A– C	B– C	A – B	A – C	B- C
Difference (PTA-ASSR) (RE) 500Hz	4.7	2.8	2.5	2.9	9	6.5	7.1	5.8	5.091	0.010	2.2	4.3	6.5	0.739	0.029	0.067
Difference (PTA-ASSR) (RE) 1000Hz	4.4	3	5	0	10	6.7	7.8	6	6.175	0.004	–0.6	5.6	5.0	0.98	0.004	0.211
Difference (PTA-ASSR) (RE) 2000Hz	3.5	4.9	5	4.1	8	6.2	6.3	6	3.427	0.041	–1.5	4.5	3.0	0.889	0.034	0.589
Difference (PTA-ASSR) (RE) 4000Hz	3.8	3.3	5	4.1	8	4.7	6.4	4.6	5.686	0.006	–1.2	4.2	3.0	0.859	0.005	0.383

- One Way Anova comparison between Types of Hearing Status on the basis of Pure tone audiometry at different levels frequencies in left Ear amongst 51 patients. Mean threshold levels between both the tests were compared to each other with the same patients in their left ear at 500Hz, 1000Hz, 2000Hz, and 4000 Hz (Table 15). The mean threshold levels amongst normal (n=17) individuals by PTA at 500, 1000, 2000, and 4000 Hz were 14.4±6.6, 15±4.7, 17.1±6.1 and 18.5±8.6 respectively. The mean threshold levels amongst CHL (n=4) by PTA at 500, 1000, 2000, and 4000 Hz were 33.8±6.3, 35±7.1, 40±8.2 and 43.8±8.2 respectively. The mean threshold levels amongst SNHL (n=30) individuals by PTA at 500, 1000, 2000, and 4000 Hz were 54.2±15.2, 59.2±13.2, 63.8±13 and 66.2±14 respectively. The three groups differ significantly in the one way anova comparison. The Normal and CHL group were significantly different from each other at all four frequencies on the basis of PTA. (Table 2)

Table 2: One way anova comparison between types of hearing statuson the basis of pure tone audiometry at different levels frequencies in left ear

	Normal		CHL		SNHL		Total		F	P Value	Mean difference			p value		
	Mean	S D	Mean	S D	Mean	SD	Mean	S D			A-B	A-C	B-C	A-B	A-C	B- C
PTA (LE) 500 Hz	14.4	6.6	33.8	6.3	54.2	15.2	39.3	22.3	55.183	<0.001	-19.3	39.8	20.4	0.021	<0.001	0.01

PTA (LE) 1000Hz	15	4.7	35	7.1	59.2	13.2	42.6	23.2	92.534	<0.001	–20.0	44.2	24.2	0.004	<0.001	<0.001
PTA (LE) 2000Hz	17.1	6.1	40	8.2	63.8	13	46.4	24.4	100.051	<0.001	–22.9	46.8	23.8	0.001	<0.001	<0.001
PTA (LE) 4000Hz	18.5	8.6	43.8	7.5	66.2	14	48.5	25.2	84.271	<0.001	–25.2	47.6	22.4	0.001	<0.001	0.003

- Relationship between pure tone audiometry and auditory steady state response assessed by linear regression at 500 Hz. At 500 Hz, the coefficient constant was calculated to be 4.709 (95% CI -8.341- -1.077). The relationship was found to be significant (p<0.001) Hence, the ASSR could be represent edas PTA 500=ASSR (500 Hz) × 0.925 − 4.709. (Table 3)

Table 3: Relationship between pure-tone audiometry and auditory steady state respons eassessed by linear Regression 500Hz

	Unstandardized Coefficients		Standardized Coefficients	T	p value	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	–4.709	1.807		–2.606	0.012	–8.341	–1.077
ASSR Average 500Hz	0.925	0.036	0.966	25.979	<0.001	0.854	0.997

- Relationship between pure tone audiometry and auditory steady state response assessed by linear regression at 1000Hz.At 1000Hz, the coefficient constant was calculated to be –1.923 (95% CI–4.124- -0.278). The relationship was found to be significant (p>0.05)Hence, the ASSR could be represented as PTA 1000 = ASSR (1000 Hz) × 0.898 – 1.923. (Table 4)

Table 4: Relationship between pure-tone audiometry assessed by linear Regression 1000 Hz and auditory steady state response

