Radiographic Measurement of Nasopharyngeal Depth from the Anterior Nasal Spine (ND-ANS) Among Filipino Adults

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ABSTRACT

Objective: To determine a normative value for the nasopharyngeal depth from the anterior nasal spine (ND-ANS) among normal adult Filipinos using Computed Tomography scans.

Methods:

Design: Cross-sectional study
Setting: Tertiary National University Hospital
Participants: Of 516 adult patients that underwent facial, neck and temporal bone CT scans in our hospital between January 1 to June 30, 2019, 100 cases were randomized to be included in the study and 91 CT scans were analyzed.

Results: The mean nasopharyngeal depth from the anterior nasal spine among Filipino adults is 7.17 ± 0.42. There was a significant difference between sexes with a mean measurement of 7.23 cm ± 0.44 in males and 7.09 ± 0.37 cm in females. There was no statistically significant difference in mean nasopharyngeal depth across age groups.

Conclusion: A statistically significant difference was observed between sexes in our study sample. Our study provides initial normative values of nasopharyngeal depth among adult Filipinos, and additional studies may use this as a basis for further research.

Keywords: *nasopharynx; adult; Filipino; distance; measurement; sinonasal; anthropometry; Computed Tomography*

The nasopharynx is the upper division of the pharynx posterior to the nasal cavity extending via a straight line to the level of the soft palate. Anatomically this small confined space can harbor multiple pathologies and is difficult to assess and access. Such pathologies include soft tissue masses, malignant lesions and also infectious pathologies such as viruses like SARS-COV2 and Epstein-Barr Virus (EBV)[1] and microbial pathogens that commonly cause respiratory tract infections and chronic rhinosinusitis in adults.[2]

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Nasopharyngeal swabs (such as for diagnosis of coronavirus disease 2019 COVID-19) require personnel with knowledge of the anatomy of the nasopharynx and in accessing this area safely with limited discomfort to the patient. Knowledge of the approximate depth of the nasopharynx in Filipino adults may minimize inadequate access as well as avoid injury to the nasopharyngeal region and complications associated with nasopharyngeal swabbing. Our recent experiences with nasopharyngeal swabbing underscore the clinical importance of adequate nasopharyngeal depth. Shallow swabbing may result in false negatives, while too deep swabbing may result in complications such as discomfort, lacrimation, headache, and the more serious examples such as epistaxis, swab impaction and cerebrospinal fluid leak.[3] Knowledge of the depth of this space may also help to properly acquire samples by using swabs for testing of multiple pathologies (including COVID-19 infection) without the need for direct visualization. Previous studies used an indirect measurement; the curved distance from the alar-facial groove to the tragus, with a mean distance of 9-10cm, to approximate the distance from the nasal sill to the nasopharynx along the nasal floor.[4,5] But to the best of our knowledge, it has not been described among Filipinos. A search of HERDIN Plus, the ASEAN Citation Index (ACI) and MEDLINE (PubMed and PubMed Central) using the keywords or search terms "nasopharynx," "sinonasal" "distance," "adult" and "Filipino" yielded no studies on sinonasal distance among adult Filipinos.

The aim of this study is to determine a normative value for the nasopharyngeal depth from the anterior nasal spine (ND-ANS), which is defined as a parallel measurement running along a straight line starting from the anterior nasal spine to the anterior nasopharyngeal mucosal wall posteriorly along the nasal cavity mimicking passage of a nasopharyngeal swab or rigid sinoscope, among a sample of normal adult Filipinos.

METHODS

With University of the Philippines Manila Research Ethics Board approval (UPMREB-ORL 2021-571-01), a total of 516 facial, neck and temporal bone CT scans obtained using a 16-slice General Electric Computed Tomographic scanner (GE Discovery RT 16-slice, General Electric Healthcare, Philippines) at the Philippine General Hospital from January 1, 2019, to June 30, 2019, were considered for inclusion in this study. The scanner was chosen due to the availability at the time of the study, other scanners were inconsistently available due to repairs and maintenance during this time. Inclusion criteria were age ≥ 20 years with normal intranasal structures and anatomy. Excluded were scans of patients with known history of sinonasal pathology, and those with problems in reconstructing and identifying key landmarks.

Using Openepi® online (Version 3, Rollins School of Public Health, USA), a minimum of 82 samples were needed based on the source population size of 516 CT scans, 50% frequency to maximize sample size, and 10% margin of error. An initial 100 scans were identified via Random Number Generator, comprehensive version, accessible via calculator.net, (Maple Tech International LLC., Texas, USA) and screened according to inclusion and exclusion criteria. Data were collected from CT scan files and official CT scan readings.

