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"Evaluation of 3d Position and Size of Ear Using Anthropometric Landmarks Amongst General Population: A Cross Sectional Study."

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KEYWORDS
Facial proportions, Anthropometrics, Population study, ear angulation, ear dimensions, ear position, ear visibility, reference plane

ABSTRACT:

Aim

Anthropometry is an amalgamation of art and science which together is put to use extensively for measuring the soft tissue proportions. The study was carried out with an aim of restoring the normalcy in patients with bilaterally missing ears which can be significantly reduced by just the knowledge and simple execution of anthropometric measurements of natural ear in local population. The main objective is to evaluate the corelation of natural ear dimension and position with thirds of face in both the genders and in relation to mid coronal plane and also to examine the protrusion of external ear from mastoid bone in both the genders. And lastly to identify corelation of ear angulation to nose angulation from lateral aspect.

Materials and Methods

Study was done on 100 participants with normal facial features. Anthropometric landmarks like glabella, trichion, subnasale, superaurale, subaurale, gnathion, tragus were determined and various anthropometric measurements and facial proportional indices were evaluated (both horizontal and vertical) using standard anthropometric instruments like vernier calliper, spring calliper, measuring tape, measuring scale and goniometer as described by Farkas L. G.

Results

The statistical analysis showed the average ear length 60.66 ± 3.415 mm with bigger ear in males and mostly corelated to middle third of face in dimensions. Ear vertical position is within the middle third of face and the average inter coronal tragus difference 15.87± 2.7 mm. Average ear protrusion from mastoid is 19.60 ±2.0 mm. The average difference of degree in nose and ear angle= 10-11°.

Conclusion

After careful assessment of statistics, measurements and outcomes we were able to conclude that the glabella to subnasale distance was the most dependent variable with respect to the length and position of the ear, while the ear protrusion of average 19-20 mm from mastoid is seen in all 100 subjects. Regardless of gender, ear angulation was generally less than that of nose angulation with difference of 10-11°. All the measurements showed lower values in case of female population as compared to males. Further studies are necessary in this regard with bigger samples size, more parameters and

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ruling out confounding factors and results will be more specific if the results are corelated with cephalometrics.

INTRODUCTION

It was the 17th and the 18th centuries when the proportional evaluation of the face actually came into being. It was then, that the artists and the anatomists showed their interest in neoclassical cannons of facial proportions. (1) Many Renaissance artists believed that facial beauty was rooted in balanced proportions and facial symmetry.(2) When it comes to facial symmetry and attractiveness, perfection is not necessary. This is because only 2% of the world's population has true facial symmetry. Facial symmetry is desired, but a completely symmetric face is not seen as normal and has the opposite effect on people. The relationship between size and proportion of different facial measurements is considered to affect the perception of aesthetics. In the pretext of attaining the entire concept of esthetic facial beauty, the artistry of a prosthodontic pair of hands comes in for co-operation. The growth of prosthodontics has enabled the restoration of patients with maxillofacial defects. An important aspect of successful rehabilitation is the positioning of any prosthesis on the face.(3) The ear prosthesis presents several challenges to the clinician. Regardless of the treatment plan selected for unilaterally missing ear, the existing ear's dimensions, position, level, and prominence must be measured to predict the seating and shaping of the final ear prosthesis, but no such guide exists for bilateral missing ear. To overcome this situation, reliable techniques are required wherein facial measurements could be used as a guide during fabrication of a prosthesis.(4) Once the cephalometrics came into existence, more importance was given for the hard tissue relationship, and their correction. But the outcome of the experiment was not as favourable. It was realized that the correction of hard tissue alone does not bring about the desired results in many occasions. Soft tissue plays a major role in determining the final outcome of facial aesthetic surgical procedures. Manual anthropometry, two-dimensional photography, and three-dimensional photogrammetry were the three most widely used methods for facial measurements.(5)