	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
	B	Std. Error	Beta	T	pvalue	Lower Bound	Upper Bound
(Constant)	–1.923	1.095		–1.755	0.085	–4.124	0.278
ASSR Average 1000Hz	0.898	0.021	0.987	43.301	<0.001	0.856	0.939

- Relationship between pure tone audiometry and auditory steady state response assessed by line arregression at 2000Hz. At 2000Hz, the coefficient constant was calculated to be -2.506 (95% CI-4.810- -0.201). The relationship was found to be significant (p>0.05). Hence, the ASSR could be representedas PTA 2000 = ASSR (2000 Hz) × 0.933 – 2.506. (Table 5)

Table 5: Relationship between pure-tone audiometry assessed By linear Regression 1000 Hz and auditory steady-state response

	Unstandardized Coefficients		Standardized Coefficients	T	pvalue	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	–1.923	1.095		–1.755	0.085	–4.124	0.278
ASSR Average 1000Hz	0.898	0.021	0.987	43.301	<0.001	0.856	0.939

- Relationship between pure tone audiometry and auditory steady state response assessed by linear regression at 4000Hz. At 4000Hz, the coefficient constant was calculated to be -2.031 (95% CI-4.290- -0.227). The relationship was found to be significant (p>0.05). Hence, the ASSR could be representedas PTA 4000 = ASSR (4000 Hz) × 0.920 – 2.031. (Table 6)

Table 6: Relationship between pure-tone audiometry assessed Bylinear Regression 4000 Hz and auditory steady-state response

	Unstandardized Coefficients		Standardized Coefficients	T	p value	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	–2.031	1.124		–1.808	0.077	–8.341	–4.290
ASSR Average 500Hz	0.920	0.019	0.989	47.712	<0.001	0.881	0.959

- Correlation coefficient values between the PTA and ASSR results at each frequency 500, 1000, 2000, and 4000 Hz in all the three groups. We found strong correlation between PTA and ASSR measurement satall the four frequencies were 0.966,0.987, 0.988 and 0.989. (p<0.001). The correlation was strongest at 4000 Hz in all the groups. (Table 7)

Table 7: Pearson correlation coefficient values (r) between PTA and ASSR results at each frequency amongst all the patients

		ASSR Average 500Hz	ASSR Average 1000Hz	ASSR Average 2000Hz	ASSR Average 4000Hz
PTA Average 500Hz	Pearson Correlation	.966**	.961**	.917**	.912**
	p value	<0.001	<0.001	<0.001	<0.001
PTA Average 1000Hz	Pearson Correlation	.947**	.987**	.937**	.949**
	p value	<0.001	<0.001	<0.001	<0.001
PTA Average 2000Hz	Pearson Correlation	.942**	.962**	.988**	.958**
	p value	<0.001	<0.001	<0.001	<0.001
PTA Average 4000Hz	Pearson Correlation	.892**	.945**	.954**	.989**
	p value	<0.001	<0.001	<0.001	<0.001

- Correlation between the PTA and ASSR results at each frequency 500, 1000, 2000, and 4000 Hz in normal individuals. Very strong correlation between PTA and ASSR measurements at all the four frequencies were 0.970, 0.990, 0.981 and 0.994. (p<0.001). The correlation was strongest at 4000 Hz in all normal individuals. (Table 8)

Table 8: Pearson correlation coefficient values (r) between PTA and ASSR results at each frequency amongst normal study participants

		ASSR Average 500Hz	ASSR Average 1000Hz	ASSR Average 2000Hz	ASSR Average 4000Hz
PTA Average 500Hz	Pearson Correlation	.970**	.968**	.931**	.925**
	p value	<0.001	<0.001	<0.001	<0.001
PTA Average 1000Hz	Pearson Correlation	.941**	.990**	.927**	.941**
	p value	<0.001	<0.001	<0.001	<0.001
PTA Average 2000Hz	Pearson Correlation	.943**	.964**	.981**	.959**
	p value	<0.001	<0.001	<0.001	<0.001

PTA Average 4000Hz	Pearson Correlation	.883**	.951**	.962**	.994**
	p value	<0.001	<0.001	<0.001	<0.001

**.Correlation is significant at the 0.01 level (2-tailed).

*.Correlation is significant at the 0.05 level (2-tailed).

