RUSSIAN ELECTRONIC JOURNAL OF RADIOLOGY

ОРИГИНАЛЬНАЯ СТАТЬЯ

CRANIAL-ATLANTOAXIAL VERTEBRAE-RELATIONSHIPS: A MORPHOMETRIC STUDY

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The skull or the neurocranium is the bondy part protecting the brain, while the atlanto-axial complex is the one responsible for prtecting the spinal cord during it's jurney from the brain to the spinal canal. Understanding these relationships is essential for surgical planning, biomechanical analyses, and diagnosing abnormalities in the craniovertebral junction. The findings of this study contribute to a more comprehensive understanding of the anatomical variations and correlations within this complex region. This study investigated the morphometric relationship between the skull's biparietal diameter and the atlanto-axial complex morphometry-a crucial region for head movement and spinal cord protection.

Materials and methods. Seventy-five patients who underwent brain CT scans were included. Various measurements were obtained, including the biparietal diameter (BPD), anterior-posterior (AP) diameter, and inner cross-sectional area (CSA) of the skull. Measurements of the atlas vertebra, specifically the atlas transverse diameter, atlas AP inner diameter (with and without dens), and atlas inner area space were also taken from the CT scans. CT scans were performed using a Siemens 64 slice multidetector scanner, and 3D multiplanar reconstruction was employed to facilitate accurate measurements.

Results. There was a strong positive correlation between the biparietal skull diameter (BPD)and the inner skull surface area in males, females, ages more than and less than 40, also there was strong positive correlation between the skull inner surface area and the atlas inner surface area, however there was only strong positive correlation between the skull BPD and the atlas inner traverse diameter in those older than 40 years. Otherwise there was weak correlation between the skull BPD and other atlanto-axial measurements.

Discussion. The atlas-axis complex is highly differentiated in mammals, reflecting adaptations for head movement and stability The atlas and axis vertebrae are unique among the cervical vertebrae, as they are highly specialized for head movement and stability. The atlas lacks a vertebral body and spinous process, while the axis has a prominent dens that articulates with the atlas. This unique morphology allows for a wide range of head movements, including flexion, extension, and rotation.[10]

Understanding the relationship between skull dimensions and atlas morphology may have significant implications for the diagnosis and management of conditions affecting the craniovertebral junction. [11] For instance, certain genetic syndromes or developmental disorders known to affect skull growth may also impact the development of the atlas, predisposing individuals to craniovertebral instability or neurological compression. By elucidating the correlations between BPD and atlas morphometry, clinicians may be better equipped to identify individuals at risk for these complications and implement preventive or therapeutic interventions. Additionally, a comprehensive understanding of these relationships can inform the design of more effective surgical strategies for managing craniovertebral junction abnormalities [6, 12].

Conclusion. There was a strong positive correlation between the biparietal skull diameter (BPD) and the inner skull surface area in males, females, ages more than and less than 40, also there was strong positive correlation between the skull inner surface area and the atlas inner surface area, however there was only strong positive correlation between the skull BPD and the atlas inner traverse diameter in those older than 40 years.

Keywords: biparietal diameter; atlanto-axial complex; morphometry; neurosurgical; CT scan.

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For citation: Rana A. Aziz Altae, Tara Farooq Kareem, Sabeeh Sameer Ibrahim, Shams Nameer Qasim Al-Qadhi, Rafal Raed Kadhem Aljanabi, Younis A. Cranial-atlantoaxial vertebrae-relationships: a morphometric study. REJR 2026; 16(1):6-19. DOI: 10.21569/2222-7415-2026-16-1-6-19.

Received: **11.03.26** **Accepted:** **14.04.26**

КРАНИО-АТЛАНТОАКСИАЛЬНЫЕ ВЗАИМООТНОШЕНИЯ ПОЗВОНКОВ: МОРФОМЕТРИЧЕСКОЕ ИССЛЕДОВАНИЕ

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Череп (нейрокраниум) представляет собой костную структуру, защищающую головной мозг, тогда как атланто-аксиальный комплекс отвечает за защиту спинного мозга во время его прохождения от головного мозга к позвоночному каналу. Понимание этих взаимоотношений необходимо для планирования хирургических вмешательств, биомеханического анализа и диагностики аномалий краниовертебрального перехода. Результаты данного исследования вносят вклад в более полное понимание анатомических вариаций и корреляций в этой сложной области. В исследовании изучалась морфометрическая взаимосвязь между бипариетальным диаметром черепа и морфометрией атланто-аксиального комплекса – ключевой области, отвечающей за движения головы и защиту спинного мозга.

Материалы и методы. В исследование были включены 75 пациентов, которым была выполнена компьютерная томография (КТ) головного мозга. Проводились различные измерения, включая бипариетальный диаметр (БПД), передне-задний диаметр и внутреннюю площадь поперечного сечения черепа. Также по данным КТ выполнялись измерения атланта: поперечный диаметр атланта, внутренний передне-задний диаметр атланта (с зубовидным отростком и без него) и внутренняя площадь пространства атланта. КТ выполнялась с использованием 64-срезового мультидетекторного сканера Siemens, для обеспечения точности измерений применялась 3D-мультипланарная реконструкция.

Результаты. Выявлена сильная положительная корреляция между бипариетальным диаметром черепа (БПД) и внутренней площадью поверхности черепа у мужчин, женщин, лиц старше и моложе 40 лет. Также отмечена сильная положительная корреляция между внутренней площадью поверхности черепа и внутренней площадью поверхности атланта. Однако сильная положительная корреляция между бипариетальным диаметром черепа и внутренним поперечным диаметром атланта наблюдалась только у лиц старше 40 лет. В остальных случаях корреляция между бипариетальным диаметром черепа и другими измерениями атланто-аксиального комплекса была слабой.

