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# Morphometric analysis of pterygoid hamulus and its clinical impact: A retrospective study

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**Abstract:**
Pterygoid hamulus morphology influences diagnosis and surgical planning. Therefore, it is of interest to evaluate the bilateral pterygoid hamulus morphometry using CBCT across age and sex. Hence, sixty CBCT scans (31 males, 29 females) were analysed using ANOVA, Tukey post-hoc and Pearson correlation. The left hamulus was longer and more angulated, while the right was wider; males showed greater interpterygoid distance and larger right-sided dimensions ($p < 0.05$). Thus, CBCT-derived normative data confirm side- and sex-related variations, improving diagnosis of pterygoid hamulus syndrome and surgical planning.

**Keywords:** Pterygoid hamulus (PH), CBCT imaging, linear measurements, angular measurements, interpterygoid distance, craniofacial morphometry, retrospective study

**Background:**
The pterygoid hamulus (PH) is a hook-like bony projection at the inferior end of the medial pterygoid plate of the sphenoid bone that anchors the tendon of tensor veli palatini and the pterygomandibular raphe, thereby contributing to orofacial and pharyngeal function **[1]**. Its length, angulation, width, interpterygoid distance and spatial relationships to neighbouring structures have direct clinical relevance, influencing conditions such as pterygoid hamulus bursitis (PHB) and obstructive sleep apnoea and referred orofacial pain **[2]**. Anatomical studies performed on dry skulls and radiological studies using two- and three-dimensional imaging have reported discrepant PH dimensions and these structural variations can complicate diagnosis and treatment planning in the posterior maxillary region **[3]**. Cone beam computed tomography (CBCT) offers a non-invasive, three-dimensional means of visualising the PH *in vivo* with submillimetric precision, overcoming many of the limitations of two-dimensional radiographs and *ex vivo* skull measurements **[4]**. Despite this, normative CBCT-based morphometric data correlating PH dimensions with age, sex and adjacent craniofacial landmarks remain limited **[5,6]**. Therefore, it is of interest to examine the PH morphometric using three-dimensional CBCT imaging to correlate anatomy with pathology, with the aim of clarifying risk factors for PH syndrome and enhancing clinical management through more precise anatomical insight.

**Methodology:**
**Study design and setting:**
A retrospective cohort study was conducted using 60 craniofacial Cone Beam Computed Tomography (CBCT) scans retrieved from a dedicated imaging database between May 2023 and May 2024. All scans were acquired using the Kodak Carestream Dental CS 9600 imaging system, following standardised imaging protocols for patient positioning, exposure parameters (10.8-second acquisition time) and a field of view optimised to visualise the pterygoid bones in the coronal plane.

**Inclusion criteria:**
CBCT images encompassing the posterior maxillary region were included, irrespective of demographic parameters (age, sex).

**Exclusion criteria:**
Images exhibiting streak artefacts obscuring the anatomical regions of interest were excluded. Additional exclusions comprised scans from patients with a history of maxillofacial trauma involving PH fractures, traumatic extraction of maxillary third molars, osseous pathologies (*e.g.*, cysts, tumours) or inflammatory lesions in the posterior maxillary region and systemic skeletal disorders (*e.g.*, osteoporosis, craniofacial asymmetries).

**Sample size:**
The sample size was estimated from data reported in a previous study by Komarnitki I *et al.*, using the formula for comparison of two independent group means:

$$n = (\sigma1^2 + \sigma2^2)\,(z1\text{-}\alpha/2 + z1\text{-}\beta)^2 / \Delta^2$$

Where n = sample size to be determined; σ1 and σ2 = standard deviations of Group 1 and Group 2; Δ = difference in group means; z1-α/2 = two-sided z value (1.96 for a 95% confidence interval); and z1-β = power. Substituting σ1 = σ2 = 0.6, Δ = 0.3, k (ratio n2/n1) = 1, z1-α/2 = 1.96 at 95% confidence and z1-β = 0.84 at 80% power, the estimated total sample size was 63 per side.