- Correlation between the PTA and ASSR results at each frequency 500, 1000, 2000, and 4000 Hz in CHL patients. Very strong correlation between PTA and ASSR measurements at 2000 Hz and 4000 Hz were 0.995 and 0.989. (p<0.001). Non- significant correlation between PTA and ASSR measurement sat 500Hz and 1000Hz were.0.776, 0.936 (p>0.05).

  The correlation was strongest at 2000Hz in all CHL patients. (Table 9)

Table 9: Pearson correlation coefficient values (r) between PTA and ASSR results at each frequency amongst CHL patients

Pearson Correlation		**ASSR Average 500Hz**	**ASSR Average 1000Hz**	**ASSR Average 2000Hz**	**ASSR Average 4000Hz**
PTA Average 500Hz	Pearson Correlation	0.776	0.935	0.753	0.929
	p value	0.224	0.065	0.247	0.071
PT Average 1000Hz	Pearson Correlation	0.781	0.936	0.755	0.934
	p value	0.219	0.064	0.245	0.066
PTA Average 2000Hz	Pearson Correlation	.990**	.967*	.995**	.953*
	p value	0.010	0.033	0.005	0.047
PTA Average 4000Hz	Pearson Correlation	0.898	.987*	0.876	.989*
	p value	0.102	0.013	0.124	0.011

**.Correlationis significant at the 0.01 level (2–tailed).

*.Correlationi ssignificant at the 0.05 level (2–tailed).

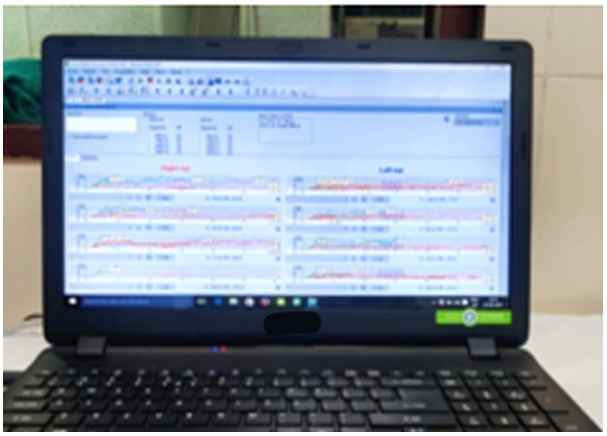
- Correlation between the PTA and ASSR results at each frequency 500, 1000, 2000, and 4000 Hz in SNHL patients. Very strong correlation between PTA and ASSR measurements at all the four frequencies were 0.980, 0.991, 0.990 and 0.987. (p<0.001). (Table 10)

Table 10: Pearson correlation coefficient values (r) between PTA and ASSR results at each frequency amongst SNHL patients

Pearson Correlation		**ASSR Average 500Hz**	**ASSR Average 1000Hz**	**ASSR Average 2000Hz**	**ASSR Average 4000Hz**
PTA Average 500Hz	Pearson Correlation	.980**	.957**	.927**	.905**
	p value	<0.001	<0.001	<0.001	<0.001
PT Average 1000Hz	Pearson Correlation	.964**	.991**	.967**	.965**
	p value	<0.001	<0.001	<0.001	<0.001
PTA Average 2000Hz	Pearson Correlation	.933**	.962**	.990**	.961**
	pvalue	<0.001	<0.001	<0.001	<0.001
PTA Average 4000Hz	Pearson Correlation	.898**	.944**	.968**	.987**
	p value	<0.001	<0.001	<0.001	<0.001

**.Correlation is significant at the 0.01 level (2-tailed).

*.Correlation is significant at the 0.05 level (2-tailed).



DISCUSSION

Hearing loss leads to impaired communication, and causes psychosocial effects that leads to social isolation and reduced quality of life. Audiological testing is performed to assess hearing thresholds across range off requencies that are important for human communications. Pure tone audiometry one among them is the subjective test and auditory steady state response is the objective test to find out the hearing loss.

Types of Hearing Losson the difference between PTA and ASSR:

The difference of threshold levels between PTA and ASSR amongst normal (n=17) individual sat 500, 1000, 2000, and 4000 Hz were 4.7±2.8, 4.4±3, 3.5±4.9 and 3.8±3.3 respectively. The difference of threshold levels amongst CHL (n=4) by PTA at 500, 1000, 2000, and 4000 Hz were 2.5±2.9, 5±0, 5±4.1 and 5±4.1 respectively. Themean differenc eofthre shold level samongst SNHL (n=30) individuals by PTA at 500, 1000, 2000, and 4000 Hz were 9±6.5, 10±6.7, 8±6.2 and 8±4.7 respectively. The three groups differ significantly. The SNHL group has higher difference of threshold levels than patients with normal hearing and CHL at all the frequencies. ($p<0.05$).

