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# Simplified Formula for Estimating Nasal Dimensions for 3-Dimensional Facial Reconstruction among Japanese Adults

**Haruto Matsuda, Tomokazu Kawashima * and Fumi Sato**

Department of Anatomy, School of Medicine, Toho University, 5-21-16 Omori-Nishi, Ota-ku, Tokyo 143-8540, Japan
* Correspondence: tomokazu.kawashima@ed.toho-u.ac.jp

**Abstract:** The eyelids, external nose, and lips play an important role in individual identification and facial recognition; however, they are excluded from tissue marker points, and are reconstructed based on generic methods for 3D facial reconstruction or facial approximation. Therefore, this study focused on nasal dimensions and evaluated whether Krogman's widely used formula for estimating the dimensions of an external nose, regardless of sex, race, and body physique, can be applied to Japanese adults. A total of 146 postmortem CT images of Japanese adult cadavers (64 males and 82 females, aged 58–105 years old) were retrospectively analyzed. The total nasal projection (TNP) among Japanese adults was estimated using the formula, TNP = 1.9 × the anterior nasal spine projection (ANSP) + the mid-philtrum depth (MPD), which differed significantly from the coefficient (3.0) in the conventional formula, regardless of sex, race, and body physique, and therefore needed modification for Asians. Although there was no positive relationship between the total nasal width (TNW) and the maximum width of the anterior nasal aperture (ANAW), the TNW could be estimated by adding soft tissue that varies by sex and body physique to both sides of the nearly constant ANAW. Therefore, we determined a simple and practical formula to estimate nasal dimensions among Japanese adults for conventional 3D facial reconstruction and manual 3D facial sculpture.

**Keywords:** 3D facial reconstruction; computed tomography; nasal approximation; imaging anatomy; nasal anatomy; nasal approximation



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## 1. Introduction

Three-dimensional facial reconstruction or approximation has long been used as an alternative method in forensic sciences, physical anthropology, and anatomy to identify unknown individuals and skeletal remains [1–4]. Therefore, a large amount of skull data, categorized by sex, race, age, and size, have accumulated for facial approximation [5–8]. However, 3D facial approximation of skeletal remains is used less frequently in Japan, and limited data are available on soft tissue thickness [9–15]. Similarly, of the three major ancestry classifications, there is a dearth of gold standard studies on Asians, in contrast to the Caucasoids (European-derived) and Negroids (African-dervived) data that have been collected and analyzed. However, with the development of CT imaging techniques, valuable data on Asians have been published in recent years [16–19]. It is also noteworthy that the anthropology community is attempting to change to another classification system, away from ancestry classification [20].

The conventional 3D facial reconstruction method estimates an unknown face based on soft tissue thickness, which varies by sex, ethnicity, and body physique. Due to the large number of reference points that are generally used (for example, 14 pt [21]; 21 pt [2,15]; and 52 pt [7]), it is difficult to collect a sufficiently large enough number of data points for each sex, race, age, and body physique.

However, reconstruction criteria for eyes, nose, and mouth, which play an important role in personal identification and facial recognition [4,22,23], have been excluded from the conventional measuring marker points of 3D facial reconstruction due to their complex morphometry, large individual differences, and difficulties in obtaining scientific criteria for measurement. Furthermore, these features are also subject to change depending on the degree of skin tension in facial expressions. To address this, Taylor divided the 3D facial reconstruction process into two-phases: “the technical phase” which involves reconstruction based on conventional soft tissue thickness markers, and “the artistic phase” which involves reconstruction using markers such as the eye, nose, and mouth [2].

In the artistic phase, while the setting position of the eyeballs has been analyzed [24–26], methods to reconstruct the eyelids, external nose, and lip dimensions remain controversial [22,23,27]. Considering these technical difficulties, it is better to obtain scientific measurement data for 3D facial reconstruction using the external nose because of low-mobility cartilage framework and thin skin covering [28,29].

To date, the data for estimating nasal projection in 3D facial reconstruction have been proposed using various methods such as the average size of the total nose projection, similar to other markers of soft tissue thickness [30]; the nasofrontal angle method [31]); the angle between the projections of Prosthion and Rhinion points [32]; the two-tangent method [33]; simple calculation formulas [2,34]; and correction measurements using multiple factors [35,36]. Importantly, several studies have detailed the history and the recent advances in methods for predicting nasal projection in facial reconstruction [22,27].

A detailed analysis of more scientifically accurate data and methods using multiple points and factors would be significant for future advances in personal identification. However, considering the complex process of 3D facial reconstruction/sculpture (number of markers, texture, etc.) and tissue thickness data (sex, race, age, and size, etc.), a simple and practical nasal reconstruction method such as a calculating formula is desirable as a means for personal identification. Moreover, while there are other factors related to facial soft tissue thickness, such as measurement methods, sample conditions, and nutrition status in the past and present, we omit them from this report as previous studies have discussed them in detail [4,5,15].

Among these historical and technical transitions [2,4], Krogman’s method is one of the most-used 3D facial reconstruction methods among US practitioners. We hypothesize that there is a need to modify the formula used for nasal reconstruction for Asians, which is considered constant across race and physique. Therefore, this study focuses on evaluating the widely used Krogman’s formula in the US, and aims to provide a simplified and practical formula to estimate nasal dimensions in manual 3D facial reconstruction for practitioners.

