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A Radiological Study of the Morphological Variations in the Odontoid Process of the Axis Vertebra, Benghazi

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الملخص:

الخلفية: فقرة المحور (C2)غير نمطية في شكلها وخصائصها المورفولوجية وتشكل جزءًا لا يتجزأ من التقاطع القحفي فوق العمود الفقري . **الهدف من الدراسة:** لقياس الطول والأقطار العرضية لنتوء السني من المترددين الليبيين باستخدام الأشعة المقطعية ومقارنة نتائج هذه الدراسة مع نتائج الدراسات الأخرى التي أجراها مؤلفين مختلفين في مختلف الإسكان. **الطريقة:** استخدمت دراسة وصفية بأثر رجعي من خلال مراجعة 167صورة المسح الضوئي ثم اختيارهم بشكل عشوائي من دعوي التصوير المقطعي من قسم الأشعة في مستشفى الجلاء للجراحة والحوادث /بنغازي من إبريل إلى يوليو 2019. المرضي الذين يعانون من أمراض الباثولوجي أو مرض عظام التنكسية استبعدوا دليل علي وجود إصابة أو كسور في العمود الفقري العنقي العلوي من الدراسة. قيم قياسات عملية سنية (الطول وأقطار عرضية). وأدخلت البيانات وتحليلها. **النتائج:** كان متوسط ووسيط الارتفاع النتوء السني متساوية تقريبا، مع الحد الأدنى والحد الأقصى للقيم (12.70 و17.60 ملم) على تولي. بالنسبة إلى القطار الأمامي الخلفي للنتوء، كان المتوسط والوسيط تقريبا (11.18 و11.30 ملم) على التولي. كانت القيم الأدنى والأقصى 9.10 و13.10 ملم على تولي. متوسط القطر العرضي كان (9.04 +-0.63 مم). -+SD. **الخلاصة:** معرفة هذه الأبعاد يمكن أن توفر معلومات مفيدة لبعد التخطيط الأمني للتثبيت العظمي وفهم تطور العملية السنية، سواء بشكل طبيعي أو بإشكال مختلفة، وكذلك التشكل الظاهري لها شرطا أساسيا لتشخيص وعلاج المرضي الذين يعانون من اضطرابات تؤثر على العمود الفقري العنقي.

الكلمات المفتاحية: النتوء السني الاختلافات التشريحية، قياس الأشكال، صورة المقطعية.

Abstract

Background: The axis vertebra (C2) is atypical in its shape and morphological characteristics and forms an integral part of the craniovertebral junction. **Aims:** to measure height, AP and transverse diameters of the odontoid process of Libyan subjects using CT scans and to compare the results of the present study with the results of other studies conducted by different authors in different populations. **Method:** A descriptive, retrospective study was used by reviewing 167 CT scan images that were randomly selected from the CT suit of the Radiology Department at Aljalaa Hospital for Surgery and Accidents in Benghazi from April to July 2019. Patients with gross pathology or degenerative bone disease and those with evidence of an injury to the upper cervical spine were excluded from the study. The measurements of the odontoid process (height, AP and transverse diameters) were assessed. The data was entered and analyzed by using SPSS version 22. **Results:** The mean and median of the dens height of the odontoid process were nearly equal, with minimal & maximum values of 12.70 &17.60 mm respectively. Regarding the anteroposterior diameter of the process, the mean & median were nearly equal (11.18 & 11.30 mm respectively). The minimum & maximum values were (9.10 & 13.10 mm respectively). The mean ± SD of the transverse diameter was 9.04 ± 0.63 mm. **Conclusion:** The knowledge of these dimensions can provide useful information for the safe planning of osseous fixation and understanding of the development of the odontoid process, both in normal and in variant forms. Additionally, its phenotypical morphology is a prerequisite for the diagnosis and treatment of patients presenting with disorders affecting the craniocervical spine.

Keywords: odontoid process, anatomical variants, morphometry, CT.