Anthropometry has been shown to be useful in orthodontic research and in reconstructive surgery, where the soft tissue morphology of the face can be studied more reliably than from radiographs. Much of the modern facial anthropometric data comes from Farkas' work on North American white populations. Currently, more than 20 landmarks and parameters are being used in the medical and dental professions for facial measurements to correlate with ear landmarks. In addition, use of a reference plane is also considered to be critical in planning the position of the prosthetic ear. (5)

Studies with comprehensive guidance in designing bilateral ear prosthesis are limited to date. Hence, This study was carried out with an aim of determining the external ear dimension, angulation, position and visibility in relation to facial soft tissue proportions in the local population using anthropometry, to restore normalcy in patients with bilaterally missing ears.

MATERIAL AND METHODOLOGY

Classical methods were the choice of paths for the measurements of physical anthropology which used standard instruments described by Farkas L. G. (6) Vernier calliper and spring calliper were used for measuring linear values whereas goniometer was used for angle calculation, apart from this measuring tape and scale were used for transferring the reading. (**Fig 1**)

Standardized method and the points of measurements were taken by the description given by Authors De Carlo et al (7), Mc Kinney et al and Brucker et al. (8)

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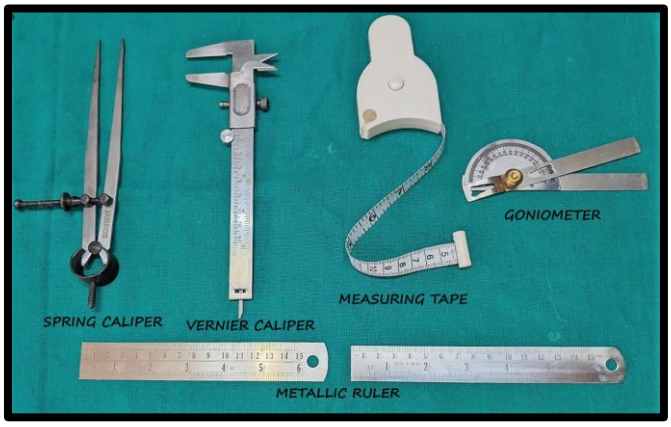

Fig 1: Instruments Used For Measurement

SAMPLE SIZE ESTIMATION

Sample size estimation was done by using nMaster2.0 (CMC, vellore)

A minimum sample size of 92 was calculated with an alpha of 0.05, power of 95%. Sample size of 100 participants both male and female belonging to the age group of 18–25 years were taken for the study.

In order to obtain optimum results, the subjects were between 18-25 years of age both male and female, belonging to north Indian population, healthy and had Skeletal class I relationship. Care was taken that the subject should not have missing unilateral and bilateral ear, no congenital ear or nose deformity or facial asymmetry, no history of ear or nose surgeries and facial trauma.

Anthropometric points:

A total of 12 anthropometric points were chosen for anthropometric measurements for vertical/horizontal measurement of the face and identification of ear angulation, neoclassical canons were also used. For standardization, only the right ear was used to measure the dimensions, visibility, and angulation because, according to Barut and Aktunc (9), dimensions differ between the right and left ears.(4). These measurements shown in figures below, are as follows (**Figure 2**).

