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Evaluation of Sella Turcica Bridging, Ponticulus Posticus Calcification and Sella Turcica Volume in Individuals with Different Malocclusions

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ABSTRACT

Aim: The aim of this study was to evaluate sella turcica bridging, ponticulus posticulus calcification and sella turcica volume in individuals with different skeletal malocclusions on cone beam computed tomography (CBCT) images.
Material and Methods: Sella turcica volume calculations were performed on a total of 84 individuals, 28 individuals in each class. Ponticulus posticus calcification and sella turcica bridging were performed on a total of 162 patients (27 male, 27 female) in each class. Sella turcica bridging and ponticulus posticulus calcifications were analyzed on sagittal sections of CBCT images and data were recorded as no bridging, partial bridging and complete bridging. Sella turcica volume calculations were performed with 3D-DOCTOR (Able Software Corp., Lexington, MA, USA) by manual segmentation method on KIBT sagittal sections.
Results: There was no statistically significant difference in ponticulus posticus calcification and sella turcica bridging according to skeletal malocclusions and gender. Sella tursica volume did not show a statistically significant difference between skeletal malocclusions, while sella tursica volume was found to be statistically significantly higher in female than in male individuals. ($p=0.004$, $p<0.005$).
Conclusion: Ponticulus posticus calcification, sella turcica bridging and sella turcica volume do not vary according to skeletal malocclusions. Sella turcica volume is statistically significantly higher in female individuals. It should be kept in mind that calcifications and shape changes in structures such as the sella turcica and atlas bone on lateral cephalometric radiographs may be a sign of certain diseases.

Farklı Maloklüzyonlara Sahip Bireylerde Sella Tursika Köprüleşmesi, Pontikulus Postikus Kalsifikasyonu ve Sella Tursika Hacminin Karşılaştırılması

Makale Bilgisi

Makale Geçmişi

Geliş Tarihi: 30.09.2023
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Anahtar Kelimeler:
Sella turcica,
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Malokluzyon.

ÖZET

Amaç: Bu araştırmada farklı iskeletsel maloklüzyona sahip bireylerde sella tursika köprüleşmesi, pontikulus postikus kalsifikasyonu ve sella tursika hacminin konik ışınlı bilgisayarlı tomografi (KIBT) görüntülerinde değerlendirilmesi amaçlanmıştır.
Gereç ve Yöntemler: Sella tursika hacim hesaplamaları her bir sınıfta 28 birey; toplam 84 birey üzerinde yapılmıştır. Pontikulus postikus kalsifikasyonu ve sella tursika köprüleşmeleri her bir sınıfta 54 (27 kadın, 27 erkek) toplam 162 hasta üzerinde yapılmıştır. Sella tursika köprüleşmeleri ve pontikulus postikus kalsiifikasyonları KIBT görüntüleri sagittal kesitler üzerinde analiz edilerek; köprüleşme yok, kısmi köprüleşme ve tam köprüleşme şeklinde veriler kaydedilmiştir. Sella tursika hacim hesaplamaları KIBT sagittal kesitleri üzerinden manuel segmentasyon yöntemi ile 3D-DOCTOR (Able Software Corp., Lexington, MA, USA uygulaması ile yapılmıştır.
Bulgular: Pontikulus postikus kalsifikasyonu ve sella tursika köprüleşmesi açısından iskeletsel malokluzyonlara ve cinsiyete göre istatistiksel olarak anlamlı bir fark gözlenmemiştir. Sella tursika hacmi iskeletsel malokluzyonlar arasında istatistiksel olarak anlamlı bir fark göstermezken kadınlarda sella tursika hacmi istatistiksel olarak anlamlı bir şekilde erkeklere göre daha yüksek olduğu tespit edilmiştir ($p=0,004$, $p<0,005$).
Sonuç: Pontikulus postikus kalsifikasyonu, sella tursika köprüleşmeleri ve sella tursika hacmi iskeletsel malokluzyonlara göre değişiklik göstermemektedir. Sella tursika hacmi kadınlarda istatistiksel olarak anlamlı bir şekilde daha yüksektir. Lateral sefalometrik radyografilerde sella tursika ve atlas kemiği gibi yapılarda meydana gelen kalsifikasyonların ve şekil değişikliklerin bazı hastalıkların da habercisi olabileceği unutulmamalıdır.