Similar observations were obtain edina study done by Himanshu et al[5], except that the threshold was about 10 d Bhigherin this study. In another study done by Wadhera et al,[6] showed similar results with mean threshold of 6±5 dB. The results obtained by Komazec Z et al,[7] were similar where they observed the highest threshold difference of 7.5 dB amongst the normal hearing individuals. Never the less, in a study done by, Ozdek et al[8], Mean threshold difference values between PTA and ASSR thresholds were between 10–15 dB in normal hearing Group.

Amongst all these studies, ASSR was significantly able to detect thresholds at about 5–15 dB higher than that of PTA in either ears.

In addition to above mentioned studies We have observed that, The Normal and CHL group were comparable each other at all four frequencies on the basis of PTA and ASSR. The SNHL group has higher difference of threshold levels than patients with normal hearing based on PTA but not on ASSR.

The similar study was done by Hosseinabadi R et al[9], The difference among PTA and ASSR thresholds was similar in patients with SNHL or CHL and there was no significant difference between two types of hearing loss. Whereas, similar to present.

study, Normal hearing group differed from other two groups in frequency of 1000, 2000, and 4000 Hz and significant differences existed between normal hearing and SNHL groups.

A study by D'haenens et al[10] found that patients with moderate SNHL had lowermean threshold differences than their normal participants, but there was no significant difference between the normal participants and patients with mild SNHL. But in our study, the mean threshold differences at each frequency in our normal participants were significantly lower than those SNHL patients.

Pearson correlation between PTA and ASSR results at each frequency in the three groups.

Very strong correlation between PTA and ASSR measurements at all the four frequencies were found between Normal and SNHL groups. However, in CHL group, there was no correlation between PTA and ASSR measurements at 500 Hz and 100 Hz.

Wadhera et al,[6] showed similar results, wherein a strong correlation between PTA and ASSR values in SNHL group, with r values of 0.76, 0.82, 0.79, and

0.68 for the four frequencies.

Similar findings were observed in the study by Ozdek et al.[11] They reported that the r values between the PTA and ASSR results in their control group were 0.165, 0.352, 0.146, and 0.472 at 0.5k, 1.0k, 2.0k, and 4.0 kHz respectively.

However, in study by D'haenens et al[10] found that patients with CHL had good correlation between PTA and ASSR results in their CHL group: Their corresponding r values were 0.76, 0.89, 0.81, and 0.82 at the four frequencies.

Relationship between pure tone audiometry and auditory steady state response assessed by linear Regression at all four frequencies.

In the present study, PTA can be represent ed in terms of ASSR for each frequency by the equation derived by regression: PTA (500 Hz) = ASSR (mean 500 Hz) × 0.925 − 4.709, PTA (1000Hz) = ASSR (mean1000Hz) × 0.898 – 1.923, PTA (2000Hz) = ASSR (mean 2000 Hz) × 0.933 – 2.506, and for PTA (4000 Hz) = ASSR (mean 4000 Hz) × 0.920– 2.031.

Similar observations were obtain edina study done by Himanshu et al[5], where the regression equation were calculat edas PTA (500Hz) = ASSR (mean 500Hz) × 0.995 − 9.773, PTA (1000Hz) = ASSR (mean 1000Hz) × 1 − 9.986, PTA (2000Hz) = ASSR (mean 2000Hz) × 1.004 – 10, and for PTA (4000Hz) = ASSR (mean 4000Hz) × 0.998−9.957.

In an other study done by Ahn J et al,[12] relationships between the pure-tone threshold (PTT) and the ASSR thresholds for the frequencies tested are described by the following equations: at 0.5 kHz, PTA = 1.08 × ASSR – 10.4; at 1 kHz, PTA = 1.13 × ASSR – 9.6; at 2 kHz, PTA = 1.07 × ASSR – 5.3; and at 4 kHz, PTA = 0.99 × ASSR – 6.3.