**Methodological protocol:**
**I. Linear morphometric parameters:**
Pterygoid hamulus (PH) length was measured as the linear distance (in millimetres) from the anatomical junction of the medial pterygoid plate with the PH to the osseous apex of the hamulus. Interpterygoid distance was quantified as the transverse distance between the medial cortical margins of the bilateral PH structures, measured at the level of their maximum transverse projection **(Figure 1).**

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**II. Angular morphometric analysis:**

PH width was defined as the maximum mesiolateral dimension between the most prominent convexities of its mesial and lateral cortical surfaces **(Figure 2).** The acute angulation of the PH was calculated using a trigonometric model in which the numerator was the perpendicular (vertical) distance from the hamular apex to a reference line connecting the bilateral bases of the PH, aligned with the horizontal plane and the denominator was the direct linear distance (hypotenuse) between the hamular apex and its osseous base, representing the curvature of the PH. Based on the resulting angle (θ), cohorts were stratified into Group A, hypoangulated (θ < 45°) and Group B, hyperangulated (θ > 45°). All measurements were performed by calibrated examiners on standard DICOM visualisation software, achieving submillimetric precision and anatomic landmarks were validated via multiplanar reformation (MPR) to minimise interobserver variability.

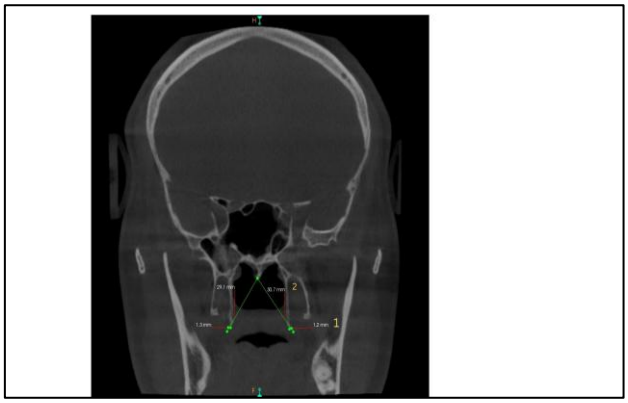


**Figure 1:** CBCT coronal image illustrating measurement of the interpterygoid distance (1-2) and coronal angulation of the pterygoid hamulus (3)



**Figure 2:** CBCT coronal image illustrating measurement of the distance from the pterygoid hamulus tip to the posterior nasal spine (1-2) and pterygoid hamulus width at the hamular tip

**Statistical analysis:**

Data were grouped by age (<30, 30-50 and >50 years) and sex for comparison and analysed using one-way ANOVA with Tukey post-hoc testing for between-group comparisons and Pearson's correlation coefficient was used to assess dimensional-angulation associations. Statistical significance was set at $p < 0.05$.

**Results:**

Sixty participants (31 males, 29 females) with a mean age of 40.12±16.12 years were examined and categorised into three age groups (<30, 30-50 and >50 years). Measurements focused on bilateral pterygoid hamulus dimensions, angles and spatial relationships to adjacent anatomical structures, summarised by age group and sex in **Table 1**, with inter-parameter correlations presented in **Table 2**. The mean length of the right pterygoid hamulus was 5.83±1.64 mm, while the left measured slightly longer at 6.22±1.83 mm. No statistically significant differences were observed across age groups for either side. Males showed marginally greater right-sided length (6.00±1.75 mm vs 5.65±1.27 mm in females), but this difference was not statistically significant and left-sided measurements were nearly identical between sexes. The right hamulus width averaged 1.57±0.50 mm compared with 1.28±0.45 mm on the left. A non-significant trend toward increased width with advancing age was noted bilaterally. Males showed significantly greater right-sided width (1.69±0.52 mm vs 1.43±0.44 mm in females; $p<0.05$), while left-sided width showed no sex disparity. The right hamulus angle averaged 51.97±10.27° compared with 53.43±10.63° on the left. The left angle showed significant variation with age, being most acute in the 30-50 year group (50.32±9.88°) compared with younger participants (58.00±10.19°). No significant sex differences were observed in angular measurements. The mean interpterygoid distance was 31.71±2.94 mm. Males exhibited significantly larger distances than females (32.49±3.20 mm vs 30.88±2.43 mm; $p<0.05$). Although not statistically significant, a gradual increase in distance was observed with advancing age. The mean distance from the hamulus tip to the posterior nasal spine was 25.62±4.38 mm on the right and 25.04±4.45 mm on the left. Males showed significantly greater distances bilaterally ($p<0.05$). No significant age-related differences were noted. Strong bilateral symmetry was observed for nasal spine-to-hamulus distances. Larger left hamulus angles correlated with smaller interpterygoid distances and shorter nasal spine-to-hamulus distances. Wider interpterygoid distances showed positive correlations with nasal spine-to-hamulus distances bilaterally.