Обсуждение. Атланто-аксиальный комплекс высокодифференцирован у млекопитающих, что отражает адаптацию к движениям головы и обеспечению стабильности. Позвонки атланта и аксиса уникальны среди шейных позвонков, благодаря высокой специализации, обеспечивающей движения головы и стабильность. Атлант не имеет тела позвонка и остистого отростка, тогда как аксис обладает выступающим зубовидным отростком, сочленяющимся с атлантом. Такая уникальная морфология обеспечивает широкий диапазон движений головы, включая сгибание, разгибание и вращение [10].

Понимание взаимосвязи между размерами черепа и морфологией атланта может иметь важное значение для диагностики и лечения заболеваний, затрагивающих краниовертебральный переход [11]. Например, некоторые генетические синдромы или нарушения развития, влияющие на рост черепа, могут также воздействовать на развитие атланта, предрасполагая индивидов к нестабильности краниовертебрального перехода или неврологической компрессии. Выяснение корреляций между бипариетальным диаметром и морфометрией атланта может помочь клиницистам лучше выявлять лиц с риском развития этих осложнений и проводить профилактические или терапевтические вмешательства. Кроме того, всестороннее понимание этих взаимосвязей может способствовать разработке более эффективных хирургических стратегий для лечения аномалий краниовертебрального перехода [6, 12].

Заключение. Выявлена сильная положительная корреляция между бипариетальным диаметром черепа (БПД) и внутренней площадью поверхности черепа у мужчин, женщин, лиц старше и моложе 40 лет. Также отмечена сильная положительная корреляция между внутренней площадью поверхности черепа и внутренней площадью поверхности атланта. Однако сильная положительная корреляция между бипариетальным диаметром черепа и внутренним поперечным диаметром атланта наблюдалась только у лиц старше 40 лет.

Ключевые слова: бипариетальный диаметр, атланто-аксиальный комплекс, морфометрия, нейрохирургия, компьютерная томография.

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Для цитирования: Рана А. Азиз Альтае, Тара Фарук Карим, Сабих Самир Ибрагим, Шамс Намир Касим Аль-Кади, Рафаль Раед Кадхем Аль-Джанаби, Юнис А. Рашид. Кранио-атлантоаксиальные взаимоотношения позвонков: морфометрическое исследование. REJR 2026; 16(1):6-19. DOI: 10.21569/2222-7415-2026-16-1-6-19.

Статья получена: **11.03.26** **Статья принята:** **14.04.26**

Introduction. The craniovertebral junction (CVJ) is a complex anatomical region that includes the occiput, atlas (C1), and axis (C2), playing a crucial role in head support, movement, and protecting the spinal cord as it transitions from the brainstem [1]. The cranium or the skull, is an important bony structure its main function is to protect the precious brain giving rise to the name 'neurocranium', it consists of eight bones; occipital, two temporal, two parietal, sphenoid, ethmoid and frontal [2].

The biparietal diameter (BPD) serves as a standard biometric parameter widely used in fetal ultrasound to estimate gestational age and assess fetal growth, providing essential information about the development and well-being of the fetus, this draw our attention to the importance of this measurement pushing us towards comparing it to many other parameters in the unique atlas in addition to the skull other morphometric parameters, the BPD is the widest parameter of the skull [2].

The atlas (C1) vertebra, distinguished by its lack of a vertebral body and spinous process, represents a unique adaptation within the vertebral column, primarily designed to articulate with the skull and facilitate head movement [3]. The same rule is applied for the vertebral column whose responsibility is to protect the delicate spinal cord [4].

Atlanto-axial part consists of two modified cervical vertebrae drawing the attention to a sort of transitional bony zone between the cranium above and the typical cervical vertebrae below the atlantoaxial joint is a type of synovial joint that represent a uniaxial pivot joint [5].

Those two vertebrae are sharing the cranium in protecting the important neural tissue in one hand and sharing the other cervical vertebrae in allowing movement of the head in many directions over the relatively more stable, less movable thoracic vertebrae [6]. However; the two unique vertebrae with their special shape allows more special movements although they do not have the spinous processes which acts as a leaver of the attached 'inter-ligaments' and paraspinal muscles increasing their force of movement and concomitant protection; these two vertebrae they have more free movement allowing better movement in the neck area. The atlas vertebra with its plane ring shape giving the feeling of being a transitional zone between the spherical skull and the remaining cervical vertebrae [7]. This vertebra with the Dennis of the axis are special area drawing the focus of the neurosurgeons and orthopedic surgeons giving rise to many special procedures related to this important area. It is important to have any information related to the morphometric parameters wether anatomical or radiological that can help these two teams of surgeons to decide their plans when attempting surgical intervention at this alarming specific area [8].

With the presence of the more sophisticated CT scan devices with its clear images that describe the radio anatomical reality of the bones, this advanced technology allows us to measure precisely the diameters with estimation of the surface area of the rounded inner skull, and the rounded spinal canal [9].

Aim of the study is to find the biometric correlation between the cranium and the atlan-to-axial complex.

Materials and methods.

This study was conducted in the Oncology Teaching Hospital in Medical City Complex in Baghdad from 1st of october 2024 till 15th of february 2025.

It is a retrospective cross- sectional study in which includes the data for patients who underwent a check CT scan for their skull and cervical region for any reason, the data then processed taking care while selecting the data.

Exclusion criteria

1. Any abnormal skull shape especially with congenital anomalies.
2. Congenital vertebral anomalies involving the atlas (such as bifid vertebra).
3. Images with motion artifact
4. Cases of head trauma

A total of 73 patient's CT included in this study in whom brain CT scan were performed for various indications and the skull was apparently normal in shape.

The study sample consisted of 42 male and 31 female, with their age ranges from 2 years to 76 years (mean 27.59 ± 18.093).

CT was performed on Siemens 64 slice multidetector scanner somatom definition (AS 64, Siemens). A tube voltage of 120 kVp, tube current of 250 - 300 mA, collimation of 0.652 mm, slice thickness of 5 mm and Pitch of 1 mm were used in all patients.

Variable measurement taken for each case after reconstruction of 1.5-2 mm was done followed by 3D Multiplanar reconstruction (3D MPR) and correlation between multiple variables was done.