1. **Trichion**- The point where the normal hairline and middle line of the forehead intersect.
2. **Glabella**- The glabella, in humans, is the area of skin between the eyebrows and above the nose. The term also refers to the underlying bone that is slightly depressed, and joins the two brow ridges. It is a cephalometric landmark that is just superior to the nasion.
3. **Superaurale** - The highest point on the upper edge of the helix of the ear.
4. **Subaurale** - Subaurale is an anthropometric landmark consisting of the lowest point on the lobe of the ear.
5. **Subnasale** - A point on the living body where the nasal septum and the upper lip meet in the midsagittal plane. This point is not identical to the bony subnasion, or nasospinale, which is the midpoint of the anterior margin of the apertura pyriformis at the base of the spina nasalis anterior.
6. **Gnathion** - The lowest point of the midline of the lower jaw: a reference point in craniometry. It is the lowest median landmark on the lower border of the mandible which is identified by palpation and is identical to the bony gnathion.
7. **Tragus** - A prominence on the inner side of the external ear, in front of and partly closing the passage to the organs of hearing.
8. **Rule of thirds**- The face is divided into horizontal thirds. The upper third extends from the hairline to the glabella, the middle third from the glabella to the subnasale and the lower third from the subnasale to the menton.
9. **Mid coronal plane**- a plane which transect a standing body into two halves (front and back, or anterior and posterior).
10. **Anterior reference point**- straight line passing through glabella and mentolabial angle.
11. **Posterior reference point**- straight line passing through occipital bone.
12. **Ear angle and Nose angle**- Angle formed between the line passing through the long axis of the ear and

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the nose and line passing through the vertical axis of the face.

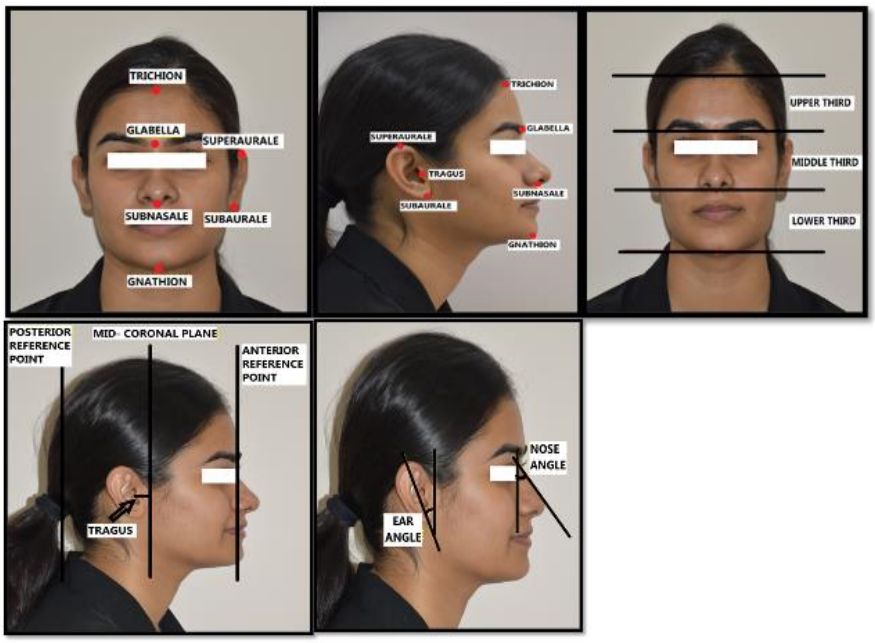

Figure 2: 12 Anthropometric Points

METHODOLOGY:

Measurements of all 100 students was done by taking their consent. Subjects were asked to sit in an upright relaxed position and made to look at a distant object, methods used were as follows:

- Ear length- was measured using a vernier calliper as distance from the most inferior projection of the ear lobule to the most superior projection of the helix. (**Figure 3**)
- Thirds of face - The 3 halves of face was measured using vernier calliper by marking trichion, glabella and gnathion on subject's face and measuring the difference between the marked points. Trichion to glabella is upper third, glabella to subnasale is middle third and subnasale to gnathion is lower third (**Figure 3**)
- Tragus- mid coronal difference- To locate how far the ear is oriented from midcoronal plane, Coronal tragus difference was measured first by taking the circumference of head by measuring tape in which 5mm of error was taken care of, the value was divided into half which gave us the mid coronal plane and marked. The distance between anterior border of tragus of the ear and the marked midcoronal plane was measured. (**Figure 3**)
- Ear and nose angle- For ear and nose angulation comparison- both angles were measured using goniometer in which the fixed arm was the vertical axis of face and the mobile arm were vertical axis of ear and nose respectively, the angle formed was ear and nose angle. (**Figure 3**)

