Journal of Morphological Sciences
J Morphol Sci
Brazilian Society of Anatomy

Original Article
J Morphol Sci 2023;40:290-294

The Anatomy of the Uncinate Process of C3-C7 Cervical Vertebrae in the Ghanaian Population

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Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT

Introduction: the uncinate processes are bony ridges located on the superior surface of the C3-C7 (subaxial) vertebrae. The presence of the uncinate process result in the formation the uncovertebral joint, which play an important role in vertebral motion and hence head and neck movement. The purpose of this study was to examine the uncinate processes of the cervical vertebrae in the Ghanaian population. Seventy dried disarticulated cervical vertebrae were obtained from the Department of Anatomy and Cell Biology School of Medical Sciences, University of Cape Coast, for the purpose of conducting this study. The height, width and length of the uncinate processes were measured. The height of the uncinate processes ranged from 2.72mm to 7.32mm, their lengths ranged from 6.0mm to 14.02mm, while their widths ranged from 2.46mm to 6.23mm. Their angle of inclination relative to the sagittal plane was found to range from 20˚ to 56˚ with a mean value of 40.62˚ for the right side and 41.09 for the left side.

There was no significant difference in mean height and width of the uncinate process of the sub-axial cervical vertebrae, there was, however, a significant negative correlation with regards to the length of the uncinate process and its position on the cervical spine. The finding of this study will contribute to the reduction of complication and ensure good outcomes during cervical spine surgeries.

Keywords: Ghana; Herniation; Cervical vertebrae; Uncinate process.

Introduction

Studies have shown that the uncinate process and the uncovertebral joint that it forms develop over the lifetime of an individual and degenerate after the point of maturation. This degeneration is characterized by the development of osteophytic spurs[1,2], which may encroach on neurovascular structures that lie in close proximity to the joint. The compressive effects of these osteophytes have been implicated in the aetiology of conditions such as radiculopathy, myelopathy and vertebral vascular insufficiency[1, 3].

Surgical removal of the impinging spur is a common intervention in such situations. Adequate anatomic knowledge of the uncinate process appears to be key in performing a safe and successful surgery without compromising the structural integrity of the uncovertebral joint[1, 3–5].

There however, appears to be no anatomic study in literature on the uncinate process in the Ghanaian population. The purpose of this study was therefore to examine the uncinate processes of the sub-axial cervical vertebrae in this population.

Materials and Methods

Seventy five dried disarticulated cervical vertebrae were obtained from the Department of Anatomy and Cell Biology, School of Medical Sciences, University of Cape Coast, for the purpose of conducting this study. The conduct of study complied with research guideline of the University of Cape Coast. After examining the bones, 5 vertebrae (two C3, one C6 and two C7) were excluded due to the presences of osteophytes and/or the degeneration of the uncinate process. The study sample for this study was therefore 70 sub-axial cervical vertebrae. The ages of the specimen were not know and the bone were not categorized according to gender.

The height, width and length of the uncinate processes were measured.

Height. This was measured as the vertical distance between the upper tip of the process and the superior surface of the vertebral body (Fig. 1).

Width. This was defined as the distance between the medial and lateral surface at the largest part of its base (Figure 1).

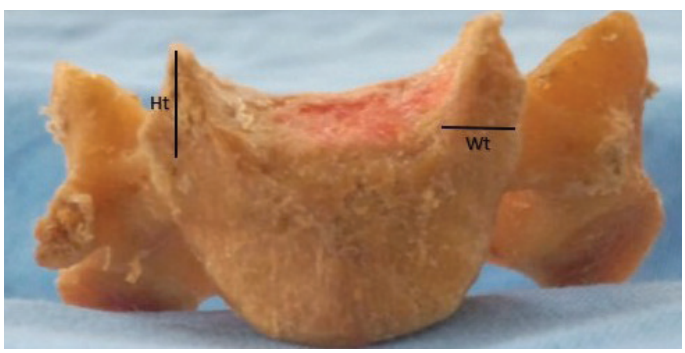

Figure 1. Ht; the height of the uncinate process, Wt; the width of the uncinate process.