**Table1:** Comparison of pterygoid hamulus length, width, angle, interpterygoid distance and distance from the PH tip to the posterior nasal spine, by age group and sex.

| | <30 years | 30-50 years | >50 years | p value | Male | Female | p value |
|---|---|---|---|---|---|---|---|
| **Length (Rt) mean** | 5.83±1.53 | 5.97±1.42 | 5.63±1.62 | 0.797 | 6.00±1.75 | 5.65±1.27 | 0.38 |
| **Length (Lt) mean** | 6.22±1.68 | 6.30±1.64 | 5.78±1.51 | 0.448 | 6.22±1.95 | 6.22±1.35 | 0.996 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Width (Rt) mean** | 1.41±0.51 | 1.61±0.49 | 1.72±0.47 | 0.15 | 1.69±0.52 | 1.43±0.44 | 0.039* |
| **Width (Lt) mean** | 1.13±0.36 | 1.32±0.51 | 1.41±0.43 | 0.138 | 1.36±0.49 | 1.19±0.49 | 0.134 |
| **Angle (Rt) mean** | 54.73°±9.54 | 49.09°±10.56 | 52.13°±10.39 | 0.192 | 51.84°±12.20 | 52.10°±7.92 | 0.922 |
| **Angle (Lt) mean** | 58.0°±10.19 | 50.32°±9.88 | 51.44°±10.64 | 0.036* | 53.42°±11.44 | 53.45°±9.88 | 0.992 |
| **Interpterygoid distance mean** | 30.94±2.39 | 31.78±3.43 | 32.68±2.77 | 0.198 | 32.49±3.20 | 30.88±2.43 | 0.033* |
| **Distance PH-PNS (Rt) mean** | 24.60±3.28 | 25.96±4.73 | 26.54±5.15 | 0.366 | 27.0±4.21 | 24.14±4.13 | 0.010* |
| **Distance PH-PNS (Lt) mean** | 23.96±3.37 | 25.31±4.99 | 26.16±4.89 | 0.306 | 26.22±4.39 | 23.79±4.22 | 0.033* |

** Statistically significant (p < 0.05). Rt = right; Lt = left.*

**Table 2:** Pearson correlation (r) and significance (p) between pterygoid hamulus length, width, angle, interpterygoid distance and distance from the PH tip to the posterior nasal spine.

