



# Assessment of Anatomical Variation of Styloid Process in Multidetector Computed Tomography

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## Abstract

**Objective:** This study aimed to assess the anatomical variation of the styloid process of Nepalese individuals by using multi-detector computed tomography scans. It was carried out to establish the baseline for the normal length of the styloid process and to compare the variability of styloid process measurement between different age group and gender.

**Materials and methods:** This quantitative, cross-sectional was performed in the Department of Radiology and Imaging, Tribhuvan University Teaching Hospital. Imaging data were collected over the period of January to April 2021 with the total number of 153 individuals. The age and gender of the individuals were noted. The measurement was done in the Multiplanar Reconstruction (MPR) coronal sections of Head and Neck, PNS and Cerebral Angiography. Various Styloid Process (SP) morphology parameters like RLSP, RGSP, LLSP, LGSP, Right Elongation Type, Right Calcification Type, Left Elongation Type, and Left Calcification Type was measured.

**Results:** The measurement of the length of SP was found to be  $3.06 \pm 0.72$  cm (ranged 1.80-5.54 cm) in right SP while that of left SP was  $3.08 \pm 0.72$  cm (ranged 1.45-5.69 cm). The gap between the SP and the calcification pattern was found to be  $0.51 \pm 0.30$  cm (ranged 0.08-1.20 cm) in right SP while that of left SP was  $0.63 \pm 0.43$  cm (ranged 0.08- 1.97cm). Similarly, there was a statistical significant difference between the RLSP-RGSP and LLSP-LGSP. The length of styloid process was found to be higher among male than in female. But there was no statistical significant difference between male and female in the SP measurement. The series of elongation patterns were found to be normal SP, followed by elongated, distant elongated, pseudoarticulated, and segmented SP. The series of calcification patterns were found to be calcified SP, followed by nodular, partial, and outlined SP.

**Conclusion:** In this study, the valuable information regarding anatomical length and variation of styloid process with respect to age and gender among the Nepalese individuals was found. 3D CT reconstruction is a gold standard investigation that helps in studying the relation of the SP with surrounding structures.



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## Introduction

The styloid process (SP) is a cylindrical bony projection that passes throughout the skull base and lies in front of the stylo-mastoid foramen. It lies in between the internal and external carotid arteries, posterior to the tonsillar fossa, and lateral to the pharyngeal wall [1,2]. The normal length is between 2 and 3 cm. The styloid process is considered to be elongated if more than this. The elongated SP is associated with Eagle syndrome [3-6]. In an adult individual, the styloid ligament, which is usually formed by dense fibrous connective tissue, may retain some of its embryonic cartilage and thus has the potential of becoming partially or completely ossified. Thus, the solidification of these structures may cause pain in some individuals [7]. On various variations of SP, the most common is the elongation of the styloid process, while the least common is the complete ossification of the styloid chain. All of these variations may be associated with some clinical symptoms, such as sore throat, foreign body sensation, pain during swallowing, facial neuralgia, headache, and temporomandibular joint disorders. These symptoms are present in Eagle syndrome and the main cause of it is due to the compression of various nervous and vascular structures around it [3-6]. Computed tomography (CT) provides a three dimensional visualization of styloid process and thus aids on an accurate diagnosis. CT scan provides the detailed anatomical visualization of several variations in the styloid chain, including differences in styloid process length, levels of styloid ligament ossification, and the type calcification [8, 9].

Thus, the study aimed to assess the anatomical variation of the SP of Nepalese individuals by using multi-detector computed tomography scans as well as to establish the baseline for the normal length of the styloid process with various parameters like length of Right Length of Styloid Process (RLSP), Right Gap of Styloid Process (RGSP), Left Length of Styloid Process (LLSP), and Left Gap of Styloid Process (LGSP) and to compare the variability of styloid process measurement between different age group and gender.

## Materials and Methods

This was a quantitative cross-sectional study conducted at the Department of Radiology and Imaging, Tribhuvan University Teaching Hospital (TUTH) for the period of four months from January to April 2021. All the subjects who visited for CT scan examination of Head and Neck, Paranasal Sinuses (PNS) and Cerebral Angiography without pathological findings related to SP were included in the study. Measurement was performed on coronal sections and evaluation of its variation in coronal and sagittal sections.

Adult subjects of both the genders above 18 years of age were included in the study. Individuals with incomplete SP or only on one side and with the clinical history of chronic tonsillitis and chronic throat pain were excluded. In this study, different measurements were taken in coronal MPR of CT scan of Head and Neck, PNS and Cerebral Angiography. CT scan was performed on 128 slice MDCT scanner (Seimens Somatom Definition As<sup>+</sup>, TUTH, Biomedical equipment no: 1001915) and data collection and measurement was done in Syngo.Via workstation with resolution of 3 megapixel. Statistical analysis was carried out with the help of SPSS version 20 (IBM, Version: 20.0, Window OS) and Microsoft Excel 2013 (64 bit OS). The mean, SD, and comparison of the length of RLSP, RGSP, LLSP, and LGSP. Data were presented as mean and SD for all variables. The patient's age, sex, RLSP, RGSP, LLSP, LGSP, Right elongation, and

calcification, and Left elongation and calcification were recorded. Data were obtained and analyzed using descriptive statistics to summarize the information and non-parametric test like Wilcoxon, Mann-Whitney, Chi-Square, and Spearman's correlation coefficient. A 95% confidence interval was taken and p value less than 0.05 was considered to be statistically significant.