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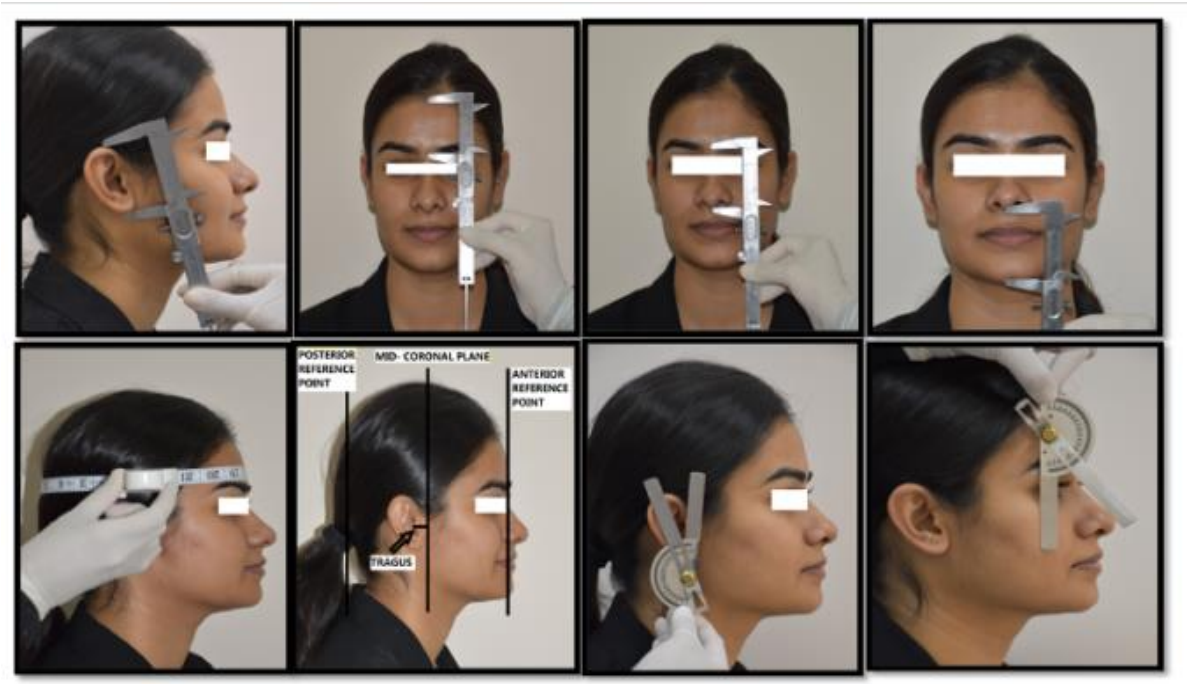

Figure *3*: Measurements of Ear Length, Thirds of Face, Tragus- mid Coronal Difference, Ear and Nose Angle

- Visibility of the ear from the frontal view(Ear Protrusion) was measured using a spring calliper with its one base touching the mastoid area and 2nd base at the middle third of posterior helical border of antihelix region of the external ear. The readings were transferred over metallic scale for linear value assessment. (**Figure 4**)
- Vertical ear position- Two metallic ruler were placed on the two ends of vernier calliper with fixed arm at glabella and the mobile arm at subnasale. The position of ear in relation to these two rulers were marked from front at a distance. Measurements were made with binocular vision. (**Figure 4**)