| | | Length-Rt | Length-Lt | Width-Rt | Width-Lt | Angle-Rt | Angle-Lt | Interpt. dist. | Dist.-Rt | Dist.-Lt |
|---|---|---|---|---|---|---|---|---|---|---|
| **Length-Rt** | r | - | 0.589 | 0.184 | | 0.339 | | -0.19 | -0.197 | |
| | p | - | <0.0001* | 0.158 | | 0.008* | | 0.146 | 0.132 | |
| **Length-Lt** | r | | - | | -0.021 | | 0.439 | -0.136 | | -0.216 |
| | p | | - | | 0.874 | | <0.0001* | 0.302 | | 0.098 |
| **Width-Rt** | r | | | - | 0.503 | -0.047 | | 0.378 | 0.252 | |
| | p | | | - | <0.0001* | 0.72 | | 0.003* | 0.052 | |
| **Width-Lt** | r | | | | - | | -0.376 | 0.407 | | 0.197 |
| | p | | | | - | | 0.003* | 0.001* | | 0.13 |
| **Angle-Rt** | r | | | | | - | 0.593 | -0.32 | -0.243 | |
| | p | | | | | - | <0.0001* | 0.013* | 0.061 | |
| **Angle-Lt** | r | | | | | | - | -0.372 | | -0.41 |
| | p | | | | | | - | 0.003* | | 0.001* |
| **Interpt. dist.** | r | | | | | | | - | 0.484 | 0.531 |
| | p | | | | | | | - | <0.0001* | <0.0001* |
| **Dist.-Rt** | r | | | | | | | | - | 0.942 |
| | p | | | | | | | | - | <0.0001* |
| **Dist.-Lt** | r | | | | | | | | | - |
| | p | | | | | | | | | |

** Statistically significant (p < 0.05).*

**Discussion:**

The present study evaluated the morphometric characteristics of the pterygoid hamulus (PH) using CBCT and found significant variations according to side and sex. The left PH was longer and more angulated, whereas the right PH was wider. Males also exhibited significantly greater interpterygoid distances and larger right-sided PH dimensions than females. These findings provide useful reference values for radiological evaluation and surgical planning. Our findings are consistent with those of Gachinamath *et al.* (2026) **[7]**, who evaluated 496 CBCT scans and reported that PH dimensions vary with age and sex, with males generally having larger PH measurements than females. Their study also highlighted the usefulness of CBCT for establishing normative morphometric data, similar to the present investigation. The present PH length (5.83–6.22 mm) was also comparable with the recent observations of Malkidou *et al.* (2024) **[8]**, who demonstrated considerable variability in PH morphology and emphasized that elongation is a normal anatomical variation in many individuals. Both studies indicate that morphometric diversity should be considered during clinical assessment rather than assuming pathology based solely on size. The left PH showed greater angulation than the right, which agrees with the findings of Mehra *et al.* (2024) **[9]**, who reported age-related changes in PH inclination and highlighted the importance of CBCT in evaluating hamular orientation. Their study suggested that PH angulation may influence the biomechanics of the tensor veli palatini muscle, supporting the anatomical observations of the present study. The wider interpterygoid distance observed in males is similar to the findings of Syutkina *et al.* (2022) **[10]**, who reported significant sex-related differences in craniofacial dimensions. Such variations should be considered during maxillofacial surgery and prosthodontic procedures because they may influence surgical access and anatomical landmarks. The present findings also support the review by Mahdavi *et al.* (2024) **[11]**, which emphasized that the pterygoid hamulus is an important anatomical landmark involved in swallowing, speech, middle-ear ventilation and pterygoid implant placement. The authors further noted that accurate CBCT evaluation of PH morphology improves the diagnosis of hamular disorders and facilitates safer surgical planning. Overall, the present study confirms previous evidence that PH morphology shows normal anatomical variation related to side and sex. The CBCT-derived measurements provide reliable reference data that may improve the diagnosis of pterygoid hamulus syndrome and assist clinicians during surgical and prosthodontic treatment planning.

**Conclusion:**

We show the pterygoid hamulus shows significant side- and sex-related morphometric variations, with the left side generally longer and more angulated and males exhibiting wider interpterygoid distances. Pterygoid hamulus length alone is insufficient for diagnosing pterygoid hamulus syndrome, emphasizing the need to integrate clinical findings, patient history and imaging features. Age-related morphological changes may influence upper airway and palatal function, highlighting the value of CBCT-based morphometric assessment for accurate diagnosis and safer surgical planning.

**Conflict of interest:**

The authors declare no conflict of interest.

**Funding:**
No external funding was received for this study.

**Ethical approval:**
This retrospective study used de-identified, pre-existing CBCT scans retrieved from the institutional imaging database; approval was obtained from the Institutional Ethics Committee prior to data collection, in accordance with the Declaration of Helsinki.

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