1. INTRODUCTION

The axis vertebra (C2) is atypical in its shape and morphological characteristics and forms an integral part of the craniovertebral junction [1,2]. The dens/odontoid process is a small, tooth-like upward projection from the second cervical vertebra of the neck which forms the pivot median atlanto-axial joint with the anterior arch of the atlas[3]. The odontoid process is the central pillar of the craniovertebral junction. Imaging this small structure continues to be a challenge for radiologists due to complex bony and ligamentous anatomy. A wide range of developmental and acquired abnormalities of odontoids have been identified. Their accurate radiologic evaluation is important as different lesions have markedly different clinical courses, patient management, and prognosis[4].

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The integrity of the odontoid process is critical for the stability and proper function of the atlanto-axial articulation and to assure the integrity of the enclosed vulnerable neurovascular structures of the cranio-cervical region. Therefore, a sound understanding of this region's osseous development, both in normal and invariant forms, as well as its phenotypical morphology is a prerequisite for the diagnosis and treatment of patients presenting with disorders affecting the cranio-cervical spine[5]. The odontoid process was once thought to be a displaced body of the atlas but is now believed to have separated from the anterior part of the atlas between the 6th and 7th week of gestation and to have migrated caudally to fuse with the body of the axis[6].

The dens or odontoid process exhibits a slight constriction or neck where it joins the body. On its anterior surface is an oval or nearly circular facet for articulation with that on the anterior arch

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of the atlas. On the back of the neck, and frequently extending onto its lateral surfaces, is a shallow groove for the transverse atlantal ligament which retains the process in position.

The apex is pointed, and gives attachment to the apical odontoid ligament; below the apex, the process is somewhat enlarged, and presents on either side a rough impression for the attachment of the alar ligament; these ligaments connect the process to the occipital bone. The internal structure of the odontoid process is more compact than that of the body[7].

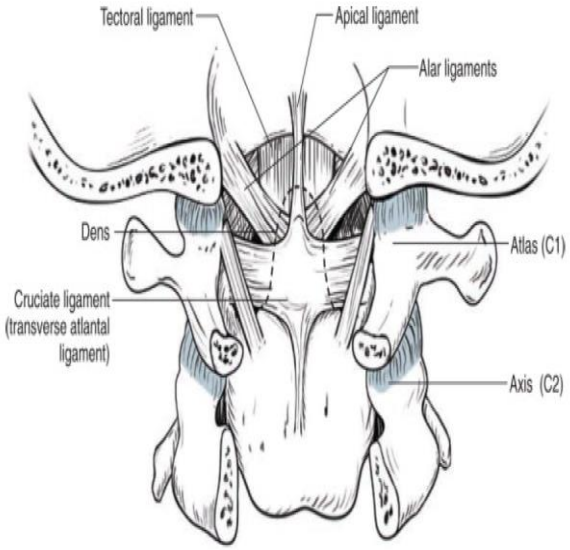


Figure 1:Coronal cross-section of the occipital-atlantoaxial ligamentous complex[8].



Figure 2: CT scan bone window shows the normal appearance of the odontoid process of the axis vertebra; axial A, coronal B and sagittal C sections.

2. MATERIAL AND METHOD

A descriptive retrospective study was used by reviewing 167 CT scan images. Human cases were randomly selected from the CT suit of Radiology department at Aljalaa Hospital for Surgery and Accidents / Benghazi from April to July 2019. Patients with gross pathology or degenerative bone disease and those with evidence of an injury to upper cervical spine were excluded from study. the measurements of odontoid process (height, AP and transverse diameters) were assessed. The data was entered and analyzed by using SPSS version 22.

3. RESULTS

CT images of a total of 167 cases were used to study the anatomical variation of the odontoid processes of the axis vertebra.

Table 1 shows that the youngest patient of the studied cases was 18 years old and the eldest one was 70 years old.

The mean ± SD = 37.91±14.55 years and the mode was 27 years.

Table 1: Descriptive statistics of the ages of studied cases

Descriptive statistics	Age in years
Mean	37.91
Median	35.00
Mode	27
Std. deviation	14.55
Minimum	18
Maximum	70

Table 2 shows that the mean and median of the dens height of the odontoid process were nearly equal, with minimal & maximum values of 12.70 &17.60 mm respectively. Regarding the anterio-posterior diameter of the process, the mean & median were nearly equal (11.18 & 11.30 mm respectively). The minimum & maximum values were (9.10 & 13.10 mm respectively). The mean ± SD of the transverse diameter was 9.04 ± 0.63 mm.