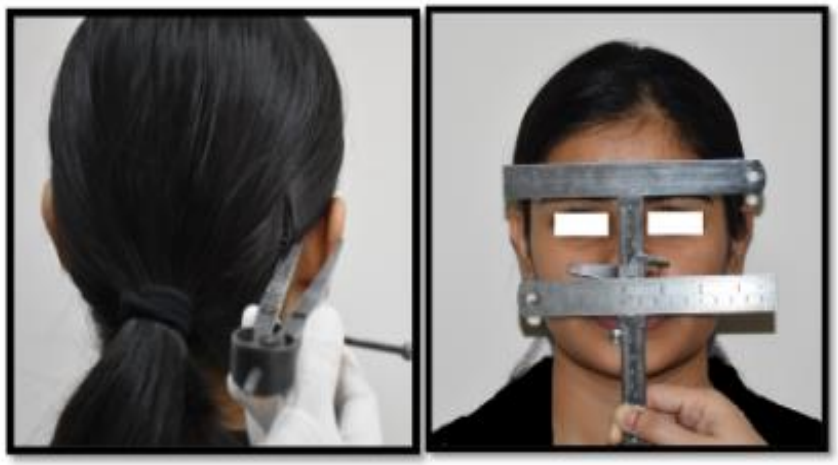

Figure 4: Ear Protrusion and Vertical Ear Position

RESULTS

All measurements were maintained in the excel sheet for individual subjects and statistical analysis.

The data obtained were statistically analyzed using ‘‘t’’ test and mean and standard deviation were obtained to establish the norms separately in males and females. An attempt has been made to correlate the findings with

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clinical application. The mean values of the anthropometric measurements were compared and evaluated (**Table 1**).

		N	Mean	Std. Deviation	Std. Error Mean	P VALUE
Circumference	F	67	20.769	.3295	.0403	<0.001*
INCH	M	33	21.779	.7921	.1379	
Ear length	F	67	59.410	2.2544	.2754	<0.001*
	M	33	61.924	4.5886	.7988	
Upper	F	67	58.137	2.6444	.3231	0.005*
	M	33	60.418	5.3444	.9303	
Middle	F	67	59.300	2.4995	.3054	0.060
	M	33	61.582	4.2127	.7333	
Lower	F	67	57.921	2.7908	.3410	<0.001*
	M	33	62.461	4.1471	.7219	

Table 1: Gender-wise Mean Values of Anthropometric Measurements

It was observed that maximum subjects showed ear length nearly equal to middle third of face with second nearest to upper third of the face in both males and females. According to **Husein et al.,** the measurements of the lower face height (subnasale–gnathion) and midface height (glabella–subnasale) are almost equal to the length of the ear (2). According to **Porter and Olson**, ear length is almost equal to forehead height (trichion–glabella) and midfacial height (glabella - subnasale) .(1)(**Graph 1**)

Results also showed that vertical ear position in relation to the third of face lies within the lines of middle third in 84 out of 100 subjects, when recorded from front at same eye level of the subject. In this study, position of the subjects' head, operator's head, parallelism of first and second rulers in the vernier calliper, and correct placement of the assembly on the face are essential for accurate results.

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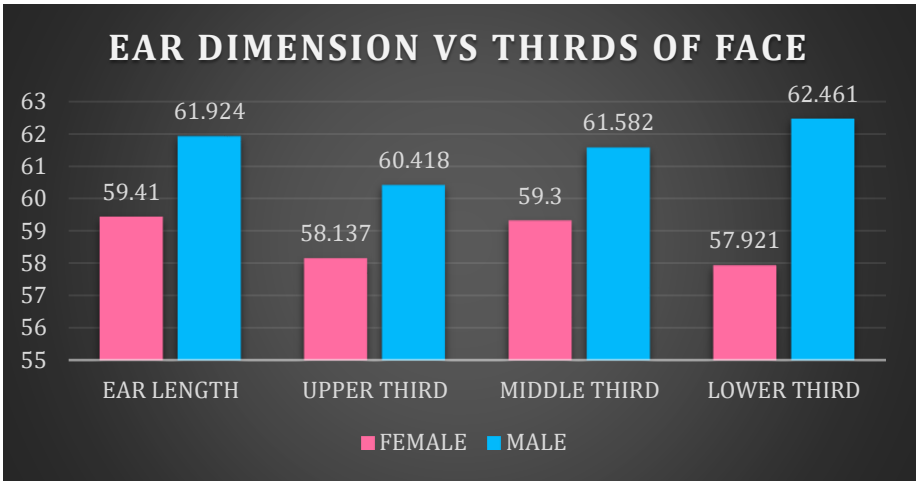
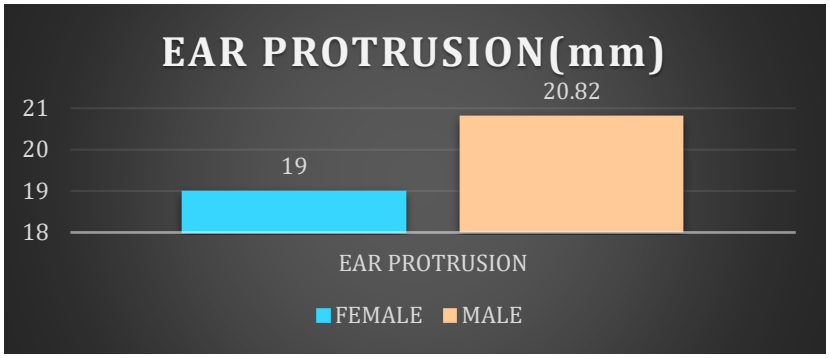