Almost similar relationship was observed by Komazec Z, et al.[7] and calculated by the equations, at 0.5 kHz, PTA = 0.833×ASSR – 1.465; at 1 kHz, PTA = 0.995 × ASSR – 2.381; at 2 kHz, PTA = 1.06 × ASSR – 10.77; and at 4 kHz, PTA= 0.924 × ASSR – 1.415.

Therefore, all the above mentioned results reiterate the findings of the previous studies, that clinically tolerable error in hearing threshold evaluation especially when making a hearing aid plan is approximately 10 dB. These findings confirm hypothesis that the ASSR examination may predict configuration of audiometric findings with a very high level of certainity, at statistically significant levels. Very Few studies have evaluated theef fect of CHL or SNHL on ASSR thresholds. We found find a significant difference between ASSR thresholds of CHL and SNHL. Never the less, significant difference between ASSR thresholds of SNHL and normal hearing was noted. It was reported that separation of normal hearing from mild hearing loss was difficult at 500 Hz. This could be there sult of poor neural synchronization and higher ASSR threshold of 500Hz in normal hearing condition.[10] In our sudy, the ASSR could separate normal hearing SNHL and CHL, except for 500 Hz. This can be related to less neural synchrony in this frequency. The apical portions of the cochlea are responsible for detecting 500Hz in low levels.[9]

CONCLUSION

- The degree of hearing loss seems to play an important role in the correlation between PTA and ASSR thresholds.
- ASSR was able to detect thresholds at about 5 dB higher than that of PTA in both the ears in normal hearing patients at all frequencies.
- In case of CHL patients, ASSR was able to detect thresholds at about 5 dB higher than that of PTA, but it was not significant forright ear but was significant for left ear at 1000 and 4000 Hz. Hence, it can be concluded that, ASSR We assume that these findings can be attributed to low sample size of CHL patients.
- Never the less, in case of Sensor ineural Hearing loss, ASSR was consistently able to detect thresholds specifically at 8-10 d Bhigher than that of PTA ($p<0.05$).
- Weal so have observed that, SNHL patient shashi gher difference of threshold levels than patients with normal hearing based on PTA but not on ASSR.
- Very strong correlation between PTA and ASSR measurements at all the four frequencies were found between Normal and SNHL groups. However, in CHL group, there was no correlation between PTA and ASSR measurements at 500Hz and 1000Hz.
- ASSR is able to differentiate between types of hearing loss based on the type of hearing.
- ASSR has a constant relationship with PTA thresholds. ASSR can predicttrue hearing thresholds in "difficult to assess" patients.
- We conclude that ASSR testing can be an excellent complement to other diagnostic methods to serve as a valuable tool in the determination of hearing thresholds.

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Isolated Haller Cell Mucocele: An Unusual Presentation

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Abstract

This article presents a rare and interesting case of isolated mucocoele of haller cell (Infraorbital ethmoid cell) presenting with extensive proptosis and visual disturbances in the absence of facial pain and symptoms of sinusitis. CT PNS with contrast revealed a heterogeneous non enhancing soft tissue lesion in the roof of the left maxillary sinus/floor of left orbit with severe thinning of the floor of the left orbit and not filling the maxillary sinus. This is the fourth reported case of isolated mucocoele of haller cell and the first case to present with significant proptosis and visual disturbances. Treatment opted was endonasal endoscopic surgical removal and restoring the appropriate orbital function and cosmesis. Early diagnosis and prompt surgical management can help avoid dangerous visual complications in these kind of rare presentations.

Keywords: Maxillary sinus mucocele; Proptosis; Haller cell mucocele; Infraorbital ethmoidal cell; Haller cell.

INTRODUCTION

Mucoceles are benign, locally expansile cyst-like lesions, lined by the mucoperiosteum of the involved paranasal sinus. More common in the fronto-ethmoidal region, they rarely involve the maxillary sinus. Antralmucoceles generally involve the lateral sinus wall first[2] andthe most common presentation is facial swelling.[3]

Migrating anterior or posterior ethmoidal air cells that pneumatize the roof of the maxillary sinus is termed as Haller cell with an incidence of 2–45% worldwide. This cell can rarely present with mucocele and mimics antralmucocele. Expansion of mucocele arising from posteriorly located haller cells when invading orbit can cause ophthalmological symptoms such as orbital edema, proptosis, diplopia, ptosis, visual or oculomotor disturbances, and pain in the eye.[8] Haller cells also have a strong association with dehiscence of the orbital floor (upto 60%).[6]

Our case was interesting as our patient neither had facial swelling nor signs of sinusitis and CT scan showed extension of lesion from roof of maxillary sinus towards orbit. And intraoperatively, a well defined calcified rim was identified surrounding the mucocele and it was found that superior wall of mucocele was extending to dehiscent orbital floor. These point towards gradually progressing mucocele arising from roof of maxillary cavity and extending to dehiscent orbital floor causing proptosis and diplopia which is quiet a rare presentation for a mucocele.