The identified CT studies were retrieved from the records section of the Department of Radiology. The obtained CT studies were then transferred to a workstation for analysis using Horos Free DICOM Medical Image Viewer version 3.0 (Horos Project, USA). The CT studies were leveled along the x-y-z axis using 3D Multiplanar Reconstruction to ensure that the images would be along the same plane. The CT scan windowing parameters were as follows: Window Width at 4000 HU and Window Level at 1500 HU were used during the collection of measurements and slice interval was 0.625mm. The team of raters included a resident of ORL-HNS and a board-certified diagnostic radiologist working simultaneously.

The anterior nasal spine was identified along the axial view and was then levelled along the hard palate as seen on the sagittal view, to correspond to point A. Point B would then be the anterior-most portion of the posterior nasopharyngeal mucosa as the image axis was scrolled along the coronal plane posteriorly, until the crosshair was positioned along the posterior nasopharyngeal mucosal wall along the sagittal and axial planes. *(Figure 1)* The distance from point A (*Figure 2*, dashed arrow) to point B *(Figure 2*, solid arrow) was measured in the axial plane (*Figure 2,* dashed line) along the nasal floor of the bilateral nasal cavities. The mean of the two measurements was used for analysis.

Data obtained was tabulated and then summarized in frequency/counts and percentages while summary measures were presented in terms of means and standard deviations. Comparisons were done to determine significant differences between sexes using t-test for independent samples, significant difference among the different age groups by analysis of variance (ANOVA) and association between age and ND-ANS through linear correlation analysis. All tabulations and statistical analyses were performed in Microsoft® Excel for Mac version 16.36 (Microsoft Corp, Redmond, WA, USA).

RESULTS

Of the 512 facial, neck and temporal bone CT scans performed during the study period, an initial random sample of 100 scans were screened according to inclusion and exclusion criteria. Of these, CT scans of 90 individuals (52 males and 38 females) were finally included

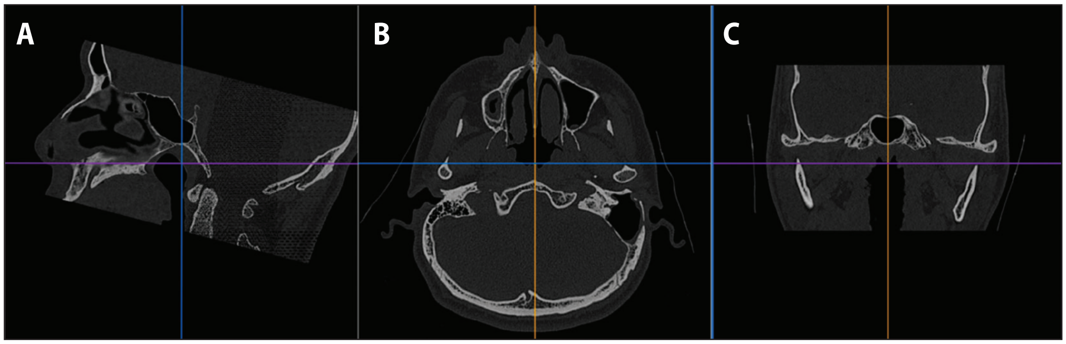

Figure 1. CT DICOM image of Multiplanar Reconstruction. **A.** Sagittal view; **B.** Axial view; **C.** Coronal view

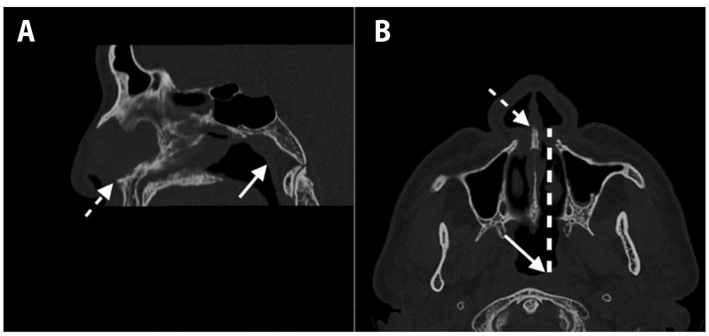

Figure 2. CT DICOM Images of landmarks used for measurement. Anterior nasal spine (dashed arrow), posterior nasopharyngeal mucosa (solid arrow) nasopharyngeal depth from the anterior nasal spine (dashed line); **A.** Sagittal view and **B.** Axial view