For the skull, the biparietal diameter (BPD), the anterior-posterior (AP) diameter and the inner cross-sectional area (CSA)were taken for each patient after adjustment of the axial

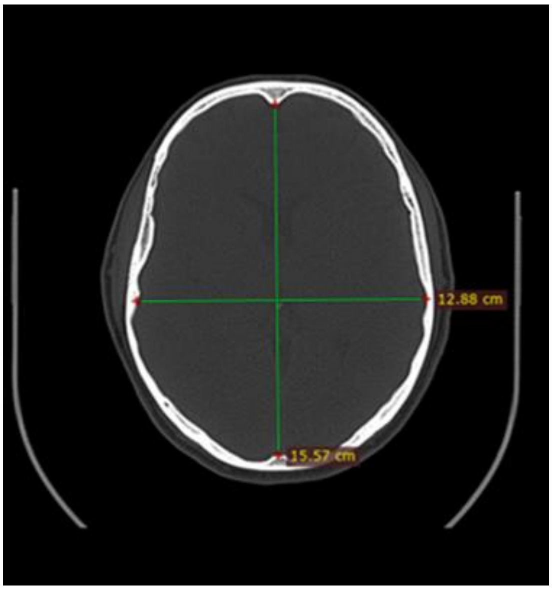

Fig. 1 a (Рис. 1 а)

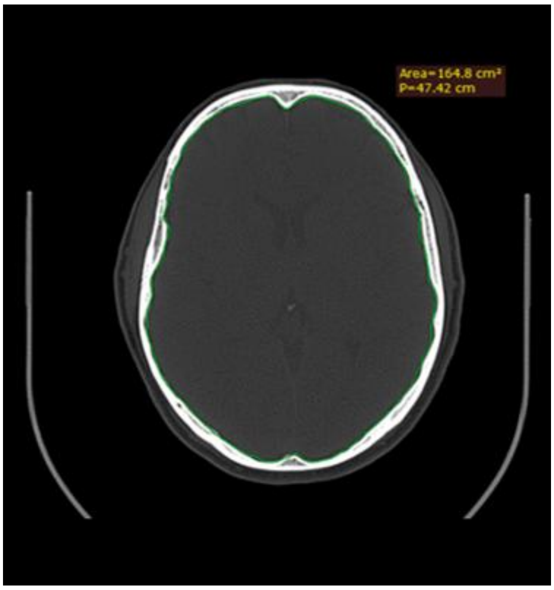

Fig. 1 b (Рис. 1 б)

Fig. 1. CT scan of the skull, axial plane, bone window.

a – Measuring the BPD and the AP diameter. b – measuring the cross-sectional area (CSA).

Рис. 1. КТ черепа, аксиальная плоскость, костное окно.

а – Измерение бипариетального диаметра (БПД) и передне-заднего диаметра. b – Измерение площади поперечного сечения (CSA).

images parallel to the corpus callosum for all the patients using the 3D MPR to overcome any abnormal tilting in patients head position. All the measurements were taken at axial view at the level of the thalami. The maximal BPD were taken between the inner surfaces of the skull, the AP diameter was taken along the midsagittal plane passes through the third ventricle and the inner CSA was traced along the inner cortical skull surface using a manual cursor and recorded automatically (fig. 1).

Other variable measurements were taken at the level of the atlas arch in axial view after adjustment of the axial slices parallel to the arch, and include: maximal inner transverse diameter (ITD), maximal inner anteroposterior (IAP) diameter, the spinal canal diameter (SCD), and the cross-sectional area (CSA) of the atlas (fig. 2).

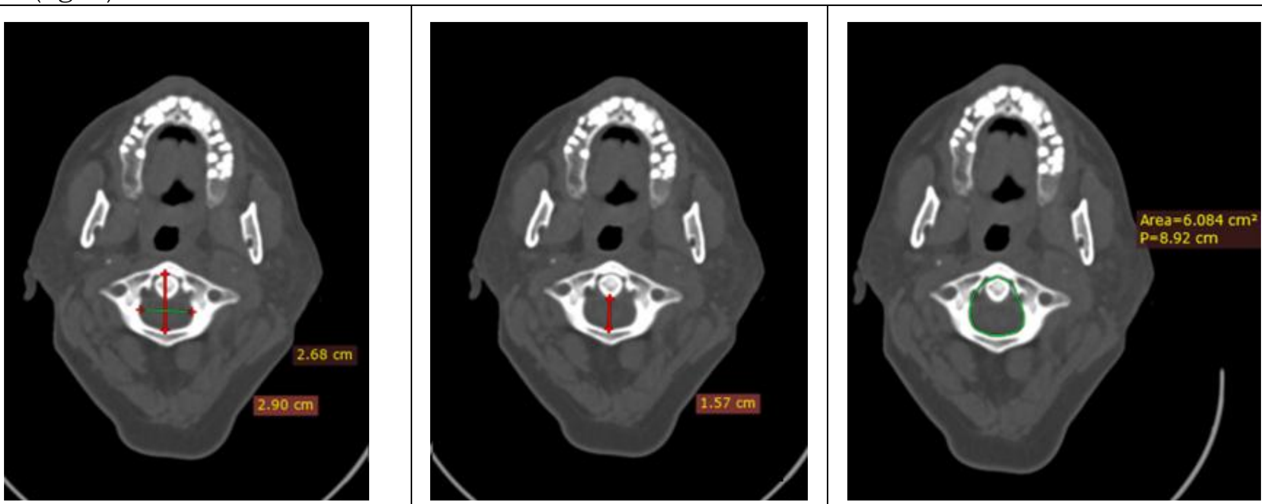

Fig. 2 a (Рис. 2 а) Fig. 2 b (Рис. 2 б) Fig. 2 b (Рис. 2 б)

Fig. 2. CT scan of the skull, axial plane, bone window.

a – Measuring the BPD and the AP diameter. b – measuring the cross-sectional area (CSA).