CASE

A 43 year old male presented with left orbital proptosis noticed by his collegues 2 months back and progressive left diplopia. An ophthalmology evaluation showed ill sustained pupillary reactions on both eyes (left > right) and diplopia in left

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inferior gaze. A screening MRI orbit showed a lesion in the left maxillary sinus and the patient was referred to otorhinolaryngology department for further evaluation and management. There was no past history of sinus trauma, infection or surgery. He was a poorly controlled diabetic and on oral hypoglycemic drugs and insulin. The patient presented to ENT OPD with evident proptosis but clinical examination and a nasal endoscopy showed no other nasal abnormalities or facial swelling.

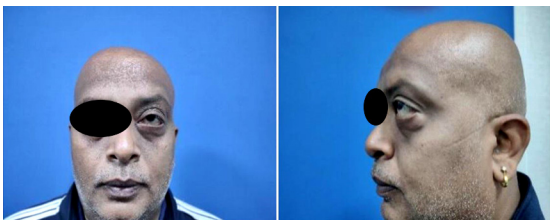


Fig. 1: Preoperative photograph of patient

A CT PNS with contrast revealed a heterogeneous,non enhancing soft tissue lesion measuring 3.1 x 3 x 2.4 cms with its epicenter in the floor of left orbit. There was severe thinning of the floor of the left orbit with displacement of the inferior rectus and proptosis. Closer attention showed ovoid lesion with a calcified rim in the upper 2/3rd of the maxillary sinus. A separate soft tissue density filled the lower part of the sinus (? Secretions). Rest of the paranasal sinuses appeared normal. In comparison to the previous MRI orbit done 2 months ago (lesion size 2.5*2.7*2.5 cm) present imaging showed gradual growth of the lesion. Radiologically a differential diagnosis of ameloblastoma /aneurysmal cyst was given.

After achieving euglycemic status we planned an endoscopic surgical management under general anesthesia. After decongesting the nose, a Diagnostic nasal endoscopy showed DNS to left, Bilateral hypertrophic inferior turbinates and a slight bulge in the medial wall of maxillary sinus. Left uncinectomy was performed. Mucocele identified and decompressed, the contents of cystic lesion was mucoid discharge. A well defined inferior calcified rim was identified and removed. Retained secretions of the maxillary sinus below the mucocele was drained out. Superior layer of mucocele wall was seperated from the dehiscent orbital floor. On table proptosis appeared to decrease and there was no prolapse of orbital contents into maxillary sinus. Anterior ethmoidectomy was done and medial wall of orbit appeared normal. As orbital floor appeared stable, no reconstruction surgery was required. Postoperative support was provided to the orbital floor using an inflated foleys catheter balloon and stabilized with a nasal pack. After pack removal 36 hours later left orbit retained its normal position, eye movements were normal and diplopia improved.

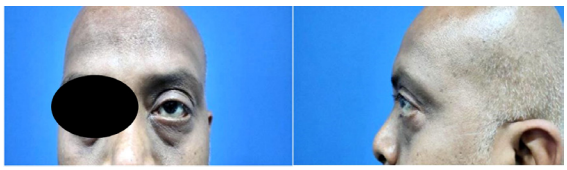
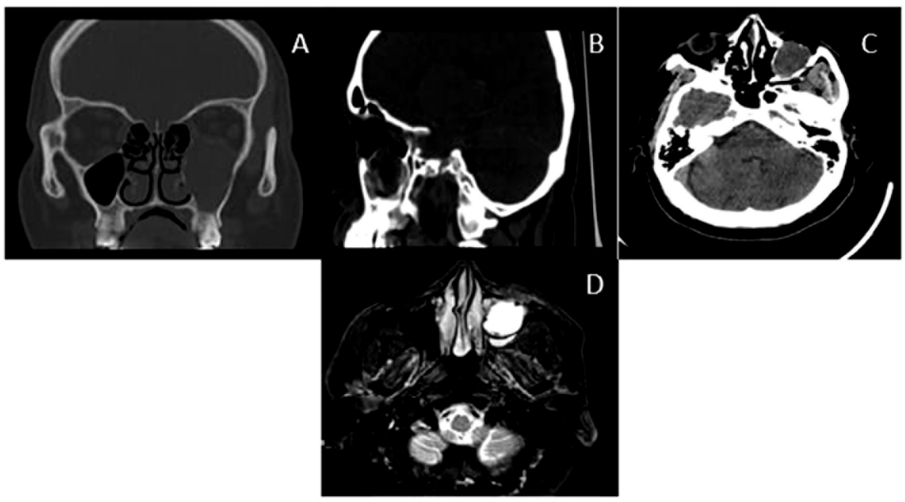