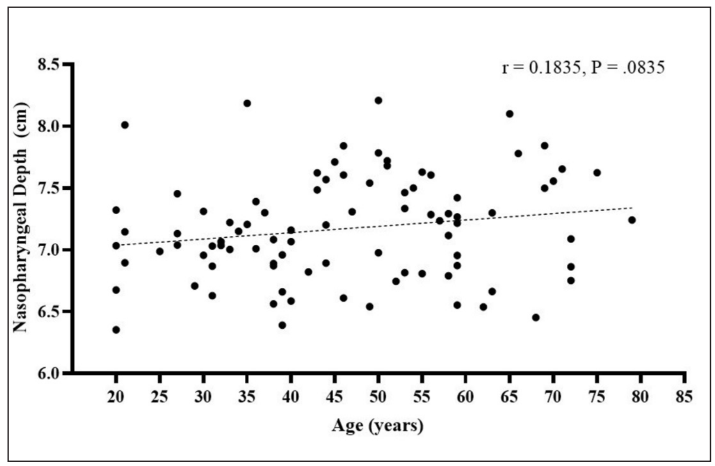

Figure 3. Scatter plot of ND-ANS (cm) versus age (years) in normal adult Filipinos

Table 1. Nasopharyngeal depth from the anterior nasal spine (ND-ANS) in normal adult Filipinos by sex and age

Variable	N	ND-ANS (cm)		
		Mean	Lowest	Highest
Overall	90	7.17 ± 0.42	6.35	8.21
Sex				
Female	38	7.09 ± 0.37	6.35	7.84
Male	52	7.23 ± 0.44	6.39	8.21
Age				
20	4	6.85 ± 0.42	6.35	7.32
21-29	8	7.17 ± 0.40	6.71	8.01
30-39	23	7.03 ± 0.35	6.39	8.19
40-49	16	7.22 ± 0.43	6.54	7.84
50-59	24	7.26 ± 0.40	6.55	8.21
60-69	8	7.27 ± 0.64	6.45	8.10
≥ 70	7	7.25 ± 0.37	6.75	7.65

in the study and analyzed to measure the distance from the anterior nasal spine to the posterior nasopharyngeal mucosa.

The overall mean, minimum, and maximum ND-ANS (measured in cm) in the sample were 7.17 ± 0.42, 6.35 and 8.21, respectively. *(Table 1)* Levene's test for homogeneity of variance showed that there was no statistically-significant difference in the variances of the age group-aggregated ND-ANS of males and females ($F_{(1,89)}$ = 1.58, *p* = .212) and two-tailed t-test for independent samples revealed that the age group-aggregated ND-ANS difference in terms of sex was statistically significant ($t_{(89)}$ = 2.39, *p* = .019). The mean ND-ANS was 7.23 ± 0.44 in males and 7.09 ± 0.37 in females, a difference of 0.14 cm between sexes.

Figure 3 shows the distribution of ND-ANS across age and sex. The mean ND-ANS varied across different age groups, with the lowest mean ND-ANS in the youngest age group and an apparent trend of increasing ND-ANS as age increased as shown in *Table 1*. However, one-way ANOVA to test if there was a difference among the mean ND-ANS across age groups did not show a statistically significant difference. To determine whether there was a correlation between ND-ANS and age, linear correlation analysis was performed which showed a weak linear relationship between these variables that was not statistically significant (Pearson's *r* = 0.184, *p* = .084).

DISCUSSION

Based on the data analyzed in our study, the mean ND-ANS among Filipino adults is 7.17cm ± 0.42, with the male distance being 0.14 cm longer than the female.

Nasopharyngeal swab nucleic acid amplification is the diagnostic gold standard compared to saliva and oropharyngeal swabs in detecting diseases such as COVID-19.[2,6,7] This is in line with the anatomical significance of the nasopharynx as a small, confined space which harbors multiple and microbial pathogens that commonly cause respiratory tract infections and chronic rhinosinusitis in adults.[8] Accuracy of nasopharyngeal swab testing relies on adequate specimen acquisition. As such, there have been active efforts to ensure proper collection of specimens to maximize the accuracy of testing while maintaining comfort for patients - i.e., providing head support, keeping the head level, and travelling along the nasal floor.[9] Such ventures have an impact on the epidemiological study and control of diseases, as well as compliance with local guidelines on testing as published by the Bureau of Quarantine; suggestions include using a 10cm swab stick and inserting it 5-6cm from the nostril; this would be an underestimation considering the findings of this study.[10] One approach involves understanding the anatomy involved in the collection of nasopharyngeal swabs.