## 2. Materials and Methods

### 2.1. Sample

This study used postmortem computed tomography (CT) data of 146 elderly Japanese cadavers (64 males and 82 females; 58–105 years-old, average 86.9 $\pm$ 8.9). All cadavers were donated for anatomical education and research. The elders had a large difference in the degree of tooth loss and alveolar bone resorption; therefore, cases in which bone resorption extended to the nose were excluded from the sample. All cadavers were fixed with 7% formalin solution through the femoral or radial artery, and scanned from the head to pelvic floor range using a 16-row detection medical CT scanner (SOMATOM Emotion 16; Siemens Healthcare GmbH Erlangen, Germany). The imaging acquisition conditions were set as follows: tube voltage, 110 kV or 130 kV; current, 110–130 mAs; detector pitch, 1.0; slice thickness, 0.75 mm; and reconstruction, 0.4–0.6 mm. The protocol for this study was reviewed and approved by the ethics committee of Toho University Faculty of Medicine (reference numbers: A21069 and A20003_A17105). All of the work was conducted in accordance with the provisions of the 1995 Declaration of Helsinki (revised in Edinburgh in 2000).

### 2.2. Physique Classification

For physique classification, the Body Mass Index (BMI) of cadaveric samples was calculated using the following formula.

Body Mass Index (BMI) = body weight (kg)/body height (m)$^2$

The physiques were classified into three groups based on BMI criteria (2002) of the Japan Society for the Study of Obesity (JASSO) [37]: slender < 18.5; normal 18.5–25; obese > 25.

Consequently, the physique groups of our samples were categorized as follows: 64 males (22 slender, 34 normal, and 8 obese samples) and 82 females (32 slender, 38 normal, and 12 obese samples).

### 2.3. Terminologies Surrounding the Nose Region

The terminologies used were modified based on terms used by Taylor [2].

Total nose projection (TNP): nose projection from anterior nasal spine base to pronasale.
Exposed nose projection (ENP): nose projection from subnasale to pronasale.
Anterior nasal spine projection (ANSP): anterior nasal spine length from base to tip.
Mid-philtrum depth (MPD): depth of vertical line connecting anterior nasal spine base and alveolar region, which corresponds to marker 5 for 3D facial reconstruction.
Mid-philtrum groove depth (MPG): maximum depth of mid-philtrum groove.
Total nasal width (TNW): maximum width between the most lateral points on the nasal ala.
Anterior nasal aperture width (ANAW): maximum width of the anterior nasal aperture.

### 2.4. Imaging Analysis

All The postmortem CT datasets were denoised to reduce various artifacts using a commercial iterative image reconstruction software (SafeCT, Media Vision Imaging Solutions, Israel). All measurements were carried out using a commercial medical imaging workstation (Osirix MD Ver. 12.0, Pixmeo SARL, Geneva, Switzerland) installed on a Macintosh PC (iMac Retina 4K, Apple Inc., Cupertino, CA, USA) and all presentation images were reconstructed using a DICOM workstation (ZioCube Ver. 1.02.0, Ziosoft Inc., Tokyo, Japan) installed on a Windows PC (Prodesk 400 G4, Japan HP development Co., Tokyo, Japan).

All image measurements were taken five times for each point using the measuring tool function of the imaging software. These measurements were relative to the Frankfurt horizontal plane that connects the infraorbital margin and the upper edge of the outer ear canal (Figure 1A). The TNP, ENP, ANSP, MPD, and MPG were measured on the left lateral plane to the Frankfurt horizontal plane (Figure 1B), and TNW and ANAW were measured on the frontal plane (Figure 1C). For the MPD and MPG in the subnasale region, the measurement was obtained using the vertical line connecting the ANSP and alveolar region for use in manual 3D facial reconstruction and sculpture methods (Figure 1D,E).