## Results

The data was collected from 153 subjects. Among them, 105 (68.63%) were males and 48 (31.37%) were females with the age range from 18 to 100 years. The mean age of the patients was  $51 \pm 19$  years.

**Table 1:** Distribution of mean, SD, and Range of the total sample.

Parameter	Mean $\pm$ SD (cm)	Range (cm)
RLSP	3.06 $\pm$ 0.72	1.80-5.54
RGSP	0.51 $\pm$ 0.30	0.08-1.20
LLSP	3.08 $\pm$ 0.72	1.45-5.69
LGSP	0.63 $\pm$ 0.43	0.08-1.97

The mean value of the RLSP of the total sample was found to be  $3.06 \pm 0.72$  cm with a maximum of 5.54 cm and a minimum of 1.80 cm. The mean value of the RGSP of the total sample was found to be  $0.51 \pm 0.30$  cm with a maximum of 1.20 cm and a minimum of 0.08 cm. The mean value of the LLSP of the total sample was found to be  $3.08 \pm 0.72$  cm with a maximum of 5.69 cm and a minimum of 1.45 cm. The mean value of the LGSP of the total sample was found to be  $0.63 \pm 0.43$  cm with a maximum of 1.97 cm and a minimum of 0.08 cm. From Wilcoxon signed test, it was found that there was no statistically significant difference between the right and left length of SP. And there was no significant difference between the right and left a gap of SP. There was a statistically significant difference between the RLSP and the RGSP and also it was found that there was a statistically significant difference between the LLSP and LGSP at a significant level of P-value of  $<0.05$ .

**Table 2:** Distribution of Mean Value, SD, Range, and P-value in males and females.

Parameter	Males	Females
RLSP	3.11 $\pm$ 0.76	2.96 $\pm$ 0.64
RGSP	0.42 $\pm$ 0.23	0.76 $\pm$ 0.36
LLSP	3.15 $\pm$ 0.76	2.94 $\pm$ 0.62
LGSP	0.54 $\pm$ 0.30	0.82 $\pm$ 0.59

The mean value of RLSP in males was found to be  $3.11 \pm 0.76$  cm with the range of 1.80 to 5.54 cm and in females, it was  $2.96 \pm 0.64$  cm with the range of 1.87 to 4.52 cm. The mean value of RGSP in males was found to be  $0.42 \pm 0.23$  cm with the range from 0.82 to 0.12 cm and the mean value in females was  $0.76 \pm 0.36$  cm with the range from 0.13 to 1.20 cm. Similarly, the mean value of LLSP of on males was found to be  $3.15 \pm 0.76$  with a maximum and minimum of 5.69 and 1.45 cm and in females, it was found to be  $2.94 \pm 0.62$  cm with a maximum and minimum of 4.48 and 2.04 cm. Similarly, the mean value of LGSP of males and females was found to be  $0.54 \pm 0.30$  with a maximum and minimum of 1.42 and 0.08 cm and  $0.82 \pm 0.59$  with a maximum and minimum of 1.97 and 0.16 cm respectively. The percentage of unilateral elongation in male and female was found to be 35.5% (22) and 30% respectively while the bilateral elongation in male and female was found to be 64.5% (40) and 70% (14) respectively. From the Man-Whitney test, it was found that there

was no significant difference between the sex and the parameters RLSP, LLSP, and LGSP ( $p>0.05$ ). But, there was significant difference between the RGSP and sex at P-value of 0.009. From the Chi-Square test, it was found that there was an association between the right elongation and right calcification of the SP. It was also found that there was an association between the right and left elongation of the SP. And also found that there was an association between the left elongation and left calcification at the significance level of P value  $<0.05$ .

The series of elongation pattern found in our study in the right SP were normal SP (47.06%), followed by elongated SP (29.41%), distant elongated SP (13.07%), pseudoarticulated SP (7.19%), and segmented SP (3.27%). Similarly the series of calcification pattern were calcified SP (63.40%) followed by nodular SP (18.30%), partial SP (12.42%) and outlined SP (5.88%). The series of elongation pattern in the left SP were normal SP (56.83%), followed by elongated SP (23.53%), distant elongated SP (7.84%), pseudoarticulated SP (6.54%), and segmented SP (5.23%). Similarly the series of calcification pattern were calcified SP (62.09%) followed by nodular SP (17.65%), partial SP (11.76%), and outlined SP (8.56%).