This is important as it has been found that one of the most common causes of false negative testing is inappropriate specimen acquisition related to failure to sample the nasopharynx.[5] To elaborate, one must review the steps and important anatomical structures involved in performing a nasopharyngeal swab test. After the patient clears their nasal cavity of mucus and tilts their head backwards by around 30 degrees, the swab is inserted as close to the floor of the nose to pass through the internal nasal valve, which has a notably small cross section of 0.65cm^2. On the way to the nasopharyngeal wall, the swab may hit several structures acting as points of resistance, such as the inferior turbinate and the anterior face of the sphenoid sinus which must be expertly navigated around in order to reach the nasopharynx. Furthermore, obstructions caused by septal deviation, polyps, mucosal hypertrophy, or nasal masses may cause resistance at depths that vary per individual. Use of external estimates to guide the distance and route to the nasopharynx, such as the distance from the philtrum to tragus and the nasal ala to tragus, may lead to overestimation of depth and cause complications.[5] This, paired with the lack of direct visualization to the nasopharynx poses a significant risk of inadequate sampling without proper knowledge of nasal anatomy. As such, it is recommended that swab collectors note the adequate swab depth to best ensure arrival at the nasopharynx.[9]

Nasopharyngeal swab testing is inherently uncomfortable even with a good technique. A study found that Asians recorded a greater level of discomfort from such swabs compared to Caucasian participants possibly due to the narrower nasal passage and varying distances from the nasal ala to nasopharyngeal wall.[11] This is relevant as the greater risk of discomfort has been identified as a factor in deterring testers from inserting the swab to an adequate length especially as increasing depth of swab is directly related with discomfort scores.[11,12] Such deviations from guidelines carries a risk of false negative results which lead to underestimation of the prevalence of disease and a potential increase in the transmission of disease and associated morbidities. On the other hand, there is also a risk of overexaggerating the depth of the nasopharyngeal swab. The measurement found in our study contrasts with the frequently cited mean distance of 9-10cm, based on Western and Korean samples.[4,5] Without considering the shallower nasal cavity of Filipino patients, blind adherence to international figures may lead to false exaggeration that may lead to complications, such as increased discomfort and epistaxis.[3] Indeed, a more recent study demonstrated a shorter nasal cavity length (NCL) of approximately 6 cm among Thais; although dissimilar from our current study, other nasal dimensions and comparisons may be investigated by future studies.[13]

In resource-strained healthcare settings, testers may lack the skill to navigate possible points of resistance in the nasal cavity to arrive at the nasopharynx. This can be due to inadequate training and experience to perform accurate testing.[14] Elucidation of the ND-ANS may provide health care providers with better guidance in collecting nasopharyngeal swab samples.[15]

The immediate clinical significance of the ND-ANS measurement may be helpful in other procedures such as nasogastric tube insertion and nasotracheal intubation, wherein resistances at a certain length may inform that the nasopharynx has indeed been reached. The use of the anterior nasal spine to measure ND-ANS, although ensuring better accuracy of measurements, may differ from a ND-ANS, clinically measured from the alar rim to the posterior nasopharyngeal mucosa which is the actual distance travelled during nasopharyngeal swab testing.

There are other limitations of this study, measurements were simultaneously obtained by an otorhinolaryngology resident together with a board-certified diagnostic radiologist and inter- and intra-observer differences were not identified and no anthropometric measurements were directly collected from the patients. We recommend that future studies have multiple reviewers or teams to separately perform the measurements and identify the landmarks on the CT scans, wherein inter- and intra- observer differences may also be compared, and actual anthropometric measurements may also be compared against these radiographic measurements. A 64-slice or better CT scan unit can also be employed for future studies.

From an epidemiological standpoint, aside from COVID-19, nasopharyngeal samples are also used in the diagnosis of other conditions, such as EBV and other etiologies of URTI. This precludes the need to obtain adequate samples for accurate diagnosis of such diseases while ensuring patient comfort and reducing adverse effects. It is in the researchers' shared opinion that key to this is identifying the depth to the posterior nasopharyngeal wall.

Likewise, knowledge of the ND-ANS may be of interest to medical companies that are looking to reduce cost of production of nasopharyngeal swabs and other cost effectiveness analysis studies may be undertaken from this information. The advent of 3D printing and the proposition of other methods to increase efficiency in production speaks of the maintained interest in this research field. In line with this, such normative values may be used to entice creation of appropriately sized rhinologic and skull base instruments for Filipino and Southeast Asian patients. Such advancements may be mutually beneficial to clinicians, patients, and product designers.

In conclusion, our study provides initial normative values of nasopharyngeal depth from the anterior nasal spine among adult Filipinos. Our recommendations may be explored by other researchers to improve and add on to this knowledge, even among sample populations of the Southeast Asian region.

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