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Table 2: Descriptive statistics of some measurements of the studied odontoid processes

Descriptive statistics	Dense height in mm	Anteroposterior diameter in mm	Transverse diameter in mm
Mean	15.26	11.18	9.04
Median	15.30	11.30	9.10
Mode	14.70	11.70	9.12
Std. deviation	1.12	.75	.63
Minimum	12.70	9.10	7.67
Maximum	17.60	13.10	10.90

Table 3 reveals that there are statistically significant differences between means of the anterio-posterior diameters of the head of odontoid processes of females & males (10.78vs 11.28 mm respectively). The transverse diameter of the head of the odontoid process in both females & males was nearly equal (9.00 vs 9.05 mm respectively). This difference was statistically not significant; P< 0.05.

Table 3: The relationship between gender and some measurements of the studied head of odontoid processes

Measurements of the head of the odontoid process	Gender	Mean	Std. Deviation	P value
Dens height in mm	Female (33)	15.1000	1.263	P= .40
	Male (134)	15.3022	1.091	
Anterio-posterior diameter in mm	Female (33)	10.7848	.81892	P= .002
	Male (134)	11.2878	.70338	
Transverse diameter in mm	Female (33)	9.0097	.59958	P= .674
	Male (134)	9.0596	.64075	

Table 4 shows the means of dens height of the heads of odontoid processes in both age categories (30 years and less & above 30 years) were nearly equal (15.16 & 15.33 mm) respectively. These differences were statistically not significant; P< 0.05. There are no statistically significant differences between means of the anterio-posterior diameters of the head of odontoid processes of both age categories (30 years and less & above 30 years) as they were equal (11.18&11.18 mm respectively). The transverse diameter of the head of the odontoid process in both females & males was nearly equal (9.05 vs 9.04 mm respectively). This difference was statistically not significant; P< 0.05.

Table 4: The relationship between age categories and some measurements of the studied head of odontoid processes

Measurements of the head of the odontoid process	Age categories	Mean	Std. deviation	P value
Dense height in mm	30 years and less	15.1600	1.08846	P= .31
	Above 30 years	15.3361	1.15282	
Anterio-posterior diameter in mm	30 years and less	11.1896	.72214	P= .98
	Above 30 years	11.1875	.77712	
Transverse diameter in mm	30 years and less	9.0591	.70788	P= .87
	Above 30 years	9.0430	.57363	

The most common shape of the head of the odontoid process was pyramidal (65%), whereas the oval shape represented 35%, Figure 9.

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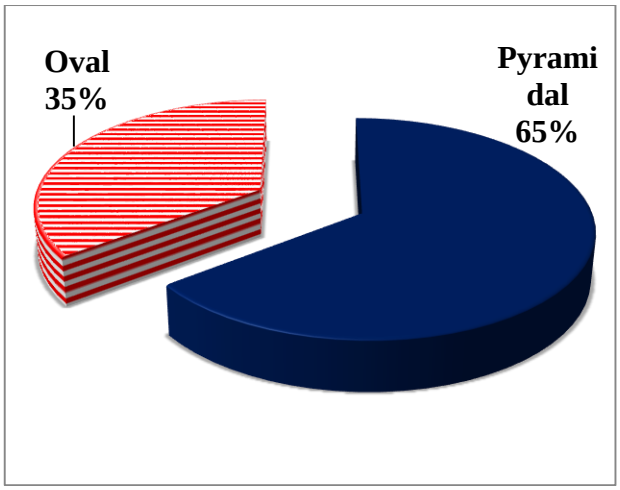


Figure 9: Shape of the head of the studied odontoid processes.

Table 5 illustrates the relationship between both gender and the shape of the head of the odontoid process. A higher proportion of males had the pyramidal shape of the head of the odontoid process compared to females (80.60 % compared to 19.40 % respectively). As regards to the oval shape of the head of the odontoid process, males had a higher proportion compared to females (79.70 % vs 20.30 %). These differences are not statistically significant; P< 0.05.