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INTRODUCTION

In lateral cephalometric radiographs, anatomical structures that can be observed are used for assessing an individual's growth and development and for orthodontic diagnosis purposes.[1,2] Genetic diseases in individuals can also affect the development of craniofacial structures, and changes in anatomical structures can be observed in these radiographs.[3] There are many studies in the literature that suggest that these diseases may also correlate with dental eruption disorders, shape abnormalities, and skeletal anomalies within the nasomaxillary complex. The relationship between orthodontic or dental anomalies and anomalies of the sella turcica and atlas bone has been a subject of particular interest for researchers.[3-13]

The sella turcica is an intracranial bony depression located anterior to the body of the sphenoid bone, housing the pituitary gland.[5] The two tuberculum sellae and two dorsum sellae form the shape observed sagittally in lateral cephalometric radiographs, protecting the pituitary gland.[4] The geometric center of the sella turcica is important for cephalometric analysis. However, based on the length, diameter, and depth of the sella turcica, it can be classified as J-shaped, double-contoured base, shallow, oblique anterior wall, irregular dorsum sella with a posterior wall, and pyramid-shaped dorsum sellae.[14,15] In some individuals, in addition to anatomical variations of the sella turcica, "bridging of the sella turcica" can be observed, characterized by the pronounced fusion of the anterior and posterior clinoid processes along with calcification of the interclinoid ligament.[16] The bridging of the sella turcica has been suggested to lead to dental and skeletal anomalies, with its cause possibly being neural crest cells, which have embryogenic origins and contribute to the formation of the nasomaxillary complex.[17,18]

Another bridging anomaly believed to correlate with dental and skeletal anomalies due to similar embryogenic reasons is the ponticulus posticus. It is a bony bridging of the canal where the vertebral artery passes through in the atlas bone, similar to the sella turcica.[3] Research examining the relationship of these anomalies with dental or skeletal anomalies has generally been evaluated on lateral cephalometric radiographs containing two dimensions.[3-12]

This study aims to evaluate the sella turcica bridging, ponticulus posticus calcification, and sella turcica volume in individuals with different skeletal malocclusions using cone-beam computed tomography (CBCT) images. The null hypothesis (H0) of the study can be expressed as "There is no difference in sella turcica bridging, ponticulus posticus calcification, and sella turcica volume among individuals with different skeletal malocclusions."

MATERIALS AND METHODS

This research received approval from the Non-Interventional Clinical Research Ethics Committee of Van Yüzüncü Yıl University (2023/05-21). This retrospective study was conducted in accordance with the principles outlined in the Helsinki Declaration, and informed consent forms were obtained from the individuals included in the research. The sample size for the study was determined to be a minimum of 84 individuals, with 28 individuals in each of the three groups, based on the effect size calculated for three groups using the G-Power statistical package (Version 3.1, Franz Faul, University of Kiel, Germany) with an effect size of 0.4, Type I error ($\alpha = 0.05$), and 90% power.

The study included individuals aged 14-35 who had not previously undergone orthodontic or orthognathic surgical treatment, had no craniofacial syndromes or obvious pathologies, and had clear visibility of both the first cervical vertebra and the sella turcica within the same Field of View (FOV) area. Patients who had previously undergone orthodontic or orthognathic surgical treatment, had a history of trauma or fracture in the maxillofacial region, or had significant skeletal asymmetry were excluded from the study if they had low-quality cone-beam computed tomography (CBCT) images with metal and motion artifacts.

For CBCT measurements, a KaVo 3D eXam (Biberach, Germany) tomography device, which undergoes routine maintenance and repairs at our Faculty of Dentistry's Department of Oral, Dental, and Maxillofacial Radiology, was used. All tomography imaging procedures were performed at 120 kVp, 5 mAs, 7 s scanning time, with a 0.4 mm voxel size and a 130 mm FOV. To reach the desired sample size, 162 CBCT images taken for diagnostic purposes between January 2018 and December 2022 at our Faculty of Dentistry's Department of Oral, Dental, and Maxillofacial Radiology were screened. Individuals were divided into three groups based on the skeletal class I ($0° \leq ANB \leq 4°$), skeletal class II ($4° < ANB$), and skeletal class III ($ANB < 0°$) values according to the ANB angle, which is the angle between Nasion, A, and B points. Cephalometric images in the content of all CBCT images were traced by an orthodontist with six years of experience using the NemoCeph NX 2005 (Nemotec, Madrid, Spain) package program.

Sella turcica bridging was analyzed on sagittal sections of CBCT images, and data were recorded as no bridging, partial bridging, and complete bridging (Figure 1). Similarly, ponticulus posticus calcifications were analyzed on sagittal sections, and data were recorded as no bridging, partial bridging, and complete bridging (Figure 2). Sella turcica volume calculations were performed using manual segmentation on CBCT sagittal sections with the 3D-DOCTOR (Able Software Corp., Lexington, MA, USA) application. The boundaries of the sella turcica were manually drawn on sagittal sections (Figure 3). All sections from the first section where the sella turcica was observed to the last section were included in the study with a section interval of 0.4 mm. The presence of ponticulus posticus, sella turcica bridging, and sella turcica volume calculations were performed by a five year experienced Oral and Maxillofacial Radiology specialist.