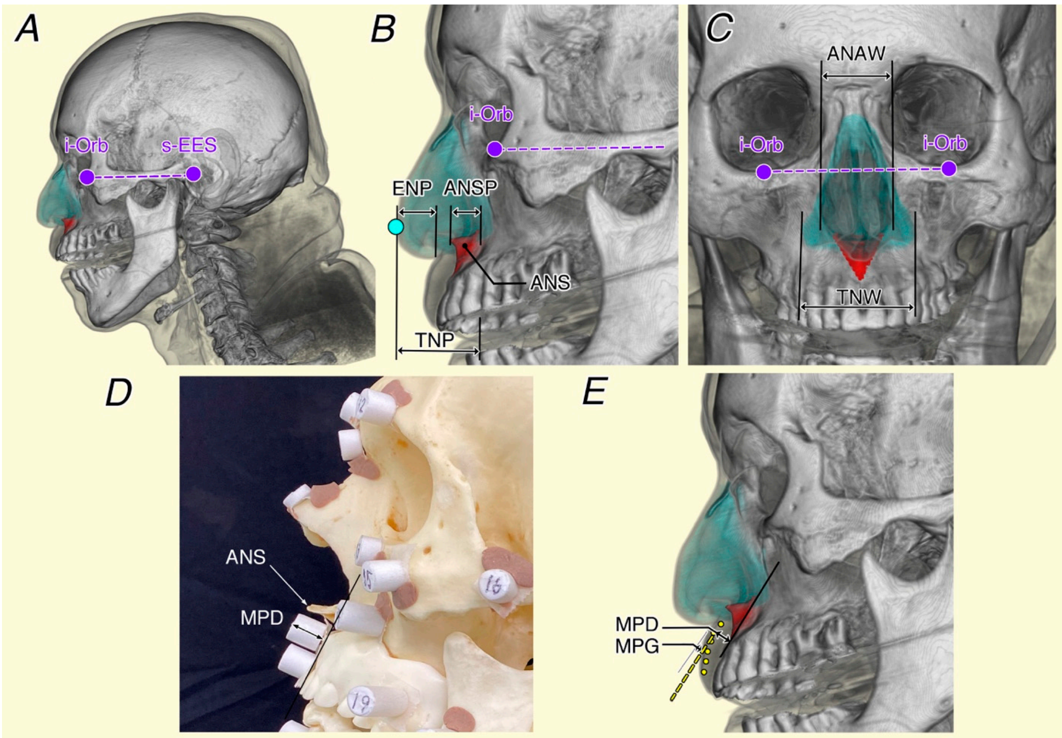


**Figure 1.** Reference anthropological landmarks. The anterior nasal spine (ANS) is shown in red and the pronasale is shown as a light blue dot. (**A**) The Frankfurt horizontal plane that connects the infraorbital margin and the upper edge of the outer ear canal was used in all measurements. (**B**) The measuring points for the total nasal projection (TNP). (**C**) The measuring points for the total nasal width (TNW). (**D**) The position of the mid-philtrum depth marker standing onto the connecting line between the anterior nasal spine base and alveolar region in the actual 3D facial reconstruct. (**E**) Measuring point for mid-philtrum depth in imaging analysis. ANAW, maximum width of anterior nasal aperture; ANS, anterior nasal spine; ANSP, anterior nasal spine projection; ENP, exposed nasal projection; i-Orb, inferior border of orbit; MPD, mid-philtrum depth; MPG, mid-philtrum groove; s-EEC, superior border of external ear canal; TNP, total nasal projection; TNW, total nasal wide.

## 3. Results

### 3.1. Anatomy of Subnasal Region

The philtrum is anatomically recognized as a groove and provides important information on nose region that is used in other nasal calculation formulas.

Due to alveolar resorption and age-related changes among the elderly, the MPG and MPD tended to be unclear compared to the younger cadavers, but were recognizable in both the axial and 3D volume rendering images (Figure 2A,B). The MPG consisting of a central groove sandwiched between two ridges, which was distinguishable as a band-like structure with different contrast. The MPD consisted of a plane thickness in the lateral 3D volume rendering view (Figure 2C), ranging from 4.3 to 19.1 mm (mean 9.8 ± 2.6 <SD>). In general, the MPD became thicker depending on body shape (Figure 3A–C and Table 1), and was somewhat thicker among males than females. However, among the elderly, we observed the opposite configuration, where the obese MPD (Figure 3D) was thinner than in the slender MPD (Figure 3E) due to alveolar resorption associated with tooth loss (Figure 3D,E). Both cases were accompanied by alveolar resorption.

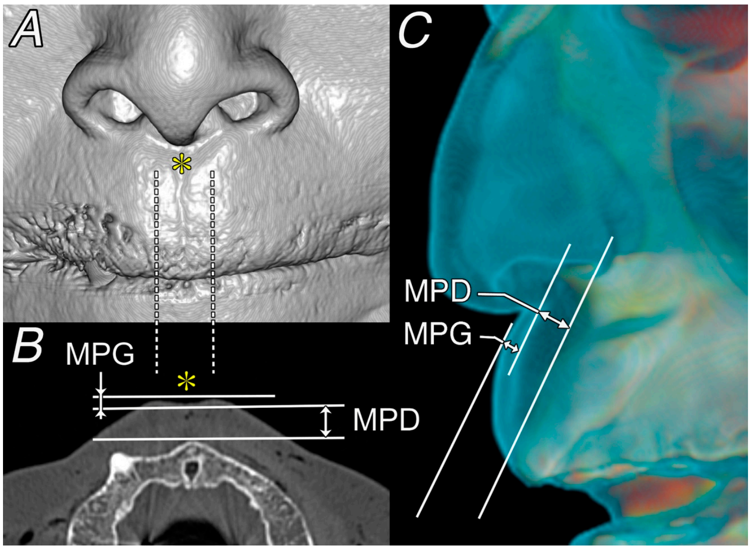


**Figure 2.** Anatomy and imaging of the nasal philtrum region in the anterior view in: (**A**) 3D volume rendering, (**B**) axial plane, and (**C**) left lateral view. The asterisk shows the groove in the mid-philtrum region. MPD, mid-philtrum depth; MPG, mid-philtrum groove.