Рис. 2. КТ черепа, аксиальная плоскость, костное окно.

a – Измерение бипариетального диаметра (БПД) и передне-заднего диаметра. b – Измерение площади поперечного сечения (CSA).

The SCD was measured in axial view from the posterior edge of the odontoid process to the inner surface of the posterior portion of the atlas arch and the IAP diameter was measured from the inner surface of the anterior part of the arch to the inner surface of the posterior part. The CSA was traced along the inner cortical surface of the atlas using a manual cursor and recorded automatically.

Statistical tools.

By using SPSS (version 26) show the statistical analysis below: The Pearson correlation shows the relationship between BPD cm & (atlas transverse D cm, Atlas AP inner diameter cm, atlas AP inner diameter without dense whole inner D. cm, atlas inner area space, AP diameter, inner surface area of the skull).

Results.

The study includes 42 males (57.5%) and 31 females (42.5%). The mean age of the study population was 27.59 ± 18.09 years. The mean skull biparietal diameter was 12.81 ± 0.62 cm, while the mean atlas inner transverse and anteroposterior diameters were 2.81 ± 0.27 cm and 3.02 ± 0.28 cm, respectively. The mean atlas sagittal canal diameter measured 1.81 ± 0.28 cm, with an average atlas inner cross-sectional area of 6.35 ± 0.93 cm². The mean skull anteroposterior diameter and inner cross-sectional area were 15.15 ± 1.41 cm and 159.81 ± 13.14 cm², respectively (table №1).

Correlation analysis demonstrated weak positive, statistically non-significant correlations between skull BPD and most atlas dimensions. In contrast, skull BPD showed a strong and statistically significant positive correlation with skull inner cross-sectional area ($r = 0.739$, $p = 0.0001$; table №2, fig. 3).

Among male patients, the mean age was 23.24 ± 16.04 years. The mean skull biparietal diameter measured 12.96 ± 0.63 cm. The mean atlas inner transverse diameter and inner anteroposterior diameter were 2.86 ± 0.24 cm and 3.09 ± 0.30 cm, respectively. The atlas sagittal canal diameter averaged 1.84 ± 0.32 cm, with a mean atlas inner cross-sectional area of 6.57 ± 0.97 cm². The mean skull anteroposterior diameter and skull inner cross-sectional area were 15.03 ± 0.61 cm and 153.17 ± 8.02 cm²,

Table №1. Means of the patients age, BPD (biparental skull diameter), Atlas transverse diameter, Atlas AP (anteroposterior diameter) with the dense, Atlas AP inner diameter without dense, and with, AP diameter of the skull, Atlas inner area space and skull inner surface area.

No.	Factors	Mean ± SD
1	Age	27.59 ± 18.093
2	Skull BPD (cm)	12.809 ± 0.616
3	Atlas ITD (cm)	2.81 ± 0.273
4	Atlas IAP diameter (cm)	3.024 ±0.275
5	Atlas SCD (cm)	1.8111 ± 0.276
6	Atlas inner CSA (cm^2)	6.348 ± 0.927
7	Skull AP diameter (cm)	15.145 ± 1.412
8	Skull inner CSA (cm^2)	159.81 ± 13.144

Table №2 Correlation between BPD with (atlas ITD, Atlas IAP, atlas SCD, atlas inner CSA, skull AP diameter, skull inner CSA).

No.	Factors	R (Pearson)	P value	Interpretation
1	Atlas ITD	0.074	0.535	Weak positive correlation
2	Atlas IAP diameter	0.223	0.058	Weak positive correlation
3	Atlas SCD	0.136	0.253	Weak positive correlation
4	Atlas inner CSA	0.086	0.469	Weak positive correlation
5	Skull AP diameter	0.197	0.116	Weak positive correlation
6	Skull inner CSA	0.739	0.0001	Strong positive correlation

respectively (table №3).

Correlation analysis in male patients demonstrated weak and statistically non-significant correlations between skull BPD and most atlas dimensions. However, a statistically significant moderate to strong positive correlation was observed between skull BPD and skull inner cross-sectional area ($r = 0.523$, $p = 0.004$; Table №4, fig. 4).

In female patients, the mean age was 33.48 ± 19.27 years. The mean skull biparietal diameter was 12.60 ± 0.54 cm. The atlas inner transverse diameter and inner anteroposterior diameter averaged 2.75 ± 0.31 cm and 2.94 ± 0.22 cm, respectively. The mean atlas sagittal canal diameter was 1.77 ± 0.21 cm, with an atlas inner cross-sectional area of 6.04 ± 0.79 cm^2. The mean skull anteroposterior diameter and skull inner cross-sectional area were 15.23 ± 1.82 cm and 164.84 ± 14.10 cm^2, respectively (Table №5).

Correlation analysis demonstrated weak and statistically non-significant correlations between skull BPD and most atlas parameters in female patients. However, skull BPD showed a strong and statistically significant positive correlation with skull inner cross-sectional area ($r = 0.779$, $p = 0.0001$; Table №6, fig. 5).

In patients older than 40 years, skull biparietal diameter demonstrated a statistically significant strong positive correlation with atlas inner transverse diameter ($r = 0.486$, $p = 0.041$). A strong and statistically significant positive correlation was also observed between skull BPD and skull inner cross-sectional area ($r = 0.622$, $p = 0.013$). Correlations between skull BPD and the remaining atlas parameters, including inner anteroposterior diameter, sagittal canal diameter, and atlas inner cross-sectional area, were weak and not statistically significant. Skull BPD showed a weak negative, non-significant correlation with skull anteroposterior diameter (Table №, fig. 6).