DOI: 10.51929/jms.40.290.2023
ISSN 2177-0298

Length. This was measured as the distance from the posterior and anterior borders above the superior surface of the vertebrae body (Fig. 2).

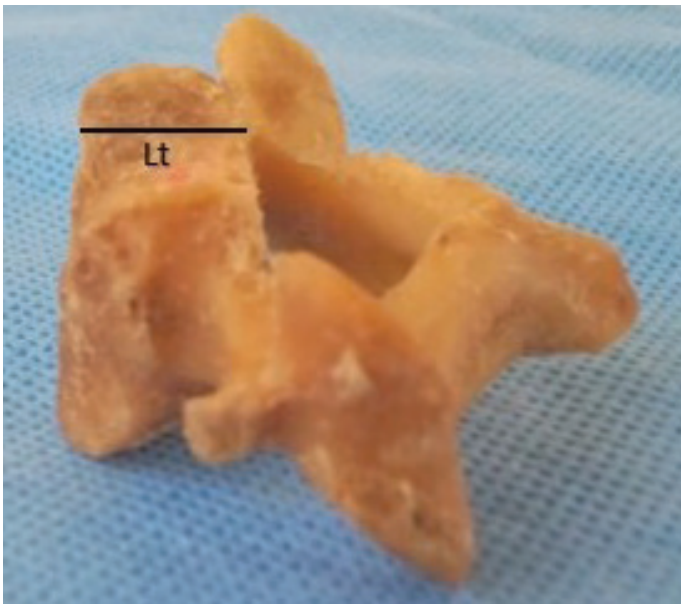

Figure 2. Lt the anteroposterior length of the uncinate process.

The distances between the medial borders of the uncinate processes were taken at the base of the uncinate processes, these were designated as the anterior, middle and posterior distances (Fig. 3).

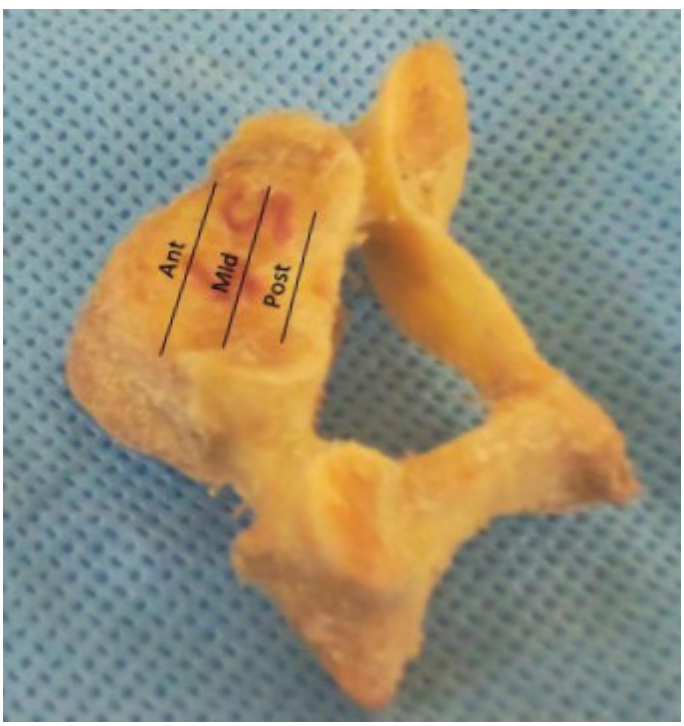

Figure 3. Ant: distance between the medial borders of uncinate process at its anterior aspect, Mid: distance between medial borders of uncinate processes at the midpoint of the uncinate process, Post: distance between medial borders of uncinate processes at its posterior aspect.

In addition to these parameters, the angle of inclination of the uncinate processes relative to the sagittal plane was also measured (A) (Fig. 4).