Table 5: The relationship between gender and shapes of the studied head of odontoid processes

Gender	No	The shape of the head		Total	P value
	%	Pyramidal	Oval		
Female	No	21	12	33	P= .52
	%	19.40	20.30	19.8%	
Male	No	87	47	134	
	%	80.60	79.70	80.2%	
Total	No	108	59	167	
	%	100.00	100.00	100.0%	

Table 6 shows a higher proportion of cases aged above 30 years had the pyramidal shape of the head of the odontoid process compared to cases aged 30 years and less (53.7 % compared to 46.3 % respectively). Similarly, a higher proportion of cases aged above 30 years had the oval shape of the head of the odontoid process, compared to cases aged 30 years and less (66.1 % compared to 33.9 % respectively). These differences are not statistically significant; P< 0.05. Table 6.

Table 6:The relationship between age categories and shapes of the studied head of odontoid processes

Gender	No	The shape of the head		Total	P value
	%	Pyramidal	Oval		
Age categories	No	50	20	70	P= .08
30 years and less	%	46.3	33.9	41.9 %	
Above 30 years	No	58	39	97	
	%	53.7	66.1	58.1 %	
Total	No	108	59	167	
	%	100.00	100.00	100.0%	

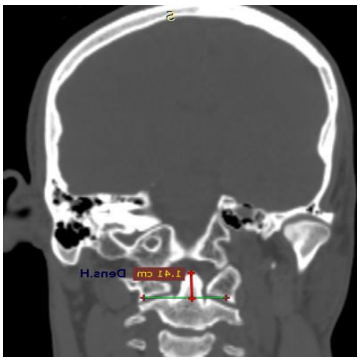


Figure 10: CT scan coronal section in the head and neck show the measurement of dens height.

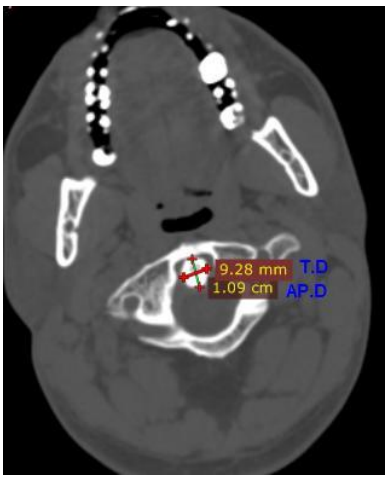


Figure 11: CT scan axial view at the centre of the dens shows the measurements of odontoid process T.D. (transverse diameter) and AP.D.(anteroposterior diameter).

Results about the morphological variants in the dens:

We found in our study regarding the morphological variants among 167 CT images one variant; a 45yrs old male whose odontoid process shows persistent ossiculumterminale as shown in (Figures 12& 13).

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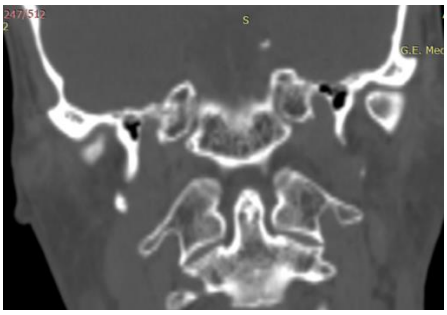


Figure 12: CT scan coronal view of 45years old male with persistent ossiculumterminale.

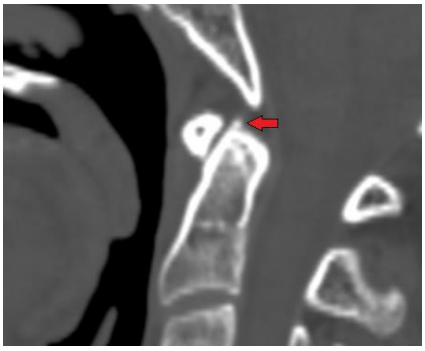


Figure 13: CT scan sagittal view showing the persistent ossiculumterminale.

