Original Article

Auricular Anthropometry of Newborns at the Singapore General Hospital

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Abstract

Introduction: External ear abnormalities accompany many syndromes and genetic conditions. Yet, there are currently limited Asian references and no local norms for ear measurements and definitions for "low-set ears". The authors therefore describe ear measurements in a Singapore newborn population and seek to establish the applicability of the general accepted definition of "low-set ears" being that of "less than a third of the entire ear height being above the inter-medial canthal line". Materials and Methods: Babies managed by the Department of Neonatal and Developmental Medicine during a 3-week period were measured by 2 investigators using the Feingold and Bossert technique. Intra- and inter-rater reliabilities were calculated. The influence of various anthropometric factors on and their relationships with ear length (EL) and width (EW) was analysed. Results: A total of 104 neonates (20% preterm at birth) were included in this study. Median gestation was 38 weeks (range, 32 to 42). Mean birth weight was 2910 ± 657 g. Mean EW and EL for term infants were 2.1 ± 0.1 cm and 3.6 ± 0.3 cm respectively, without significant differences for different-sided ears, investigators, race or gender. Mean percentage of right and left ear above the denoted line was 52 ± 9% and 47 ± 10% respectively (*P* = 0.000), with 3rd percentile being 33%. Conclusions: Singaporean neonatal ears are comparable with other Asian neonates – larger than Hong Kong Chinese babies, though similar to Japanese newborns – but smaller than Caucasian neonates. The definition of "low-set ears" is consistent with the general accepted definition.

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Key words: Babies, Ear length and width, Ear measurements, Low-set ears

Introduction

Abnormalities of the external ear are described in many syndromes and genetic conditions.[1-3] Melnick et al[4] reported an incidence of 1 in 90 births for external ear malformations and branchial sinuses and tags, with about 1 in 670 births having malformations of the pinna. Congenital malformations of the external ear are generally related to developmental defects of the first and second branchial arches and the branchial groove that joins the first pharyngeal pouch to form the external ear canal. What appears externally could present as microtia or absent ear, malformed or abnormally folded pinna, prominent ears (e.g. Fragile X syndrome),[5,6] or low-set (e.g. Noonan's syndrome, Turner's syndrome and Down syndrome)[7-10] or abnormally rotated ears (e.g. Fragile X syndrome).[5,6] Internally, there could be atresia or structural defects involving the Eustachian tube, middle ear and mastoid structure. It is further important to note that during early foetal development, the outer ear or "pinna" forms at a time when many other critical organs are developing. Abnormalities in the shape or positioning of the pinna may be an indication that there are other associated abnormalities present, such as certain renal conditions. One interesting study reported that ear abnormalities are the general category of minor abnormalities most associated with autism, which is a neurodevelopmental condition.[11]

Descriptions of abnormal facial and neck features are therefore important in any genetic diagnosis. The comparison of physical characteristics in a population may be studied using anthropometry, a series of systematised techniques that quantify the external dimensions of the human body. Instruments such as calipers and measuring tapes are used to obtain soft tissue measurements using standard landmarks. Hence, anthropometry provides quantitative values for qualitative descriptions, playing an important role in dysmorphology. However, with many varied definitions,[12-14] normality becomes difficult to

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establish. Furthermore, different racial groups have different eye slants and other facial characteristics. While normative data for auricular anthropometric measurements from many populations have previously been published, there have been no local population norms, as well as few studies for Asian newborn norms.[15-18]

Hence, this cross-sectional study aims to provide a series of gestational age-matched values that may be used for the meaningful interpretation of individual measurements in our local population. In addition, this study seeks to clarify the terminology of "low-set ears" with regard to dysmorphology.

Materials and Methods

The study population comprised all live births managed by the Department of Neonatal and Developmental Medicine, Singapore General Hospital between 14 April and 4 May 2005. The period was selected in conjunction with the duration of the investigators' (then medical students) attachment to the department. All babies were examined and screened by a member of the neonatal team. Babies with the following conditions were excluded:

i. moribund condition at birth, requiring admission to the Neonatal Intensive Care Unit,
ii. chromosomal abnormalities or genetic conditions diagnosed inutero, and
iii. congenital anomalies as determined by a consultant neonatologist at birth screening.

This was to ensure a cohort of normal babies for the purpose of establishing population norms. Approval to conduct this study was obtained from the Singapore General Hospital Institutional Review Board/Ethics Committee. A waiver of written consent was obtained.