Statistical significance of the difference between the group means was performed using a One-way analysis of variance (ANOVA) test. A Least Significant Difference (LSD) Post Hoc (multiple comparison) test was then ran to identify the group(s) that had statistically significant difference(s) in their means at a p-value of 0.05. Pearson correlation coefficient with significance at the 0.05 level (2-tailed) was also done to determine if there was a correlation between the measured parameters and the position they occupied on the cervical spine.

Results

The height of the uncinate processes ranged from 2.72mm to 7.32mm, their lengths ranged from 6.0mm to 14.02mm, while their widths ranged from 2.46mm to 6.23mm. The angle inclination range from 20˚ to 56˚ with a mean value of 40.62˚ for the right side and 41.09 for the left side. Table 1, shows the various morphometric measurements that were taken.

One way ANOVA with Post Hoc LSD analysis showed that there were significant differences in the mean angle of the C3 and C4 uncinate processes when compared to the other uncinate processes. Comparison between the mean length of C7 uncinate process and that of the other uncinate processes also yielded significantly different in their means (Table 2).

Significant differences were also observed when the mean anterior and middle distances of the C7 uncinate process was compared with those of the first 3 cervical vertebrae. (Table 3)

Correlational analysis of the parameter that measured and their position on the cervical spine showed that there was a positive significant correlation with regards to the angle of inclination relative to the sagittal plane, the middle and anterior distances. A significant negative correlation was also observed with regards to the length of the uncinate process and its position on the spine (Table 4).

Discussion

The height of the uncinate process of the different sub-axial cervical vertebrae were found to be comparable to those reported in previous studies[3-6] . Kim *et al.*, however, reported greater value compared to those of this study. The difference in value may have resulted from the type of specimen used while the present study used dry bone specimen, Kim *et al.* took their measurements from formalin fixed cadavers.

The uncinate processes of C5 and C6 vertebrae were found to have the highest mean height for both the left side and right side, this concurred with the findings of some earlier studies[3-5] . The lowest mean height for the left and right sides were recorded in C7. Kocabiyik *et al.* and Lee *et al.* in their respective studies also found that the C7 uncinate process had the shortest height. These observations contradict those of some studies

Table 1. Morphometric Measurements of the Uncinated Process.

	Height(mm)		Length(mm)		Width(mm)		Angle (°)		Distance between Medial Borders of Uncinate Process(mm)		
	Lt	Rt	Lt	Rt	Lt	Rt	Lt	Rt	Posterior	Anterior	Middle
C3	5.24±1.27	5.09±1.05	9.55±1.10	9.70±1.50	4.82±0.72	4.61±0.83	38.92±4.19	36.77±3.49	15.61±3.00	17.36±2.24	16.09±2.11
C4	4.84±1.10	4.85±0.91	9.38±1.32	10.11±1.82	4.36±0.97	4.63±0.86	38.93±6.16	40.73±6.19	15.20±2.42	17.35±2.16	16.71±2.09
C5	5.30±1.21	5.03±0.83	9.49±1.76	10.11±1.61	4.66±0.89	4.44±0.90	42.73±2.79	40.53±3.87	15.77±2.78	17.70±2.39	16.50±2.51
C6	5.00±1.10	5.37±1.08	9.73±1.65	9.40±1.58	4.53±0.59	4.27±0.63	42.08±2.43	42.43±5.32	15.80±2.49	18.7±51.69	17.67±2.09
C7	4.71±1.41	4.81±1.28	8.20±0.70	8.29±0.53	4.58±0.68	4.62±0.70	43.30±3.47	44.14±2.41	16.32±2.75	19.66±2.45	18.60±2.57

Values are presented as mean±standard deviation.

Table 2. LSD Post Hoc Multiple Comparison of the Mean Height, Width, Length and Angle of the Uncinate Processes of C3 to C7 Vertebrae.