In patients aged 40 years or younger, skull biparietal diameter demonstrated weak and statistically non-significant correlations

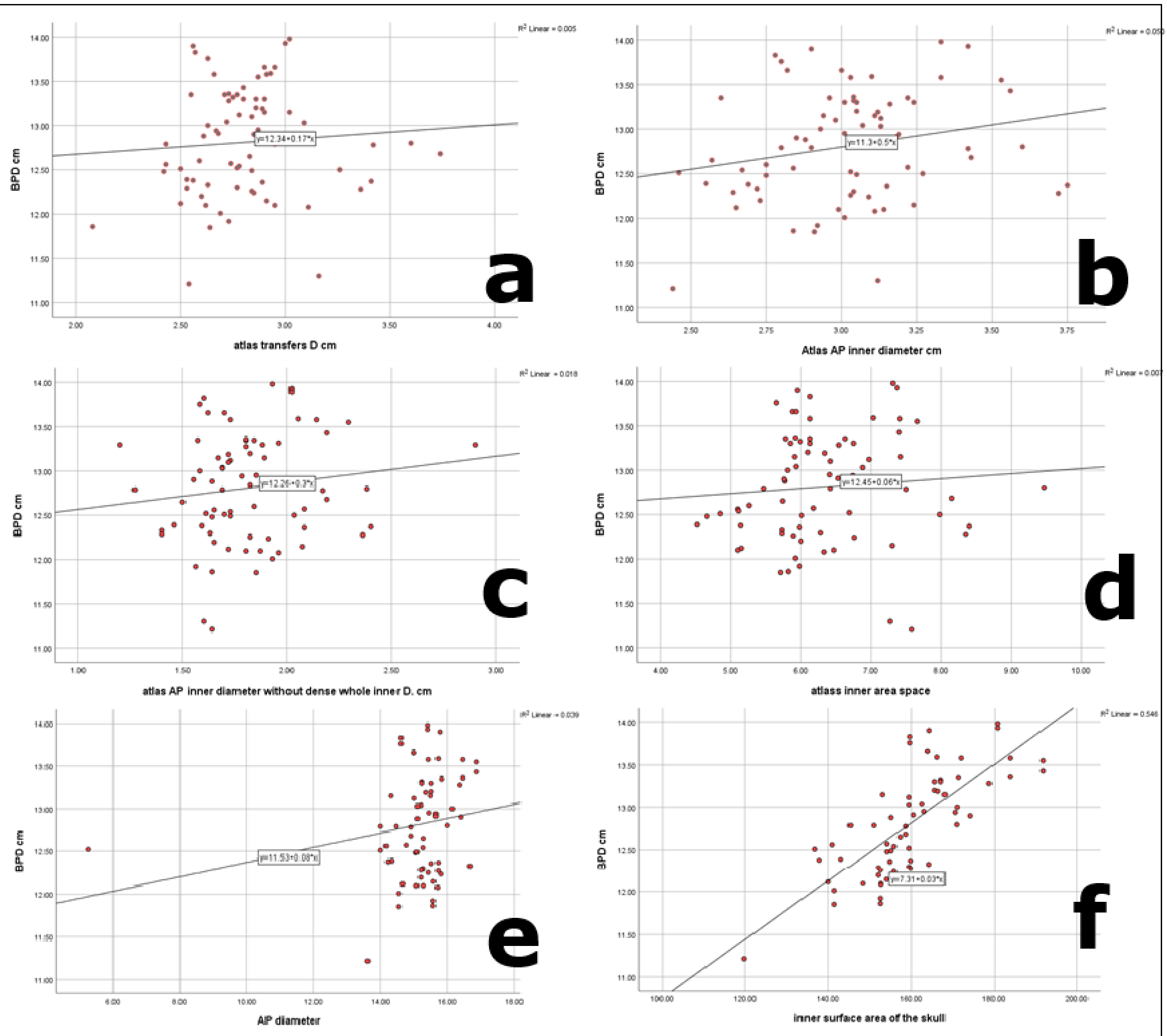

Fig. 3 (Рис. 3)

Fig. 3. Diagrams.

a – Weak correlation between skull BPD and atlas ITD. b – Weak correlation between skull BPD and Atlas inner AP diameter. c – Weak correlation between skull BPD and atlas SCD. d – Weak correlation between the skull BPD and atlas inner CSA. e – Weak correlation between the skull BPD and the skull AP diameter. f – Strong correlation between the skull BPD and the skull inner CSA.

Рис. 3. Диаграммы.

a – Слабая корреляция между бипариетальным диаметром (БПД) черепа и поперечным внутренним диаметром (ITD) атланта. b – Слабая корреляция между БПД черепа и внутренним передне-задним диаметром (IAP) атланта. c – Слабая корреляция между БПД черепа и сагиттальным диаметром позвоночного канала (SCD) атланта. d – Слабая корреляция между БПД черепа и внутренней площадью поперечного сечения (CSA) атланта. e – Слабая корреляция между БПД черепа и передне-задним диаметром черепа. f – Сильная корреляция между БПД черепа и внутренней площадью поперечного сечения черепа.

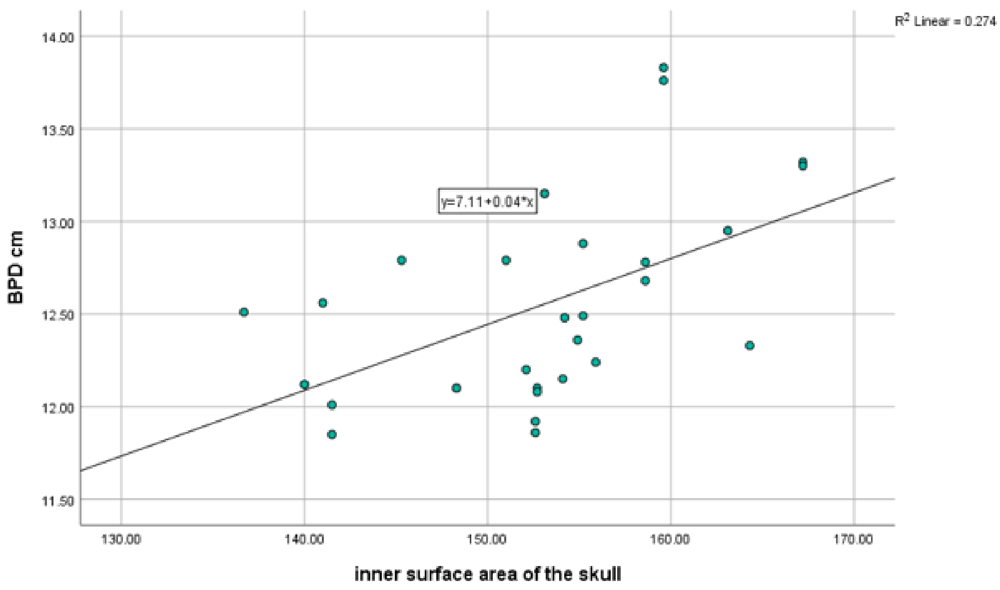

Fig. 4 (Рис. 4)

Fig. 4. Diagram.