Term gestation was defined as a gestational age of at least 37 completed weeks. Premature babies underwent gestational age assessment with the Ballard or Dubowitz score. By convention, where the scored age differed from maternal dates based on the last menstrual period or early dating scan by more than 2 weeks, the scored age will be taken as the baby's actual gestation. The babies were then, based on the plot of their birth weight against gestational age, classified to be appropriate, small or large for gestational age (AGA, SGA or LGA). A SGA baby was defined as a baby having a birth weight lower than the 10th percentile for gestational age and a LGA was defined as a baby having a birth weight higher than the 90th percentile based on gestational age. Weight was measured daily for babies less than 2 kg. Length and occipitofrontal circumference (OFC) were measured for all babies at birth and weekly thereafter for the very-low-birth-weight (VLBW) babies.

As described by Feingold and Bossert,[19] an instrument made from a pre-calibrated transparent film was used to take the measurements. Both sides of the instrument were divided into millimeters to allow the right and left ears to be measured by the same instrument. A central horizontal line was drawn on the instrument and this was placed using the medial canthi [inter-medial cathal line (IMCL)] as landmarks. The vertical height of the ear above the IMCL was determined. This vertical height of the ear above the IMCL was then taken as a percentage over the total vertical ear height (EH). EH refers to the measurement from the uppermost to the lowermost point of the ear parallel to the vertical axis of the head. Ear width (EW) was determined by measuring transversely from the palpable anterior base of the tragus horizontally across to the margin of the helical rim. The total length of the ear (EL) was determined by measuring the maximum length between the most inferior and superior aspect of the ear.

All the babies had consecutive measurements of the various aspects of both right and left ears. Each measurement was made independently by 2 investigators, each with 2 measurements per aspect per side. These duplicate measurements provided a means of estimating the error of observation and reducing of systemic errors.

Data were analysed using the Statistical Program for Social Sciences, Version 13.0, Illinois, Chicago.

Intra-rater reliability was computed to examine variability in measurements by a single investigator [determined by the standard deviation (SD) of the mean difference between a set of 2 measurements for a given variable by the same investigator]. The mean of each set of measurements for each variable by each investigator (Mean A and Mean B) was then calculated and compared. The inter-rater reliability was computed to examine variability in measurements by different investigators (determined by the SD of the mean difference between Mean A and Mean B). The standardised mean ± SD was then calculated for the following variables, where the standardised mean was the mean for Mean A and Mean B for that given variable: EL, EW, EH and EH above the IMCL. The percentage of EH above the IMCL was then calculated. The process was carried out for both right and left ears.

The influence of gestational size, age, birth weight, length and OFC on the variables was analysed using the Kruskal-Wallis test. Spearman's rho correlation coefficient was used to examine the relationships between birth weight, length and OFC and EL as well as EW.

Results

There were 109 babies managed by the Department over this 3-week period. Five were excluded because they were too ill to permit the handling needed for the measurements. The patient characteristics of the study population are presented in Table 1. The measurements were taken at a median age of 2 days (range, 1 to 97). About 87% of them were measured within 3 days of life.

Table 2 demonstrates the measurements for both right and left ear. There were no statistical differences between the standardised means for right and left ear for EW and EL. As such, averaging standardised means for both ears, the final mean EW ± S.D. was 2.04 ± 0.16 cm [median 2.04 (1.59, 2.40)] and the final mean EL was 3.60 ± 0.26 cm [median 3.60 (2.95, 4.36)]. For term babies, the final mean EW ± S.D. was 2.06 ± 0.14 cm [median 2.05 (1.74, 2.40)] and the final mean EL was 3.64 ± 0.27 cm [median 3.64 (2.95, 4.36)]. With respect to EH and the EH above the IMCL, there were significant differences in the right and left ears. The proportion of the right ear above ICML was noted to be 5% greater than the left ear (52% versus 47%). This difference was similarly observed amongst the term infants.

The intra-rater reliability for EW, EL, EH and EH above IMCL ranged from -0.21 to 0.14 mm. The inter-rater reliability ranged from -0.71 mm for right EL to 1.33 mm for right EW (Table 3).

There was no difference in the EW and EL between male and female babies (P = 0.434 and P = 0.113 by Kruskal-Wallis test, respectively). There was also no difference in EW and EL between the races (P = 0.272 and P = 0.293 by Kruskal-Wallis test, respectively).