Graph 1: Ear Dimension Vs Thirds Of Face

The anterior posterior tragus position in relation to the mid coronal plane is within the range of 15-17mm with an average of 15.87 mm. There is no data available of anterior posterior positioning of external ear on the face. The average ear protrusion from the mastoid bone when viewed from front is 19.60mm with 1mm of more protrusion was noticed in males as compared to female subjects. Limited information is available regarding measurement of the visibility of the ear from the frontal view. Few studies have described the upper and lower protrusion from behind the ear. **Mohammed et al** in 2014, carried out a study and found for all facial forms, ear visibility is approximately 1.5 cm in upper protrusion. (4). According to **Driessen et al**., protrusion of superior part of helix of ear should not exceed more than 21.5 mm in males and 17.5 mm in females (10). Protrusion of inferior most part of ear helix should not exceed more than 20.0 mm in males and 15.5 mm in females. Superior helix protrusion plays a more important role in the perception of prominence as compared with inferior protrusion (10). (**Graph 2**)



Graph 2: Ear Protrusion Comparison

The comparison of ear angle to nose angle showed that nose angle is 10-11° more than ear angle in 100% of subjects.

To rule out the discrepancy which could be caused due to manual anthropometry a relative evaluation was done with subject's lateral cephalogram and 2D pictures. And to the surprise the nose angle and ear angle was nearly equal in both cephalogram and in 2D pictures of the subjects. The lateral cephalogram could be only assessed in case of nose angle as cephalogram does not mark the outline of ear.

According **Mohammed et al**, a greater percentage of individuals showed ear inclination less than nose inclination in all the facial forms.(4) **Porter and Olson** (1), **Husein et al**. (2), and **Choe et al**. (11) found that the ear inclination is always less than the nasofacial angle. Based on the available literature and current results, while designing ear prosthesis it is preferable to keep the

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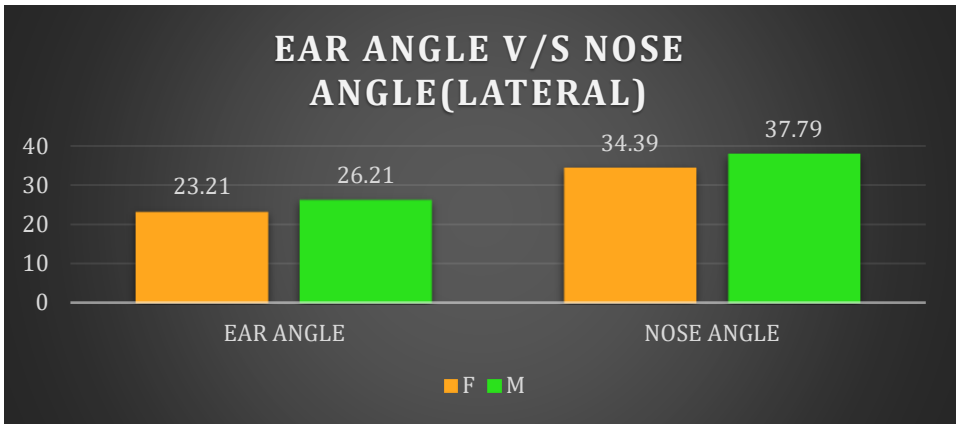
angulation of the ear 10-11° less than that of the nose.(**Graph 3**)