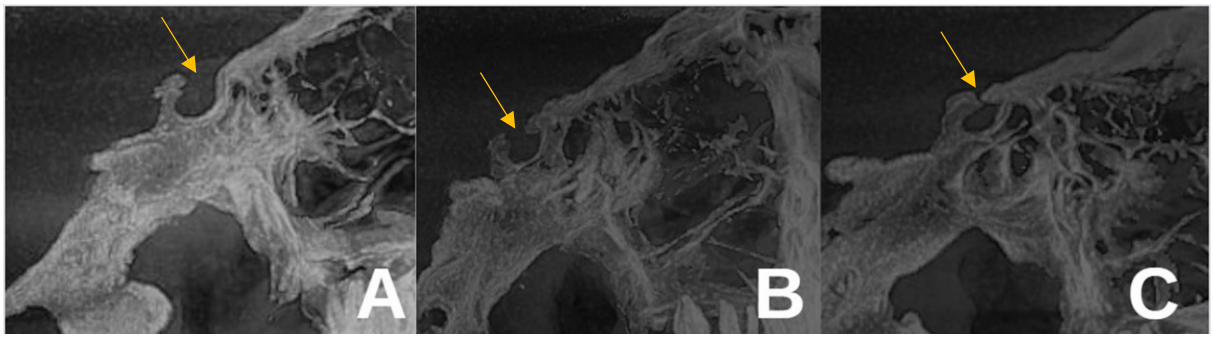

Figure 1. Sella Turcica bridging classifications: A - no bridging, B - partial bridging, C - complete bridging (yellow arrow).

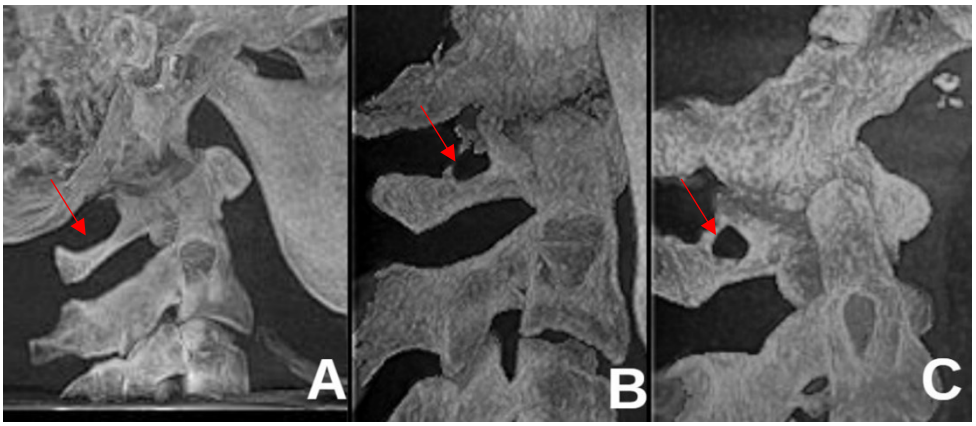

Figure 2. Ponticulus Posticus calcifications: A - no calcification, B - partial calcification, C - complete calcification (red arrow).

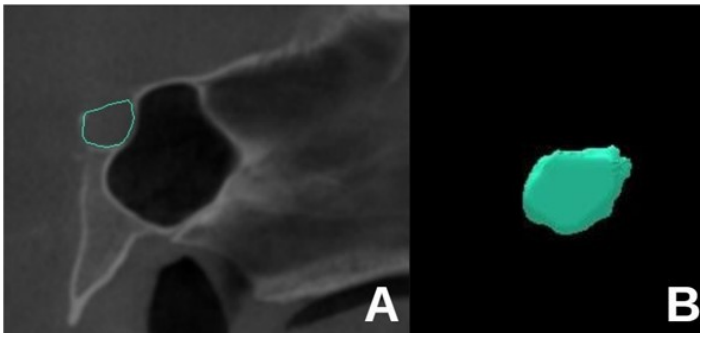

Figure 3. A - Manual segmentation of Sella Turcica volume on the sagittal section. B - Three-dimensional image of the calculated Sella Turcica volume.

Statistical Analysis

The data were analyzed using IBM SPSS v23 (IBM Co., Armonk, NY). Normality of the data was examined using the Kolmogorov-Smirnov test. As the data were normally distributed for three or more groups, one-way analysis of variance (ANOVA) was used. Chi-square analysis was used to evaluate categorical data such as ponticulus posticus calcification and sella turcica bridging. The relationship between sella turcica volume and gender was analyzed using the Student's t-test. The results of the analysis were presented as mean ± standard deviation for quantitative data and as median (minimum - maximum) for categorical data. The significance level was set at $p < 0.05$.