Exploration was carried out to study the relationship of both the final EW and EL with gestational age, birth weight, length, and OFC as well as weight, length, and OFC at the time of ear measurement (Table 4). By convention, a correlation of co-efficient of ≥0.4 would imply moderate correlation whilst ≥0.8 would imply good correlation. EW and EL generally correlated only fairly well with all the parameters indicated. Using the Spearman's rho correlation co-efficient as a better guide to validity in view of the asymmetrically distributed data, the best correlation was that for EL with birth weight (P = 0.407).

Table 5 shows the comparisons of this study's findings with those of other authors.

Table 1. Patient Characteristics of the Study Population

Parameter		n = 104
Gestation at birth (weeks)	Mean ± SD Median (range)	38.0 ± 3.0 38.0 (27.0-42.0)
Postmenstrual age at time of measurement (weeks)	Mean ± SD Median (range)	38.3 ± 1.9 39.0 (32.0-42.0)
Birth weight (g)	Mean ± SD Median (range)	2910 ± 657 3013 (855, 3970)
Weight at time of measurement (g)	Mean ± SD Median (range)	2981 ± 554 3023 (1465, 3970)
Length (cm)	Mean ± SD Median (range)	47.9 ± 3.0 48.0 (34.5, 53.0)
Length at time of measurement (cm)	Mean ± SD Median (range)	48.2 ± 2.3 48.0 (41.0, 53.0)
Occipitofrontal circumference (cm)	Mean ± SD Median (range)	33.1 ± 2.3 34.0 (23.5, 37.0)
Occipitofrontal circumference at time of measurement (cm)	Mean ± SD Median (range)	33.6 ± 1.3 34.0 (28.0, 37.0)
Gestational size (SGA:AGA:LGA)		7:96:1
Gender (Male:Female)		61:43
Race (Chinese:Malay:Indian:Others)		50: 35:11:8

AGA: appropriate for gestational age; LGA: large for gestational age; SD: standard deviation; SGA: small for gestational age

Discussion

It is generally agreed that a "standard ear" does not exist. The ear, reaching adult size in later childhood years,[22] not only hears, but also provides clues on genetic syndromes and congenital abnormalities. Neither too large nor too small a ear confers any advantage to the individual. In newborn medicine, exclusion of any malformations or genetic syndromes is an essential component of any screening process. Anthropometric measurements can provide objective quantitative values for what would otherwise be purely qualitative descriptions, in which the subjective element is inherent. In a multi-racial country like Singapore, there have not been any described norms and present examinations are based on mainly Caucasian norms.

Our norms for EL compare interestingly with those for other authors. In general, it can be seen that for term infants, our babies tend to have larger ears than Hong Kong Chinese[18] and African babies,[21] although smaller than those of Caucasians.[20,23] We are perhaps more comparable with Middle-Eastern and Japanese babies.

To validate our study, we performed post-hoc sample size calculations to estimate both the mean EL and mean EW based on the confidence interval for a mean. We assumed that for the mean EL, μ = 3.6 cm, the anticipated SD was σ = 0.26 cm (both values taken from this present study) and that we wanted the precision, ε of the estimate of the mean to be 3%. Thus, the width of the 95% CI for the mean was to be $\omega = \varepsilon \mu = 0.03 \times 3.6 = 0.11$. The sample size as calculated from equation 6.19 of sample size tables for clinical studies[24] was 105 neonates. Similarly for EW, assuming mean was 2.04 cm, SD was 0.16 cm and requiring precision to be ε = 0.03, , i.e. width of 95% CI for mean was to be 0.06, the sample size needed was 105 subjects.

Reports on the influence of sex on auricular parameters have always been inconsistent. With regard to EL, both Feingold and Bossert[19] and Fok et al[18] reported that ears