Strong correlation between skull BPD and skull inner CSA for male patients.

Рис. 4. Диаграмма.

Сильная корреляция между бипариетальным диаметром (БПД) черепа и внутренней площадью поперечного сечения (CSA) черепа у пациентов мужского пола.

Table №3. Means of measured parameters for male.

No.	Factors	Mean ± SD
1	Age	23.238 ± 16.043
2	BPD	12.964 ± 0.626
3	Atlas ITD	2.859 ± 0.237
4	Atlas IAP diameter	3.087 ±0.297
5	Atlas SCD	1.838 ± 0.316
6	Atlas inner CSA	6.572 ± 0.965
7	Skull AP diameter	15.028 ± 0.605
8	Skull inner CSA	153.171 ± 8.019

Table №4. Correlation between BPD cm with (atlas ITD, Atlas IAP diameter, atlas SCD, atlas inner CSA, Skull AP diameter, skull inner CSA) by using person correlation (For male).

No.	Factors	R (Pearson)	P value	Interpretation
1	Atlas ITD	-0.042	0.791	Weak negative correlation
2	Atlas IAP diameter	0.273	0.08	Weak positive correlation
3	Atlas SCD	0.212	0.177	Weak positive correlation
4	Atlas inner CSA	-0.057	0.718	Weak negative correlation
5	Skull AP diameter	-0.311	0.107	Weak negative correlation
6	Skull inner CSA	0.523	0.004	Strong positive correlation

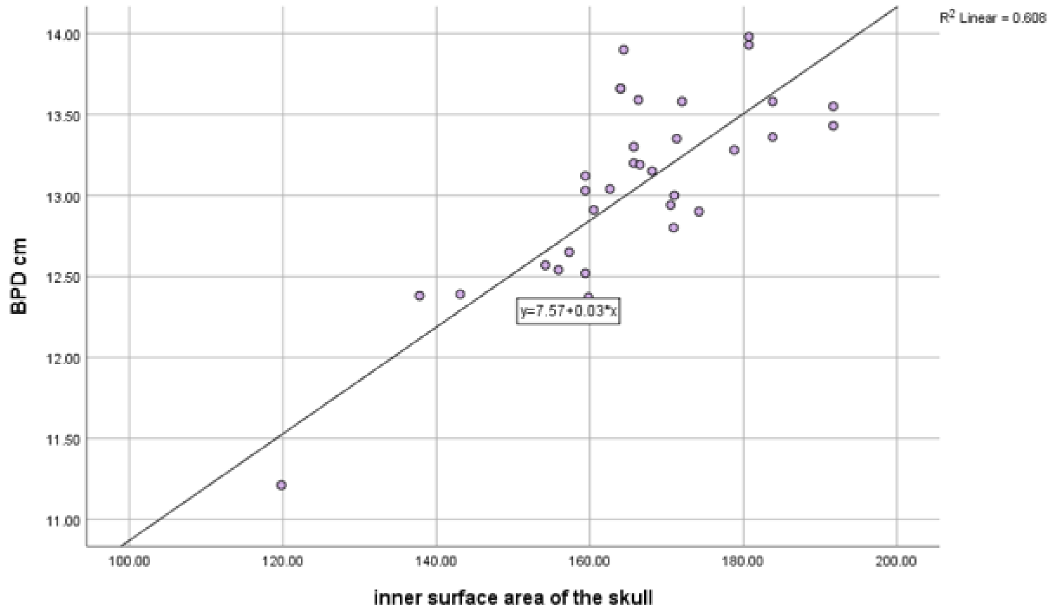

Fig. 5 (Рис. 5)

Fig. 5. **Diagram.**

Strong correlation between skull BPD and skull inner CSA for female patients..

Рис. 5. **Диаграмма.**

Сильная корреляция между бипариетальным диаметром (БПД) черепа и внутренней площадью поперечного сечения (CSA) черепа у пациентов женского пола.

Table №5. Means of measured parameters for female.

No.	Factors	Mean ± SD
1	Age	33.483 ± 19.274
2	BPD	12.601 ± 0.543
3	Atlas ITD	2.745 ± 0.308
4	Atlas IAP diameter	2.939 ±0.219
5	Atlas SCD	1.774 ± 0.210
6	Atlas inner CSA	6.044 ± 0.789
7	Skull AP diameter	15.233 ± 1.816
8	Skull inner CSA	164.835 ± 14.096

Table №6. Correlation between BPD with (atlas ITD, Atlas IAP diameter, atlas SCD, atlas inner CSA, skull AP diameter, skull inner CSA) by using person correlation (for female).