		Height			Width			Length			Angle		
		Lt	Rt	Pooled	Lt	Rt	Pooled	Lt	Rt	Pooled	Lt	Rt	Pooled
C3	C4	.404	.558	.297	.128	.954	.292	.777	.718	.647	.992	.029*	.091
	C5	.908	.891	.990	.584	.566	.422	.694	.562	.831	.020*	.038*	.002*
	C6	.628	.521	.954	.350	.265	.137	.484	.701	.932	.065	.003*	.000*
	C7	.340	.556	.255	.454	.981	.605	.031*	.065	.005*	.016*	.001*	.000*
C4	C5	.332	.641	.287	.307	.512	.794	.914	.331	.487	.014*	.907	.117
	C6	.753	.203	.270	.573	.225	.631	.328	.976	.589	.054	.334	.041*
	C7	.807	.931	.805	.468	.975	.619	.053*	.120	.015*	.012*	.117	.005*
C5	C6	.545	.419	.943	.672	.567	.463	.274	.324	.487	.686	.281	.592
	C7	.285	.628	.248	.811	.557	.802	.064	.014*	.902	.738	.098	.135
C6	C7	.614	.238	.234	.865	.265	.348	.007*	.134	.004*	.494	.432	.319

* The mean difference is significant at the 0.05 level.

Table 3. LSD Post Hoc Multiple Comparison of the Mean Anterior, Middle and Posterior Distances of the Uncinate Processes of C3 to C7 Vertebrae.

		Posterior Distance	Anterior Distance	Middle Distance
C3	C4	.690	.996	.476
	C5	.874	.693	.634
	C6	.849	.118	.083
	C7	.518	.008*	.008*
C4	C5	.563	.672	.806
	C6	.547	.098	.272
	C7	.297	.005*	.036*
C5	C6	.972	.208	.183
	C7	.606	.015*	.021*
C6	C7	.634	.219	.311

*. The mean difference is significant at the 0.05 level.

Table 4. Pearson correlation between the different anatomic measurement of the Uncinate Process and their position on the cervical spine.

	Pearson Correlation	Sig. (2-tailed)
Height	-.036	.698
Width	-.060	.485
Length	-.190*	.027
Angle	.396**	.000
Posterior	.105	.396
Anterior	.373**	.002
Middle	.342**	.004

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-taile

that have reported an increasing pattern in height of the uncinate process from C3 to C7[2,6] . Correlational analysis in the present study did not also support a pattern of increasing height as one moved down the cervical spine; in conformity with the findings of Lee *et al.* and Kim *et al.*

Lu *et al.* , in their study, observed that the uncinate processes of C4-C6 were significantly higher than those of C3 and C7. In the present study, however, there was no significant statistical difference in mean height when the uncinate processes of the various cervical vertebrae were compared.

The width of the uncinate process ranged from 2.46mm to 6.23mm. The mean width of the uncinate processes for all the 5 cervical vertebrae were found to be fairly constant. There was no significant statistical difference between the means, neither was there any statistically significant correlation between the width of the uncinate processes and their position on the

cervical spine. These finding contradict some studies that have reported significant differences in the width of the various uncinate processes[3] and a general increasing trend in the mean width as one moved down the cervical spine from C3 to C7[2] .

In the present study the mean antero-posterior length of the uncinate process was found to be smallest in the C7 vertebrae. The difference in mean length of the C7 uncinate process compared to those of the other 4 superior vertebrae were found to be statistically significant. The uncinate process of C7 thus appears to be reduced significantly in length. In a study by Kocabiyik *et al*., they found that the mean length of the C7 uncinate process was smaller compared to C6. Lu *et al*., also reported that the anteroposterior diameter of the uncinate process was greater at the C5 and C6 levels than at C7 level. Contrary to some reports in literature, which suggests, that the anteroposterior length of the uncinate processes generally increase from C3 to C7[2] , the present study interestingly found a reversal in trend, where the mean length of the uncinate processes rather decreased down the spine. Correlational analysis showed a significant negative correlation between the mean length of the uncinate process and its level on the cervical spine giving credence to the observation that, as one goes down the cervical spine, the antero-posterior length of the uncinate processes decreases.