Table 2. Measurements for the Different Variables

	Left ear		Right ear	
	Mean ± SD	**Median (range)**	**Mean ± SD**	**Median (range)**
EW 1	2.053 ± 0.202	2.025 (1.4, 2.5)	2.087 ± 0.218	2.100 (1.6, 2.7)
EW 2	2.054 ± 0.204	2.000 (1.6, 2.6)	1.954 ± 0.209	2.000 (1.4, 2.5)
Std EW*	2.053 ± 0.184	2.050 (1.55, 2.50)	2.020 ± 0.196	2.050 (1.53, 2.42)
Term EW 1	2.076 ± 0.197	2.050 (1.4, 2.5)	2.111 ± 0.198	2.100 (1.6, 2.6)
Term EW 2	2.084 ± 0.193	2.050 (1.6, 2.6)	1.984 ± 0.188	2.000 (1.5, 2.5)
Term Std EW	2.080 ± 0.174	2.050 (1.67, 2.50)	2.047 ± 0.174	2.050 (1.58, 2.42)
EL 1	3.567 ± 0.276	3.575 (2.9, 4.4)	3.573 ± 0.270	3.550 (2.8, 4.4)
EL 2	3.628 ± 0.264	3.600 (3.0, 4.4)	3.643 ± 0.275	3.600 (3.0, 4.5)
Std EL*	3.600 ± 0.266	3.600 (2.95, 4.38)	3.608 ± 0.267	3.575 (2.9, 4.4)
Term EL 1	3.612 ± 0.274	3.600 (2.9, 4.4)	3.597 ± 0.281	3.550 (2.8, 4.4)
Term EL 2	3.663 ± 0.270	3.650 (3.0, 4.4)	3.668 ± 0.285	3.650 (3.0, 4.5)
Term Std EL	3.637 ± 0.268	3.625 (2.95, 4.38)	3.633 ± 0.277	3.600 (2.9, 4.4)
EH 1	3.379 ± 0.281	3.400 (2.8, 4.1)	3.480 ± 0.295	3.500 (2.8, 4.4)
EH 2	3.405 ± 0.274	3.450 (2.8, 4.3)	3.485 ± 0.290	3.500 (2.8, 4.3)
Std EH†	3.392 ± 0.267	3.425 (2.88, 4.08)	3.483 ± 0.284	3.475 (2.85, 4.35)
Term EH 1	3.418 ± 0.268	3.450 (2.8, 4.1)	3.506 ± 0.301	3.500 (2.8, 4.4)
Term EH 2	3.436 ± 0.277	3.450 (2.9, 4.3)	3.511 ± 0.291	3.500 (2.8, 4.3)
Term Std EH†	3.427 ± 0.262	3.450 (2.88, 4.08)	3.509 ± 0.288	3.500 (2.85, 4.35)
EH above IMCL 1	1.592 ± 0.411	1.550 (0.3, 2.8)	1.812 ± 0.367	1.725 (1.1, 3.5)
EH above IMCL 2	1.583 ± 0.386	1.550 (0.3, 2.5)	1.787 ± 0.353	1.775 (1.0, 2.6)
Std EH above IMCL†	1.587 ± 0.379	1.563 (0.28, 2.65)	1.800 ± 0.343	1.750 (1.13, 3.03)
Term EH above IMCL 1	1.621 ± 0.391	1.550 (1.0, 2.8)	1.825 ± 0.384	1.700 (1.1, 3.5)
Term EH above IMCL 2	1.611 ± 0.350	1.600 (1.0, 2.5)	1.808 ± 0.337	1.800 (1.1, 2.6)
Term Std EH above IMCL†	1.616 ± 0.351	1.625 (1.00, 2.65)	1.817 ± 0.346	1.75 (1.13, 3.03)
%EH above IMCL 1	46.93 ± 10.95	46.22 (10.7, 78.7)	52.07 ± 9.30	51.34 (32.29, 88.49)
%EH above IMCL 2	46.41 ± 10.61	45.65 (8.45, 69.22)	51.30 ± 9.34	51.37 (30.56, 72.2)
Std %EH above IMCL†	46.67 ± 10.22	46.00 (9.58, 73.94)	51.69 ± 8.80	51.42 (32.19, 80.34)
Term %EH above IMCL 1	47.27 ± 10.12	46.82 (30.50, 76.8)	52.05 ± 9.60	51.28 (32.29, 88.49)
Term %EH above IMCL 2	46.89 ± 9.63	45.71 (30.50, 68.33)	51.57 ± 8.95	51.43 (30.56, 72.20)
Term Std %EH above IMCL†	47.08 ± 9.30	46.17 (30.95, 72.54)	51.81 ± 8.85	51.28 (32.19, 80.34)

EH: ear height; EL: ear length; EW: ear width; IMCL: inter-medial cathal line; SD: standard deviation; Std: standardised; 1st investigator - 1; 2nd investigator – 2