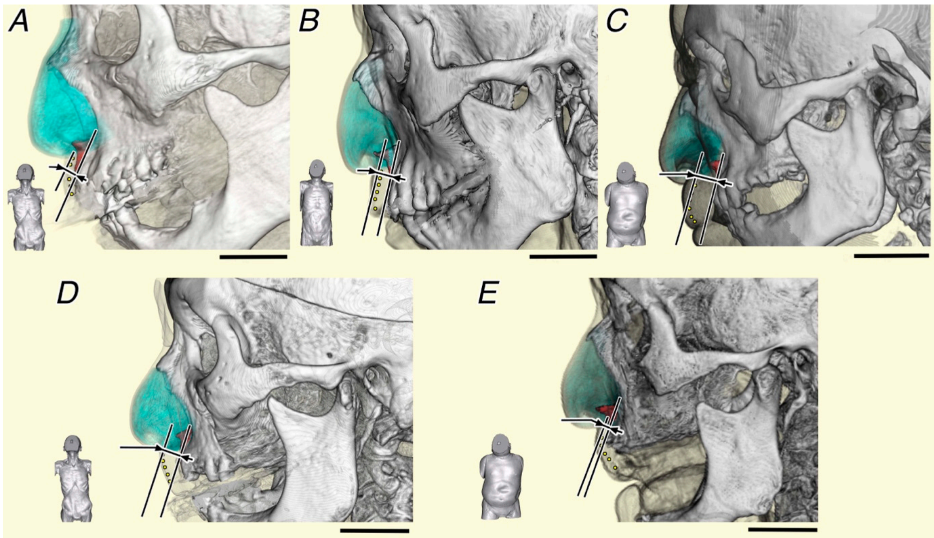


**Figure 3.** The changes in the mid-philtrum depth (MPD) in various body physiques: (**A**) slender, (**B**) normal, and (**C**) obese. In general, with physique changes from slender to obese, the MPD also thickens; however, the MPD varies widely individually. (**D**) Slender with thick MPD. (**E**) Obese with thin MPD. Scale bar: 30 mm.

**Table 1.** Sex and physique differences in mid-philtrum depth (MPD).

| | **Slender** | | **Normal** | | **Obese** | |
|---|---|---|---|---|---|---|
| **Sex (N)** | **Male (22)** | **Female (32)** | **Male (34)** | **Female (38)** | **Male (8)** | **Female (12)** |
| Ave. ± SD | 8.9 ± 2.5 | 8.2 ± 2.0 | 9.7 ± 2.8 | 9.6 ± 2.6 | 11.1 ± 2.9 | 11.6 ± 2.5 |
| Max. | 15.7 | 13.6 | 15.6 | 19.1 | 16.5 | 15.7 |
| Min. | 5.7 | 4.3 | 4.6 | 4.8 | 7.2 | 7.0 |

Even with this age-based variation, the ANSP shown in red (Figure 1) was not affected due to careful sample selection. In other words, the ANSP of our analyzed material series was independent of the MPD.

### *3.2. Total Nose Projection (TNP)*

First, we studied a simple method to estimate the TNP from only the ANSP regardless of the MPD, which varied greatly among the elderly in the calculation method.

Distribution plots were created for each gender and body physique, and approximate straight lines were calculated for each taxon to provide clues for the calculation formula (Figure 4). The results revealed positive correlations for some groups, but comparisons between groups sorted by gender and body physique resulted in different formulas. These were not practical for our use because they resulted in complex calculation formulas that differed for each classification group.