4. DISCUSSION:

Regarding the height of the dens: The mean and median of the height of the odontoid process were nearly equal, with minimal & maximum values of 12.70 &17.60 mm respectively. Similar study results were found by **Tulsi (1978)** who worked on dens height in an Australian population of known gender where male and female groups showed a range of 1.15 –1.80 and 1.10 – 1.60cm respectively[8]. This is in agreement with **Schaffler (1992)** whose study was conducted on a known gender of Caucasian and black American population where male and female groups showed a range of 1.13- 2.03 and 1.09 – 1.70cm respectively[9]**. Singla et al** (2015), whose study was designed to measure morphometric data of human axis vertebra of Indian origin, found the mean anterior and posterior height of the odontoid process was 14.66 mm and 13.89mm respectively[18]. In contrast**, the results of Maqbool et al,(2016)** in a study done on a Pakistani population, revealed the height of the odontoid process was 19.2 mm in females with a range of (14.1 _ 22.9mm) and 20.7 mm in males with a range of (16.0 _ 24.10 mm)[20]. Present results disagree with those of **Kandziora et al,(2001)** who reported it to be 20.3 ± 1.90 mm[24]. **Regarding the anteroposterior diameter of the odontoid process:**

In the present study, there were statistically significant differences between the mean of the anterio-posterior diameters of the head of the odontoid processes of females & males (10.78 vs 11.28 mm respectively). This is in agreement with **Yusof et al (2007)** in a study on a Malaysian population that found the mean AP diameter of the odontoid process in men was 11.3 (with a range of 10.0–12.6) mm, whereas in women was 10.9 (with a range of 9.4–13.2) mm[11]. A similar result was reached by **Sharma et al(2008)**. The study sample was selected to include 30 specimens of axis vertebra in a Punjabi population and found the antero-posterior diameter of dens range(1.12- 1.29) mm in males with a mean of 1.17mm, and for females, a range of(0.70-1.09) mm with a mean of 1.03mm[10-12], in agreement with **Singla et al,(2015)** whose study was designed to measure morphometric data of human axis vertebra of Indian origin and where the mean A-P diameter of the odontoid process was 9.32 mm[18]**.**

Regarding the transverse diameter of the dens: The transverse diameter of the head of the odontoid process in both females & males was nearly equal (9.00 vs 9.05 mm respectively). Similar to **Lu et al,(2009) where** the transverse diameter range was (7.9–11.9)mm[13]**. Daher et al(2011)** conducted a study on a Brazilian population by using computed tomographic (CT) scans of 88 adult patients (aged 18–78 years) and they found the mean value of the minimum external transverse diameter was 9.19 ± 0.91 and 6.07 ± 1.08 mm for the minimum internal transverse diameter[14-15], in agreement with **Singla et al(2015)** who found the mean transverse diameter of the odontoid process in an Indian population was 9.32mm[16-17-18] and **Pai et al(2017)** who found the mean transverse diameters of dens were 9.8 mm [19-20-21].

Regarding the shape of the head of the odontoid process: In our study, the majority of the males had the pyramidal shape of the head of dens (87\134) and fewer had oval-shaped dens (47\134). Among the females the oval: pyramidal shape of the head of dens was (21\33:12\33) respectively, in disagreement with **Perdikakis (2012)**. The morphology of the odontoid process was classified into Type I: pyramidoid tip and Type II: ovoid or convex tip; the result was Type I was identified in 39 cases (34.8%). It was detected in 24 male (24/39) and 15 female (15/39) patients and Type II was recorded in 73 cases (65.2%). It was depicted in 44 male (44/73) and 29 female (29/73) patients and a higher prevalence in the ≤30y age group were pyramidal while the oval type showed a higher prevalence in the >30 age group (statistically significant differences)[23-27]. **Regarding the morphological variants of the dens:** In the present study we found one variant (persistent ossiculumterminale) among the sample in contrast to **Perdikakis et al** (2012) in their study on a Greek population retrospectively reviewing 112 patients who found an osterminale could be identifiable (with different degrees of ossification and fusion) in 22 cases[22-26-27].

5. Conclusion:

We conclude from the present study that the measurements of the odontoid process of axis vertebra in Libyans were generally in line with results reported in the literature and that the findings in this study can be used as reference standards for surgeons through our observations in the selection of correct screw thickness, length, & angle. They are also useful in devising new methods of fixation of fractures of the odontoid process which may decrease the time of union and danger of nonunion. The presence of a case of persistent ossiculumterminale during this study reveals that understanding the normal appearance of the developing odontoid/dens, as well as the variant anatomy is important to be able to distinguish these anomalies from traumatic injuries. This knowledge will help ensure proper diagnosis and guide appropriate management for these patients.

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