The angle of inclination relative to the sagittal plane in the present study ranged from 20˚-56˚. The average angle of inclination for the right side was 40.62˚ and 41.09˚ for the left. These were comparable to those of previous studies[7,8]. The angle size was observed to increase down the cervical spine, contrary to the observation of Kocabiyik *et al*. and Panjabi *et al*., who found a relatively constant angle in all the vertebrae. The angles of uncinate processes of C3 and C4 were found to be significantly smaller when compared to those of the lower 3 vertebrae. A significant positive correlation was also observed between the angle size and position of the cervical vertebrae, suggesting a general increase in angle size along the spine from C3 to C7.

For all the sub-axial cervical vertebrae the posterior distance was found to be narrowest while the anterior distance was observed to be the widest. The mean anterior and middle distances of the C7 vertebra was also found to be significantly wider than those of the first 3 vertebrae (C3, C4 and C5). In addition, there was a significant positive correlation with regards to the mean anterior and middle distances measured and the position on the cervical spine.

It thus appears that, the anterior and middle distances exhibits an increasing pattern as one moves down the spine. Kim *et al*., reported a similar observation in their study. The uncinate processes are thus most narrowly spaced at the posterior aspect of the vertebra and appear to splay out progressively from the posterior aspect of the vertebra to anterior aspect. The degree of deviation also appears to widen as one move down the spine from C3 to C7.

Although the uncinate processes develops in-utero and are apparent by the four months of fetal life, their upward growth and enlargement have been reported to begin from the age of 4 and continue to the age of 14[2] . A study by Porter *et al*., which was carried out in the Ghanaian population, found that, from the age of 10, both genders regularly carried large loads on their heads. On average a boy under the age of 18 years usually carried loads of 39kg while female carried loads of 36kg. The pressures generated by the frequent head loading on the developing uncinate process may account for some of the disparities that have been observed in the Ghanaian population. Ethnicity, poor nutritional status, low socio-economic status, and diseases such have malaria[10-13], which are all prevalent in the West African sub-region have also been found to influences bone growth and may contribute to the discrepancies observed.

The clinical significance of the uncinate processes cannot be overemphasized. The position of the uncinate processes relative to the intervertebral disc, makes them act as physical barriers and helps prevent posterolateral herniation of the intervertebral disc[2,6,14-16]. The majority of lateral cervical herniations when they occur, tend to be located at the C7 level[2,14]. Post *et al*., postulated that the high incidence of lateral herniations at this level was partly due to the relative lack of physical barrier provided by the C7 uncinate process in comparison with the other uncinate processes. From our study it was observed that the C7 uncinate process had the shortest height and length, the greatest degree of angulation from the sagittal plane and the widest distances between the left and right processes. The morphology of the C7 uncinate process therefore appears to afford the intervertebral disc very little physical protection on its medial boundary and may indeed contribute to the high frequency of lateral herniation as has been reported.

Osteophytic spurs from the uncinate processes have also been implicated in the compression of structures that lie close to them. These structures include the spinal nerve root, vertebral artery, radicular (medullary) artery, cervical sympathetic trunk and the cervical spinal cord[1,3] . The encroachment of these spurs have been implicated in the aetiology of some pathologies such as radiculopathy, myelopathy and vertebral vascular insufficiency. Treatment for these conditions usually involves the surgical removal of the impinging bone spur. Surgeons therefore need to have adequate anatomic knowledge of the uncinate process to ensure adequate removal of bone tissue while preserving the integrity of the uncovertebral joint as its disruption may leading to cervical spine instability[1,3]. The close proximity of the spinal cord, nerve roots, or vertebral artery to the uncinate process is further incentive for

surgeons to have a good grasp of its anatomy so as to prevent injury to these structures.

Conclusion

The findings of this study suggest that the uncinate processes of C3 to C7 vertebrae of the Ghanaian population share some similarity with those of other races and ethnicity. They also appear to exhibit some telling differences that surgeons must be cognisant of, in order to reduce complications and ensure good outcomes of cervical spine surgeries in the Ghanaian population.

Acknowledgement

The authors are grateful to Mr. Kwesi Koomson and Mr. K.B. Mensah, technicians at the Department of Anatomy and Cell Biology, School of Medical Sciences, University of Cape Coast, for their assistance.

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Received: January 27, 2023
Accepted: March 3, 2023

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