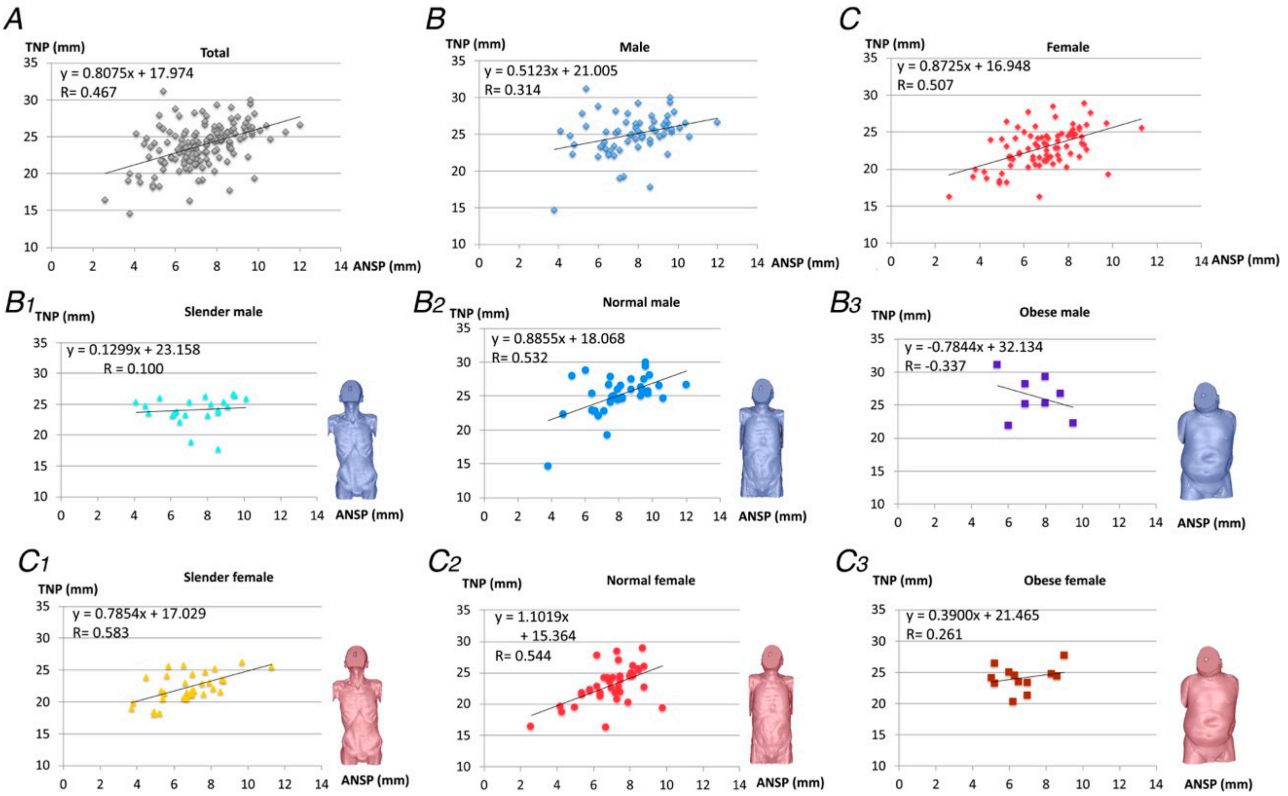


**Figure 4.** Scatterplots of the relationships between total nasal projection (TNP) and anterior nasal spine projection (ANSP) grouped by gender and body physique. (**A**) Total samples. (**B**) Male. (**C**) Female. (**B1**,**C1**) Slender. (**B2**,**C2**) Normal. (**B3**,**C3**) Obese.

Subsequently, the relationship between the exposed nose projection (ENP), from subnasale to pronasale, and the ANSP, which is considered relatively stable, was tested. The relationship between the ENP and the ANSP overall, and for each group sorted by gender and body physique, are shown in Figure 5. The results show that the slope of the approximate straight line was 1.90–1.92, indicating a similarly proportional relationship was relatively correlated for all classification groups. These results indicate that the ENP can be precisely calculated from the ANSP. While the ENP is not necessarily equal to "TNP minus MPD," the calculating formula for Japanese elderly, both male and female, can be estimated using the following formula by modifying the conventional calculation formula:

$$\text{TNP} = 1.9 \times \text{ANSP} + \text{MPD} \quad (1)$$

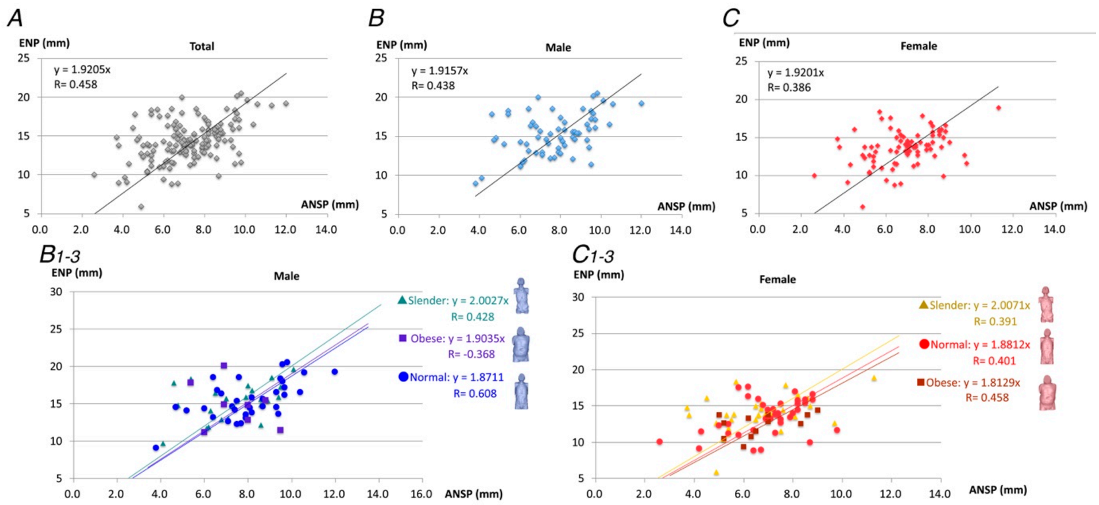


**Figure 5.** Scatterplots of the relationship between exposed nasal projection (ENP) and anterior nasal spine projection (ANSP) sorted by gender and body physique. (**A**) Total samples. (**B**) Male. (**C**) Female. Combined scatterplots and their approximate lines show consistent coefficients regardless of body physique in male (**B1-3**) and female (**C1-3**).

### *3.3. Total Nasal Width (TNW)*

For estimation of the total nasal width (TNW), the relationship between the TNW and the maximum width of the anterior nasal aperture (ANAW) was examined (Table 2). The results showed that the TNW was larger among males than females, and that it increased as the body physique changed from slender to obese, while the ANAW was almost consistent (Figure 6 and Table 3). However, it should be noted that even among pure-blooded Japanese people without mixed ancestry, there are more significant individual differences in the form of the anterior nasal aperture, similar to other ancestries (Figure 6).