No.	Factors	R (person)	P value	Interpretation
1	Atlas ITD	0.083	0.659	Weak positive correlation
2	Atlas IAP diameter	-0.090	0.629	Weak negative correlation
3	Atlas SCD	-0.138	0.459	Weak negative correlation
4	Atlas inner CSA	0.120	0.521	Weak positive correlation
5	Skull AP diameter	0.315	0.057	Weak positive correlation
6	Skull inner CSA	0.779	0.0001	Strong positive correlation

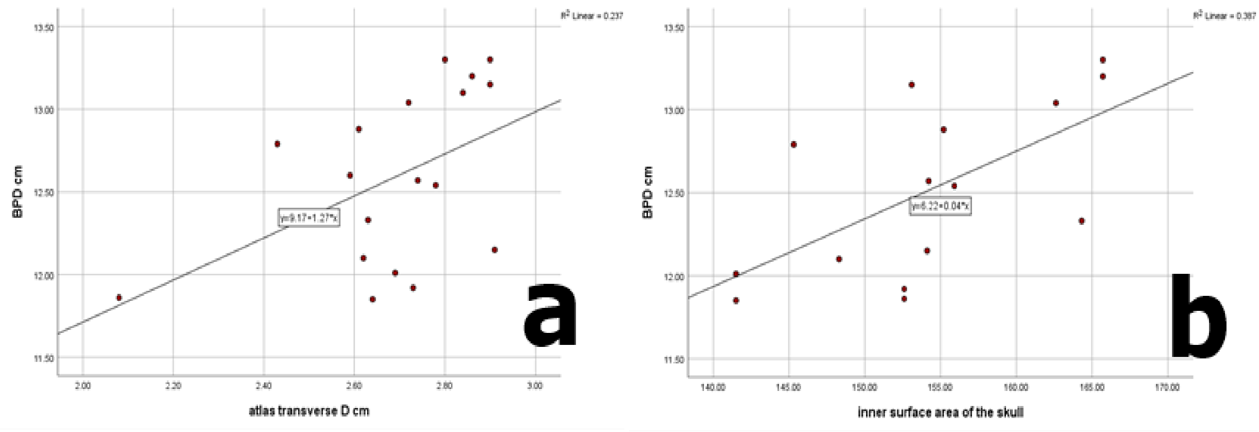

Fig. 6 (Рис. 6)

Fig. 6. **Diagram.**

a – Strong correlation between skull BPD and atlas ITD for patients with age greater than 40 years. b – Strong correlation between skull BPD and skull inner CSA for patients with age greater than 40 years.

Рис. 6. **Диаграмма.**

a – Сильная корреляция между бипариетальным диаметром (БПД) черепа и поперечным внутренним диаметром (ITD) атланта у пациентов старше 40 лет.

b – Сильная корреляция между бипариетальным диаметром (БПД) черепа и внутренней площадью поперечного сечения (CSA) черепа у пациентов старше 40 лет.

Table №7. Correlation between BPD cm with (Atlas ITD, atlas IAP diameter, atlas SCD, atlas inner CSA, skull AP diameter, skull inner CSA) by using person correlation for age greater than 40 years.

No.	Factors	R (Pearson)	P value	Interpretation
1	Atlas ITD	0.486	0.041	Strong positive correlation
2	Atlas IAP	0.297	0.231	Weak positive correlation
3	Atlas SCD	0.099	0.696	Weak positive correlation
4	Atlas inner CSA	0.289	0.245	Weak positive correlation
5	Skull AP diameter	-0.113	0.687	Weak negative correlation
6	Skull inner CSA	0.622	0.013	Strong positive correlation

Table №8. Correlation between BPD cm with (Atlas ITD, atlas IAP diameter, atlas SCD, atlas inner CSA, skull AP diameter, skull inner CSA) by using person correlation for age equal or younger than 40 years old.

No.	Factors	R (Pearson)	P value	
1	Atlas ITD	-0.060	0.666	Weak negative correlation
2	Atlas IAP diameter	0.193	0.158	Weak positive correlation
3	Atlas SCD	0.142	0.301	Weak positive correlation
4	Atlas inner CSA	0.001	0.997	Weak positive correlation
5	Skull AP diameter	0.246	0.086	Weak positive correlation
6	Skull inner CSA	0.743	0.0001	strong positive correlation

Table №8. Correlation between BPD cm with (Atlas ITD, atlas IAP diameter, atlas SCD, atlas inner CSA, skull AP diameter, skull inner CSA) by using person correlation for age equal or younger than 40 years old.

No.	Factors	R (Pearson)	P value	Interpretation
1	Skull inner CSA	0.354	0.004	Strong positive correlation

with atlas inner transverse diameter, inner anteroposterior diameter, sagittal canal diameter, and atlas inner cross-sectional area. A weak positive, non-significant correlation was also observed between skull BPD and skull anteroposterior diameter. In contrast, skull BPD showed a strong and statistically significant positive correlation with skull inner cross-sectional area (r = 0.743, p = 0.0001; Table №8, fig. 7).

Correlation analysis demonstrated a statistically significant positive relationship between atlas inner cross-sectional area and skull inner cross-sectional area (r = 0.354, p = 0.004), indicating that individuals with a larger skull inner cross-sectional area tend to have a proportionally larger atlas inner cross-sectional area (Table №9, fig. 8).

Discussion.

The atlas-axis complex is highly differentiated in mammals, reflecting adaptations for head movement and stability The atlas and axis vertebrae are unique among the cervical vertebrae, as they are highly specialized for head movement and stability. The atlas lacks a vertebral body and spinous process, while the axis has a prominent dens that articulates with the atlas. This unique morphology allows for a wide range of head movements, including flexion, extension, and rotation.[10]

Understanding the relationship between skull dimensions and atlas morphology may have significant implications for the diagnosis and management of conditions affecting the craniovertebral junction. [11]

For instance, certain genetic syndromes or developmental disorders known to affect skull growth may also impact the development of the atlas, predisposing individuals to craniovertebral instability or neurological compression. By elucidating the correlations between BPD and atlas morphometry, clinicians may be better equipped to identify individuals at risk for these complications and implement preventive or therapeutic interventions. Additionally, a comprehensive understanding of these relationships can inform the design of more effective surgical strategies for managing craniovertebral junction abnormalities [6, 12].