* difference between right and left ears not statistically significant [P = 0.157 (R); 0.508 (L) - Wilcoxon signed rank test]

† difference between right and left ear statistically significant (P = 0.00)

were longer in males. In contrast to that, similar to our study, Kalcioglu et al[15] and Adeyemo et al[22] found no differences between the male and female ear. Furthermore, Sivan et al,[20] similar to our findings, indicated that there was no difference in EL as well as the percentage of ear above the medial canthi between male and female babies. However, the number of study subjects in our study (n = 104) and Sivan et al's study[20] (n = 87) is comparatively much smaller than that of Feingold and Bossert[19] (n = 356) and Fok et al[18] (n = 2384). Therefore, these differences between the sexes may become more evident with a larger study population. Even as the babies grow, controversies on the impact of sex on ear measurements continue to exist.[25-27] Newborn norms as in our study, are therefore important prior to the effect of other factors affecting growth. The definition for small ears, being 2SDs below the norm, should also be established in relation to specific population norms.

Table 3. Intra-rater and Inter-rater Reliability

Measurement	Mean difference between measurements of 1st investigator ± SD*	Mean difference between measurements of 2nd investigator ± SD*	Mean difference between means of 1st and 2nd investigators ± SD†
Left ear			
EW	-0.012 ± 0.092	0.006 ± 0.094	-0.001 ± 0.173
EL	0.012 ± 0.086	0.014 ± 0.075	-0.061 ± 0.095
EH	0.000 ± 0.137	0.001 ± 0.118	-0.026 ± 0.153
EH above IMCL	0.007 ± 0.132	-0.021 ± 0.136	0.009 ± 0.246
Right ear			
EW	0.001 ± 0.088	0.004 ± 0.095	0.133 ± 0.170
EL	-0.005 ± 0.091	-0.015 ± 0.062	-0.071 ± 0.109
EH	0.013 ± 0.110	-0.007 ± 0.082	-0.005 ± 0.139
EH above IMCL	-0.005 ± 0.111	0.009 ± 0.124	0.025 ± 0.224

EH: ear height; EL: ear length; EW: ear width; IMCL: inter-medial canthal line; SD: standard deviation
* The SD here denotes the intra-rater reliability for that investigator for that variable
† The SD here denotes the inter-rater reliability for the 2 investigators for that variable

Table 4. Relationship Between Various Factors and EW/EL

	Ear width		Ear length	
	Pearson's correlation coefficient	Spearman's rho correlation coefficient	Pearson's correlation coefficient	Spearman's rho correlation coefficient
Gestational age	0.397	0.330*	0.325*	0.369
Postmenstrual age at measurement	0.373	0.305†	0.339	0.319*
Birth weight	0.458	0.385	0.359	0.407
Current weight at measurement	0.433	0.332*	0.384	0.394
Length	0.461	0.382	0.339	0.337
Current length at measurement	0.434	0.359	0.326*	0.275
Occipitofrontal circumference (OFC)	0.449	0.337	0.345	0.368
Current OFC at measurement	0.392	0.280‡	0.378	0.315*

* 2-tailed significance with $P = 0.001$
† 2-tailed significance with $P = 0.002$
‡ 2-tailed significance with $P = 0.005$
If not indicated – 2-tailed significance with $P = 0.000$

Table 5. Comparison of Ear Length Between Studies

Source	Year	Race	n	GA (weeks)	Sex	Mean ± SD (cm)
Sivan et al[20]	1983	Caucasian	87	Term	Mixed	3.90 ± 0.30
Tateishi and Kajii[16]	1992	Japanese	100	37-41, Term	50M	3.6 ± 0.25
					50F	3.5 ± 0.25
Adeyemo et al[21]	1998	Nigerian	200	Term, AGA	Mixed	3.2 ± 0.3*
Fok et al[18]	2004	Chinese	2095	Term	Mixed	3.19 ± 0.30†
Kalcioglu et al[15]	2006	Turkish	40	39, Term	Male	3.67± 0.73*
					Female	3.83 ± 0.69*
This study	2005	All races	83	39, Term	Mixed	3.64 ± 0.27*
		Chinese	50			3.59 ± 0.30*

* no significant difference between genders
† males have larger ears

In our study, the differences in measurements amongst the different races were not statistically significant. However, given the small numbers of the minority races in our study, a follow-up study with a larger cohort of babies would be useful in validating these findings.