**Table 2.** Unilateral soft tissue width added to the maximum width of the anterior nasal aperture (ANAW) for the total nasal width estimation.

| | Slender | | Normal | | Obese | |
|---|---|---|---|---|---|---|
| **Sex (N)** | **Male (22)** | **Female (32)** | **Male (34)** | **Female (38)** | **Male (8)** | **Female (12)** |
| Ave. ± SD | 8.9 ± 1.9 | 7.1 ± 1.3 | 9.1 ± 1.9 | 8.5 ± 1.8 | 10.5 ± 1.9 | 8.9 ± 1.7 |
| Max. | 12.6 | 9.7 | 13.9 | 12.6 | 13.0 | 11.0 |
| Min. | 5.3 | 4.6 | 5.2 | 5.5 | 7.6 | 5.6 |

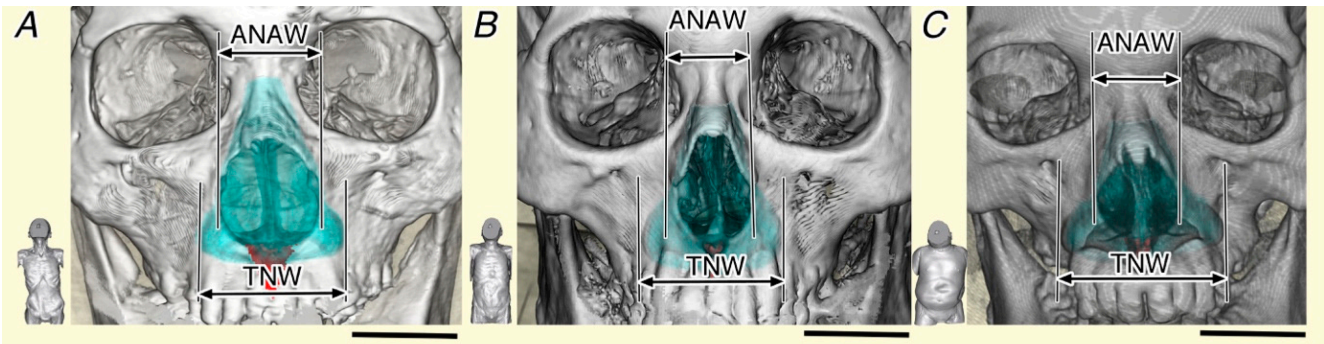


**Figure 6.** Total nasal width changes linked to body physique. (**A**) Slender. (**B**) Normal. (**C**) Obese. ANAW, maximum width of anterior nasal aperture; TNW, total nasal wide. Scale bar: 30 mm.

**Table 3.** Sex and physique differences between the total nose width (TNW) and the maximum width of the anterior nasal aperture (ANAW).

| | Slender | | Normal | | Obese | |
|---|---|---|---|---|---|---|
| | Male (22) | Female (32) | Male (34) | Female (38) | Male (8) | Female (12) |
| TNW (Ave. ± SD) | 41.94 ±3.42 | 38.78 ± 2.20 | 42.69 ± 3.14 | 40.76 ± 2.85 | 44.73 ± 3.80 | 41.23 ± 2.68 |
| ANAW (Ave. ± SD) | 24.10± 2.03 | 24.66 ± 2.04 | 24.48 ± 1.83 | 23.67 ± 2.01 | 23.75 ± 1.39 | 23.46 ± 1.98 |

To obtain further insight on the TNW, analysis of the correction coefficient between the TNW and the ANAW sorted by gender and body physique (Figure 7) showed that the trends in the distribution plots portrayed no proportional relationship and no correlation coefficient. These statistical results indicate that the TNW is independent of body physique and does not correlate with the ANAW, suggesting that it is a better alternative to add average soft tissue width values (Table 2) to the ANAW.