Fig. 2: Postoperative photograph of patient



A. Coronal CT PNS:Non enhancing soft tissue lesion with epicenter in the floor of left orbit with severe thinning of orbital floor
B. Sagittal CT PNS : Ovoid lesion with a calcified rim in the upper 2/3rd of the maxillary sinus
C. Axial CT PNS: Non enhancing soft tissue lesion extending into left orbit.
D. MRI Nose/Orbit: soft tissue lesion in left maxillary sinus

Histopathological examination was consistent with diagnosis of mucocele. Patient was followed up after 5 days and nasal endoscopy showed widely opened maxillary sinus , no remnant tissues noted. Within one week his left visual acuity and colour vision returned to normal with a visual aquity of 6/6 bilaterally and 17/17 bilaterally with the ishihara colour test plates. He also had complete resolution of diplopia and proptosis. 2 months postoperative period vision, extraocular movements and position of eyeball remains normal.

DISCUSSION

Maxillary sinus mucocoeles are uncommon but well defined entities. They may be confused with a rare entity of a Haller cell mucocoele. To the best of our knowledge, this is the fourth reported case of isolated mucocoeles of a haller cell and the first presenting with extensive proptosis and visual disturbances in the absence of facial pain and other symptoms of sinusitis.

Although uncommon, maxillary sinus mucoceles have distinct radiological findings. It usually fills the whole sinus and is nearly always associated with thinning of the anterolateral wall of the sinus, frequently with bulging of the medial wall and septum. There may be some diagnostic challenges, especially when extensive disease or anatomical variants are present.

Haller cell, a normal anatomical variant, when enlarged or infected can significantly constrict the posterior aspect of the ethmoidal infundibulum and maxillary ostium causing maxillary sinusitis & also predispose to an antralmucocoele. Inflammation of the Haller cell is common in pansinusitis, but an isolated mucocele of this cell is rare.They are usually located in the roof of the maxillary sinus. It shows a thin bony septum between the lesion and normal maxillary sinus. It can expand slowly erode the roof of maxillary sinus and extend into orbit.[5]

Diagnosis of Hallers cell is typically made by CT scan, as they cannot be identified by diagnostic nasal endoscopy because of their typical location lateral to the infundibulum. Easily seen on coronal PNS CT, they have been described as well defined, round, oval, or teardrop shaped, unilocular or multilocular radiolucencies with smooth borders that may or may not appear corticated, located medial to the infraorbital foramen.[8]

Haller cells also have a strong association with dehiscence of the orbital floor (upto 60%)[6], making the orbit more vulnerable. Expansion of a mucocele arising from such a Haller cell, when invading the orbit, can cause ophthalmological symptoms of proptosis, diplopia, ptosis, visual or occulomotor disturbances and pain in the eye. The case in point highlights both such findings.

Endonasal endoscopic approach is the preferred treatment in paranasal sinus mucoceles with low recurrence rate at or close to 0% and minimally invasive with a shorter postoperative recovery and less morbidity. Caldwell Luc approach is reserved for more extensive mucocoeles involving facial soft tissues and pterygomaxillary fossa.[7]

CONCLUSION

Though benign and slow growing in nature, early diagnosis and surgical management of Haller cell mucocele can help avoid dangerous visual complications. A prompt surgical intervention and proper ophthalmic follow up may negate the requirement of extensive reconstructive surgery even with advanced proptosis and orbital floor destruction. A high index of suspicion is needed to avoid missing such rare presentations.

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