In the current study we measured the skull biparietal diameter in 73 patients using CT scan measurements, the statistical interpretations showed that we had 42 males (57.5%)

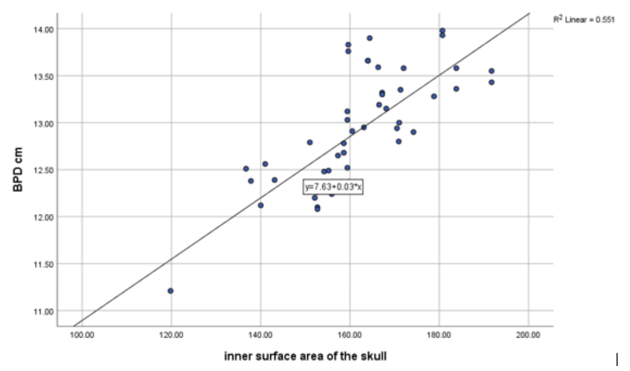

Fig. 7 (Рис. 7)

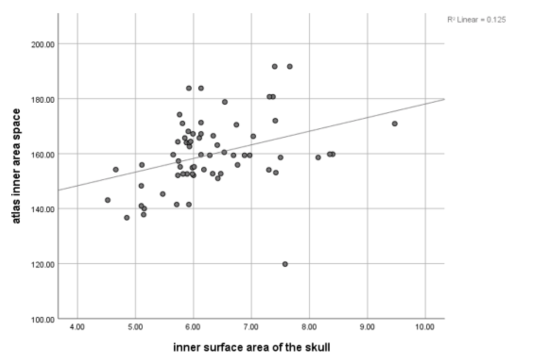

Fig. 8 (Рис. 8)

Fig. 7. Diagram.

Strong correlation between skull BPD and skull inner CSA for patients with age equal or younger than 40 years.

Рис. 7. Диаграмма.

Сильная корреляция между бипариетальным диаметром (БПД) черепа и внутренней площадью поперечного сечения (CSA) черепа у пациентов в возрасте 40 лет и младше.

Fig. 8. Diagram.

Strong correlation between the atlas inner CSA and the skull inner CSA.

Рис. 8. Диаграмма.

Сильная корреляция между внутренней площадью поперечного сечения (CSA) атланта и внутренней площадью поперечного сечения черепа.

and 31 females (42.5%).

The mean of normal biparietal diameter of the skull in this study group was 12.809 ± 0.616 cm, showing 12.964 ± 0.626 in male patients, 12.601 ± 0.543 for females, it reflects that the diameter is smaller in females than males which sounds logic. The measures are less than that obtained by Burdan, et al [12] which showed that the skull width is 149.547mm for males and 143.517mm for females, this study was conducted on Caucasian population so ethnic differences play a role in comparison to our study which conducted on Asian population.

A study conducted by Sazonova Olga et al. showed that the normal width for adult male's skull was 13.5 – 15.8cm while for females it was 13–15.6 cm indicating that there is variation in human skull morphometry according to the gender, age, and ethnicity [13].

The anteroposterior (AP) diameter of the skull means was 15.145±1.412 including 15.028 ± 0.605 for males and 15.233 ± 1.816 for females. The mean skull inner CSA was 159.81 ± 13.144 cm2 including 153.171 ± 8.019 cm2 for males and 164.835 ± 14.096 cm2 for females. Atlas vertebral morphometry was measured showing that the widest mean ITD was 2.81 ± 0.273, which was 2.859 ± 0.237 for males and 2.745 ± 0.308 for females which seems comparable to the results obtained from (Shilpa and Vatsalaswamy study) in which the maximal atlas vertebral width was 26.89 ± 1.93mm the study was conducted in Malysia. [11], while Küçükoğlu et al. in their study conducted in Turki, showed a result of 44.1 ± 3.5 mm [14].

The atlas mean inner antero- posterior (IAP)diameter extending from the inner anterior arch to the inner posterior arch was 3.024 ±0.275 cm which was 3.087 ±0.297cm for males and 2.939 ±0.219cm for females which is comparable to the results of (Shilpa & Vatsalaswamy study) which was 27.89 ± 2.59mm [11] while Küçükoğlu et al. showed the result of 29.61 ± 3.21mm [14].

Atlas spinal canal diameter (SCD) was measured showing a mean of 1.8111 ± 0.276 cm divided to 1.838 ± 0.316cm for males and 1.774 ± 0.210cm for females. The results were comparable to the study conducted by [15].

The atlas inner cross sectional area's mean was 6.348 ± 0.927 cm2 including 6.572 ± 0.965 cm2 for males and 6.044 ± 0.789 cm2 for females.

A strong positive correlation between the BPD and the inner CSA of the skull, while a weak negative in addition to the weak positive correlations between the BPD and other parameters. Similar results came out regarding correlation between the skull BPD and the other parameters from statistical point of view for female patients. Correlation between skull BPD and the other parameters for age greater than 40 years, showed a new strong correlation between the BPD and atlas ITD, in addition to the usual strong correlation between the BPD and the inner CSA of skull, this indicates that the increased age increases the correlation between these two factors which was not the case according to the results shown in younger patients with ages less than 40 years.

A strong correlation between the skull inner CSA and the atlas inner CSA where the significance is (P=0.004 which is less than 0.01), this may be explained by the fact that big skull surrounds a big brain with a big atlas vertebral foramen to surround the big spinal cord the increased overall morphometry was going hand in hand.

Conclusion.

There was a strong positive correlation between the biparietal skull diameter (BPD) and the inner skull surface area in males, females, ages more than and less than 40, also there was strong positive correlation between the skull inner surface area and the atlas inner surface area, however there was only strong positive correlation between the skull BPD and the atlas inner traverse diameter in those older than 40 years. Its highly complex region more studies are important to understand other relationships between the skull and the vertebral column.

Conflict of interest. None declared.

Funding. No funding was received to assist with the preparation of this manuscript.

Ethical approval. According to the ethical approval committee decay No.:FM.SA.158 in 28/4/2025.[the ethical committee in Al-Iraqia University, College of Medicine], the committee followed the Helsinki Declaration. We mentioned that the research is a retrospective study, depends on the patients reports, no patient's name was used no violation of patient's privacy was there according to the national regulations.

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