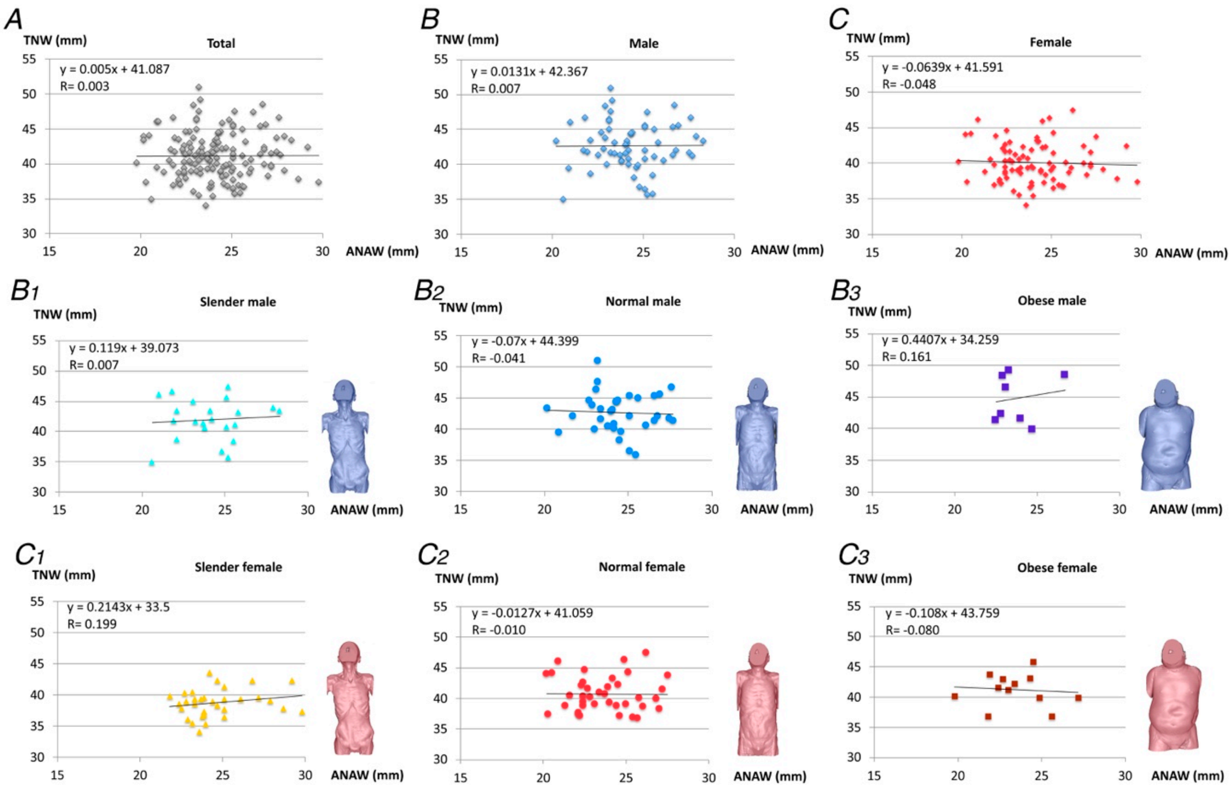


**Figure 7.** Scatterplots of the relationships between the total nasal width (TNW) and the maximum width of the anterior nasal aperture (ANAW) sorted by gender and body physique. (**A**) Total samples. (**B**) Males. (**C**) Females. (**B1**,**C1**) Slender. (**B2**,**C2**) Normal. (**B3**,**C3**) Obese.

## 4. Discussion

In this study, we successfully determined a simple and practical formula to estimate nasal dimensions among Japanese adults for 3D facial approximation.

Considering the practical aspects of 3D facial reconstruction, Krogman's formula, which is widely used in the field of facial sculpture, is a good method to calculate the nasal area. However, it does not take into account differences by race or sex. In this study, we first examined: (1) whether this method is applicable to Japanese (Asian) adults, and (2) whether a similar and simple calculation method can be used.

Krogman's formula used for nasal projection is as follows.

$$TNP = ENP + MPD = 3 \times ANSP + MPD \quad (2)$$

As an element of this calculation formula, the MPD has been analyzed in many studies. In particular, studies of the MPD comparing data sorted by gender, race, and body physique (Table 4) suggest that the MPD increases in the following order: slender, normal, and obese for body physique; male rather than female for sex; and Caucasian, Asian, and Negroid for ancestry [38–41].

**Table 4.** Comparison data on the Mid-Philtrum depth (Marker #5).

| Authors | Races | Slender | | Normal | | Obese | |
|---|---|---|---|---|---|---|---|
| | | **Male (n)** | **Female (n)** | **Male (n)** | **Female (n)** | **Male (n)** | **Female (n)** |
| Rhine & Cambell (1980) | American Negroids, Adults (African-derived) | 11.75 (24) | 10.00 (5) | 12.25 (27) | 11.25 (10) | 11.75 (1) | 12.00 (2) |
| Rhine & Moore (1984) | American Caucasoids, Adults (European-derived) | 6.25 (3) | 5.00 (3) | 10.00 (37) | 8.50 (19) | 11.00 (8) | 9.00 (3) |
| Rhine (1983) | Southwestern American Indians, Adults (Asian-derived) | 7.50 (4) | 10.00 (1) | 9.75 (9) | 10.00 (2) | 9.25 (5) | 8.51 (3) |
| De Greef (2006) | Caucasoids | | | | | | |
| | 18–29 yo | 11.6 (28) | 10.0 (56) | 11.2 (149) | 9.8 (149) | 10.8 (34) | 9.8 (29) |
| | 30–39 yo | 9.5 (3) | 8.7 (12) | 10.6 (37) | 9.2 (40) | 10.7 (31) | 8.8 (20) |
| | 40–49 yo | 13.1 (1) | 8.2 (12) | 9.7 (24) | 8.5 (32) | 10.6 (35) | 9.3 (21) |
| | 50–59 yo | 10.3 (2) | 7.3 (4) | 10.4 (18) | 8.1 (29) | 10.4 (45) | 9.1 (41) |
| | 60+ yo | NA (0) | 7.0 (7) | 9.0 (13) | 8.0 (37) | 9.9 (37) | 8.7 (43) |
| Dong et al. (2012) | Chinese, Adults | 10.87 (23) | 8.69 (42) | 11.64 (34) | 9.97 (64) | 12.66 (18) | 11.24 (19) |
| Kimura & Okazaki (2018) | Japanese, Adults | 11.7 (13) | 10.2 (25) | NA (0) | NA (0) | 11.5 (16) | 11.1 (4) |
| Present study | Japanese, Adults | 8.9 (22) | 8.2 (32) | 9.7 (34) | 9.6 (38) | 11.1 (8) | 11.6 (12) |

Our results on the average thickness of the MPD sorted by sex and body physique were also intermediate in size between Caucasians and Negroids. However, there were large individual differences among the Japanese elderly (4.3–19.1 mm, Ave., 9.8 ± 2.6 <SD>). The large individual variation among the elderly may be attributed to the effect of tooth loss, although it is observed that the effect does not often extend to the anterior nasal spine [42]. In our sample, those with severe bone resorption extending to the anterior nasal spine were excluded, suggesting that the effect of bone resorption on measurements was not significant. Therefore, it is important to compare younger Japanese samples.