Graph 3: Ear Angle Vs Nose Angle

In our study, all the parameters of external ear are greater in males than females. The result showed a proper evaluation of gender wise difference in ear anthropometric measurements. Females showed ear length, ear protrusion, tragus mid-coronal difference, ear and nose angle smaller as compared to males with difference of around 1-2.5mm in all the cases showing statistically significant difference which is in accordance with studies as follows. **U. Ekanem et al**., (12) and **Taura M.G. et al**., (13) found that all parameters were greater in males than females in Nigerians. **D. Deopa** (14) also noticed that all the measurements were higher in males than females on both sides. They also observed that Total height of ear and ear width were found to be significantly greater among males and the left ear indices were found to be higher than the right ones for all the subjects. But, in female subjects, the right indices were found to be greater than the left ones. (4) **Ebho** (15), and **Sharma N** (16) noticed that ear dimensions were higher in males whereas lobular width and height were larger in females. (17)

The measurements used in the present study can be used as a guide for length, angulation and width of the prosthetic ear. Even though tools used in manual anthropometry distort the soft tissue and introduce error in measurements, manual anthropometry is still a commonly used technique because of its simplicity and because it is more economical (18). **Coward et al.** reported that a difference of 5 mm in the length and 3 to 4 mm in the width of the ear were never perceivable to an observer (19). **Liu et al.** compared the accuracy in the use of electronic digital calliper, photocopier scanner, and digital cameras to measure the length and width of the ear. The analysis of variance revealed no significant differences in measurements between these devices. Ear dimensions by direct method, cast, computed tomography, magnetic resonance imagery, and laser scanning were compared, and the results revealed no significant differences in dimensions.(20)

Clinical Significance

The study was carried out with an aim of measuring the facial soft tissue proportion in the local population so as to know the normal aspects to correct the abnormalities later, using Anthropometry. Therefore, to orient an artificial 3D ear prosthesis in patient with missing bilateral ear, following measurements can be used in our clinical practice with.

- The average ear length = 60.66 ± 3.415 mm, mostly corelated to middle third and upper third of face in dimensions with relatively bigger ear length in males.
- The inferior superior ear prosthesis position can be placed in line with the middle third (glabella - subnasale) of the face.
- The anterior posterior ear prosthesis position can be 15.87±2.7mm from the mid coronal reference plane with tragus of ear prosthesis as posterior reference and mid coronal plane as anterior reference.
- The ear protrusion of the 3D prosthesis can be 19.60 ±2.0 mm i.e. the difference between the posterior helical border of antihelix region of prosthesis can be placed 19-20mm away from the mastoid bone of the patient.
- The nose angle is always more than the ear angle when viewed from the lateral profile with the difference of 10-11°. Therefore the inclination or

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angulation of an artificial 3D ear prosthesis can be kept 10-11° less than the nose angle in patients with missing bilateral or unilateral ear.

Limitations

This study was specific in a group of people belonging to north indian population, and variations may be seen based on the ethnicity of the individual. Therefore, Further studies are necessary in this regard, suggested with more sample size and more parameters. Keeping in mind patient related confounding factors, such as pateint weight, height, facial form, interracial ethinicity, age, etc. Cephalometric analysis can also be added that helps to measure hard tissue landmarks which can help us corelate our soft tissue landmarks with them better.

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