From the Spearman's Rho Correlation, it was found that there was not a statistically significant correlation of age with RGSP, LLSP, LGSP ( $p>0.05$ ). There was a strong positive correlation between the RLSP and LLSP ( $r=0.759$ ) which was statistically significant at a p-value of 0.001. There was no statistically significant correlation between the RLSP and RGSP and between LLSP and LGSP ( $p>0.05$ ). There was a strong positive correlation between the RLSP and Right Elongation Type ( $r=0.665$ ) which was statistically significant at a p-value of  $<0.001$ . There was not a statistical significant correlation between the RLSP and Right Calcification. But, there was a strong positive correlation between the LLSP and Left Elongation Type ( $r=0.757$ ,  $p<0.001$ ).

## Discussion

Various studies on the dimensions of SP were based on dry skulls, cadaver using digital panoramic radiograph. The use of MDCT can be considered as preferred method for the evaluation of SP. The mean length of the styloid process in RLSP and LLSP was  $3.06\pm 0.72$  cm and  $3.08\pm 0.72$  cm from the entire research participants. The mean length of RSLP in male and female was found to be  $3.11\pm 0.76$  cm and  $2.96\pm 0.64$  cm and the mean length of LLSP in male and female was found to be  $3.15\pm 0.76$  cm and  $2.94\pm 0.62$  cm. The mean length of the SP was found higher in males than in females and it concurs with the finding of study done by other authors. N. Cullu et al.[7] and Azin Shayganfar et al. [8]. But, Koduri Sridevi et al. [9] performed the similar study in South Indian population and found that the mean length of the SP was higher in females. But most of the studies suggest that the mean length of SP is higher among the male population in comparison to the female population. In our study, there was statistically insignificant difference between the mean length of the SP and sex. But, there was statistically significant difference in the study of N. Cullu et al. [7], Azin Shayganfar et al. [8], and Koduri Sridevi et al.[9]. The racial variation, demographic and environmental influence have significant effects in the range of the SP length. In our study, the range of the RLSP and LLSP was found that 1.80-5.54 cm and 1.45-5.69 cm. The similar finding was also observed among the study done by other author Basekim CC et al. [10] who found that the range of SP length was 1.58-5.48 cm. O.Onbas et al.[11] found that the average range of SP was 0-6.2 cm. N. Cullu et al. [46] also found that the average range of the SP was 1.8-5.1 cm. The mean length of the

distant calcified SP of right and left sides was  $0.51\pm 0.30$  cm and  $0.63\pm 0.43$  cm respectively. In our study, there was statistical significance difference among the RLSP-RGSP and LLSP-LGSP. The mean length of the RGSP in males and females 47 was found to be  $0.42\pm 0.23$  cm and  $0.76\pm 0.36$  cm. Similarly, the mean length of the LGSP in males and females was found to be  $0.54\pm 0.30$  cm and  $0.82\pm 0.59$  cm. In our study, the mean length of the RGSP and LGSP was found to be higher among the females. In our study, there was statistically insignificant difference among the LGSP and sex but statistically significant difference among the RGSP and sex.

The series of elongation pattern found in our study in the right SP were normal SP (47.06%), followed by elongated SP (29.41%), distant elongated SP (13.07%), pseudoarticulated SP (7.19%), and segmented SP (3.27%). Similarly the series of calcification pattern were calcified SP (63.40%) followed by nodular SP (18.30%), partial SP (12.42%) and outlined SP (5.88%). The series of elongation pattern in the left SP were normal SP (56.83%), followed by elongated SP (23.53%), distant elongated SP (7.84%), pseudoarticulated SP (6.54%), and segmented SP (5.23%). Similarly the series of calcification pattern were calcified SP (62.09%) followed by nodular SP (17.65%), partial SP (11.76%), and outlined SP (8.56%). A study performed by Haluk Oztunc et al. [47] found that 46% have normal SP and 33% have elongated SP among the participants. In the study of C. Buyuk et al. [12] it was found that 34.2% have elongated SP. S. Kailasam et al.[50] also found that the elongated SP was 47%. Koduri Sridevi et al. [9] found that the elongated SP were more common in the participants. In our study, there was no association between the SP elongation and sex. And the similar result was found in the study of Haluk Oztunc et al. [13]. Elongated SP were more common in our study after the normal SP. These findings concur with the findings of other authors. [13,12,14,9] In our study, the most common calcification pattern was calcified SP. These findings didn't concur with the findings of C Buyuk et al. [47] and S Kailasam et al. [14]. In our study, there was no association of SP calcification with sex and age groups.

## Conclusion

The MDCT is considered a gold standard for precise evaluation of anatomical length and variation of styloid process. The length of styloid process showed higher values in male than in female. But statistically, there was no significant difference between male and female in the SP measurement. Elongated and Calcified SP were more common in Nepalese individuals. Further study including large number of individuals and symptomatic patients needs to be done for correlational study.

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