Recently, Kimura and Okazaki (2018) analyzed the younger Japanese population, but they classified only two groups of body shape, namely, slightly slender and slightly obese [15]. Compared to previous data, their ages for the slightly slender individuals were higher, while those ages for the slightly obese individuals were lower, probably because the normal group was distributed among these two groups. Therefore, it was difficult to assess the effect of tooth loss from these data. In the future, further data collection on sex and body physique differences are needed for more reliable and accurate facial reconstruction, both in terms of the Japanese population and the MPD.

Due to the remarkable individual variation in this study's MPD, we first tried to identify an estimating formula for the TNP regardless of MPD; however, the calculating formula differed significantly depending on sex and body physique, making it impractical and difficult to use. However, the relationship between the ENP and the ANAP was stable across genders and body physiques with a constant proportional relationship of 1.90–1.92. With this correlation identified, the conventional formula of Krogman [34] can be simply calculated among the elderly Japanese by modifying its proportional coefficient from 3.0 to 1.9.

The limitations of this study include possible tissue shrinkage of the face due to sample fixation and postmortem changes in size. In our analysis we used formalin-fixed samples and some shrinkage effect, even in the restored face, was observed [21,43]. However, the nasal area contains little fat tissue and is dominated by external nasal cartilage. Hence, while it is not easy to compare between living and postmortem differences in the same individual, it is necessary to evaluate them in future, alongside investigations of differences in nasal fixation.

Furthermore, it is interesting to note that the relationship between the ENP and the ANSP is consistently and approximately 1.9 times greater among the Japanese population than the conventional 3.0 times in the previous formula. This is a population difference. We also recognize that no consensus has yet been reached on how to use the nasal bridge and the ANSP to predict the nose projection [27,44–46]. However, the simple Japanese (Asian) calculation formula presented here for nasal dimensions is significant as an alternative.

Consequently, after modifying Krogman's formula, at least for the Japanese (Asian) population, the following estimating formula should be used:

$$\text{TNP} = \text{ENP}\ (1.9 \times \text{ANSP}) + \text{MPD} \quad (3)$$

Compared to nasal projection research, there are limited studies on nasal width in the available literature [31,35,36]. Ryu et al. (2020) assessed many measuring points on the nose, including the ATNW, and examined their relationships to major craniofacial landmarks [36]. Their results showed that the TNW was approximately 1.6 times greater than the ANAW. Rynn et al. (2010) also showed similar results: 1.60 times in Central Asian ancestry, 1.65 times in European ancestry, and 1.75 times in African ancestry [35]. Our results do not show such proportional relationships. Allams et al. (2018) provided the following calculation formula for Caucasian children: TNW = 34.512 − 0.172 × ANAW [31]. However, this formula is applicable only to children and not to adults. In fact, the average size was 41.15 mm among males and 37.62 mm among females of Korean ancestry [36], compared to 35.97 mm among people of European ancestry, 38.68 mm among people of Central Asian ancestry, 42.90 mm among people of African ancestry [35], and 42.4 mm among males and 41.6 mm among female Japanese adults (the present study). Nevertheless, as population differences cannot be ignored with respect to the TNW, it appears that the formulas for specific ancestries cannot be adapted to other ancestries.

However, for the TNW, Krogman's formula is also frequently used as a simple method to calculate nasal width, which is calculated by adding the tissue thickness that varies by race to the maximum width of the ANAW [34]. The tissue thickness to be added was 10 mm in total with 5 mm per side for Caucasoids; 16 mm in total with 8 mm per side for Negroids; and was not stated for Asians. Therefore, Taylor calculated a total of 13 mm with 6.5 mm per side for Asians as the intermediate between Caucasoids and Negroids [2]. The above calculation method for the TNW, as with the TNP, does not take sex or body physique into account.

Our results for the Japanese elderly showed a slight sex difference in the TNW (42.4 mm for males and 41.6 mm for females), but there was no proportional relationship between the TNW and ANAW, nor any correlation coefficient. Importantly, our results showed that the TNW was larger among males than females, and it increased as body size changed from slender to obese, but the ANAW remained unchanged. Since the average soft tissue thicknesses added to the ANAW showed gender and body physique differences, adding the average soft tissue thicknesses to both sides of the ANAW (Table 2) may be an appropriate method to estimate the TNW in a simplified manner.

In the future, detailed data on nose approximation for computer-assisted and deep learning facial reconstruction will be essential, and we strongly hope for more progress in this area.

## 5. Conclusions

Along with the progress in advanced research for more detailed nasal approximation, it is important to provide practitioners with a simplified and practical formula to estimate nasal dimensions in conventional 3D facial reconstruction or sculpture that use numerous markers that vary by gender, race, body size, age, and other factors. Importantly, this study clarified the difficulty in applying Krogman's formula to Japanese adults. Our results showed that the formula for the total nasal projection, TNP = 1.9 × anterior nasal spine projection (ANSP) + mid-philtrum depth (MPD), differed significantly from the coefficient (3.0) in Krogman's formula. Hence, we modified the formula for Asian adults. Furthermore, to improve accuracy, it is necessary to examine differences in measurement and preservation methods.

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