Ultrasonographic studies have previously reported good correlations between fetal ear length and other fetal biometric measurements.[28,29] In this study, the best correlation noted was between EL and birth weight. In future studies with larger patient cohorts, for the purpose of construction of an EL normogram, weight measurements have to be taken into account.

In formal anthropometry, an objective evaluation of ear position is based on the position of the porion (the most lateral and superior point on the roof of the bony external auditory meatus). However, Robinow and Roche,[30] in their comparison of the level of the external meatus in relation to the skull base on lateral skull radiographs, concluded that the variations in the shape of the cranial base are insufficient to account for the clinical impression of "low-set ears", a subject of considerable debate, which stems from the fact that no consensus has been reached for the appropriate landmarks to be used for comparison. Technically, the ear has been considered low-set when the helix of the ear meets the cranium below that of a horizontal plane through the inner canthi of both eyes.[12] Another definition describes a "low-set ear" as one that is set below an arbitrary line between the lateral cathus of the eye and the occipital protuberance.[13] Taeusch et al[14] described "low-set ears" as ears placed below an extrapolated central horizontal line through bilateral medial canthi. Some other authors use the definition that a line drawn perpendicular to the facial plane, passing backward at the level of the outer canthus of the eye should intersect the insertion of the root of the helix to the scalp. Alternative definitions are that the superior attachment of the pinna should be on or above a line drawn through the outer canthus of the eye and the inner canthus of the eye.

Traditionally, in the local context, the definition of the landmark line vacillates between a line going through the medial and lateral canthi of the eye on the side of the ear being evaluated and a line passing through the medial canthi of both eyes. For this study, the landmark line used was that described by Feingold and Bossert[19] – a horizontal line passing through the medial canthi of both eyes, the IMCL. The lateral canthi were disregarded, as some children may have a mongoloid or antimongoloid slant. This is particularly important in our Asian context.

Further controversy revolves around the expected height of the ear above the landmark line (ranging from landmarks such as the superior attachment of the pinna to 20% of the total EH). Our results indicated that the mean percentage of the ear above the IMCL was 49 ± 8%. This value is much higher than those previously reported by Sivan et al[20] and Feingold and Bossert.[19] Hence, we deduced that the babies in our study population have ears which are "higher set" than those of previously-studied Caucasian babies. Taking 2 SDs below the mean as being "low-set", the definition of "low-set ears" should then be <33% of the EH above the IMCL, which was consistent with the generally accepted definition.

Our findings also revealed that the right ear was 5% significantly "higher-set" than the left ear. A larger ear size was unlikely to be a confounding factor, as the difference between the ear lengths was not statistically significant. A 0.1 cm difference between the right and left EH was deemed to be inadequate to account for the 5% difference in ear position.

There was less than moderate correlation between the percentage of either ear above the IMCL, and gestational or postmenstrual age. This was also previously noted by Sivan et al.[20] During embryogenesis, the pinna undergoes a 90 degrees forward rotation into its final position. Hence, in term babies, the pinna would already be in its final position, with the long axis of the pinna usually not more than 20 degrees posteriorly rotated. Therefore, expansion of the study to include more premature babies is needed to investigate the presence of a trend between the ear position and the gestational age.

Conclusion

The standards for normality in any anthropometric measurements should be clearly set for each individual population. In newborn screening, craniofacial descriptions play an integral part in evaluation and characterisation of dysmorphism. However, limited Asian reports are available, and may not be able to be extrapolated for use in our local population, due to a differing mix of ethnicities. This study has set the baseline measurement norms for a local population, which indicate the presence of differences between even Singapore Chinese and Hong Kong Chinese. Larger population studies may be useful to validate these findings as well as establish other differences more clearly, such as the influence of gender that may not have manifested in this small study.

Subjective evaluation of "low-set ears" has often been prone to misinterpretation as one's impression of "low-set ears" may be influenced by the position of an infant's head (when the neck is extended, the ears appear lower), a high cranial vault, short mandibular ramus or posterior rotation of the auricle around its axis. Hence, to avoid ambiguity, a quantitative measurement of the ear height above the medial canthi may be taken, using a simple instrument such as the one used in this study. This study further validates the general definition of "low-set ears" being "those ears of which less than 33% of the EH is above the landmark line, taken as the IMCL".

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