RESULTS

The demographic data of the individuals included in the study are presented in Tables 1 and 2. According to this, sella turcica volume calculations were performed on a total of 84 individuals, with 14 male and 14 female individuals in each class. The mean age of the individuals was found to be 22.7 in class I, 21.64 in class II, and 22.21 in class III. In addition, ponticulus posticus calcification and sella turcica bridging were performed on a total of 162 individuals, with 27 male and 27 female individuals in each class. The mean age of the individuals was 23.01 in class I, 23.54 in class II, and 23.3 in class III.

Table 1. Comparison of demographic data by classes for Sella Turcica volume.

Gender	Class I	Class II	Class III	Total
Female	14 (50)	14 (50)	14 (50)	42 (100)
Male	14 (50)	14 (50)	14 (50)	42 (100)
Age (M-SD)	22.07 ± 4.7	21.64 ± 6.3	.2,93 ± 6.3	22.21 ± 5.7

M-mean, SD: standart deviation.

Table 2. Comparison of demographic data by classes for Sella Turcica bridging and Ponticulus Posticus calcification.

Gender	Class I	Class II	Class III	Total
Female	27 (50)	27 (50)	27 (50)	54 (100)
Male	27 (50)	27 (50)	27 (50)	54 (100)
Age(M-SD)	23.01 ± 4.9	23.54 ± 6.5	23,3 ± 5.7	23.3 ± 5.6

M-mean, SD: standart deviation.

Table 3. Comparison of Ponticulus Posticus calsification and Sella Turcica bridging with respect to skeletal malocclusion and gender.

		Ponticulus Posticus calsification			Sella Turcica bridging		
		No	Partial	Total	No	Partial	Total
Class	I	48	5	1	15	27	12
	II	47	2	5	16	28	10
	III	44	7	3	17	23	14
p*			0.23			0.85	
Gender	Female	70	7	4	18	45	18
	Male	69	7	5	30	33	18
p*			0.93			0.11	

*Chi-Squared test, $p<0.005$

Comparisons based on skeletal malocclusion and gender for ponticulus posticus calcification and sella turcica bridging are shown in Table 3. According to this, no statistically significant difference was observed in terms of ponticulus posticus calcification and sella turcica bridging with respect to skeletal malocclusions and gender.

The comparison of sella turcica volumes based on skeletal malocclusions and gender is presented in Table 4. While sella turcica volumes showed no statistically significant difference with skeletal malocclusions, it was determined that the sella turcica volume in females was statistically significantly higher than in males (p=0.004, p<0.005).

Table 4. Comparison of Sella Turcica volume with respect to skeletal malocclusion and gender.

		Sella Turcica volume (M±SD)	***p***
Class	I	1906.11±617.23	0.756*
	II	1789.29±489.08	
	III	1837.57±639.57	
Gender	Female	1943.74±448.02	***0.004*****
	Male	1744.90±679.34	

* One-way analysis of variance (ANOVA).
** Student-t test, SD: Standart Deviation p<0.05

DISCUSSION

Sella turcica bridging has a prevalence of 1.1%-22%, while ponticulus posticus calcification ranges from 5.14% to 37.83%. These variations in sella turcica and atlas bone can be observed in routine orthodontic radiographs. These variations have been associated with conditions such as headaches, migraines, certain syndromes, cleft lip and palate, dental anomalies, and temporomandibular disorders. They can also vary with non-syndromic skeletal malocclusions.[3-7,9-12,19]

Current study, there was no statistically significant difference observed in sella turcica bridging and ponticulus posticus calcification concerning skeletal malocclusions and gender. However, sella turcica volume was found to be statistically significantly higher in females compared to males (p=0.004). According to the results of the present research, our hypothesis H0 is partially rejected.

In two-dimensional evaluations, sella turcica bridging and ponticulus posticus calcification can be misinterpreted due to superimpositions. Especially, false bridging, which is caused by the superimposition of anterior and posterior clinoid processes of the sella turcica and interclinoid processes, is completely eliminated in three-dimensional radiographic evaluations.[20]Therefore, in our study, we preferred cone beam computed tomography (CBCT) images for detecting sella and ponticulus ponticus bridging and calculating sella turcica volume.

When examining the literature, it is observed that both sella bridging and ponticulus posticus calcification are highly prevalent in normal individuals. However, the reason for often researching the correlation between these structures is their embryogenic origins.[12,18,21-23] The anterior wall of the sella turcica develops from different embryogenic structures than its posterior wall. The anterior wall, as well as the development of the neck, shoulder, and vertebrae, is develops neural crest cells. The posterior wall, on the other hand, develops from the mesoderm layer, which is closely related to the notochord.[3,4] The fact that the same cells play a role in the development of dental and craniofacial structures naturally strengthens the possibility of their correlation with dental and skeletal anomalies.

However, it should be noted that not every sella turcica bridging or ponticulus posticus calcification indicates an anomaly. Bavbek et al.[24] stated that it is observed in 65-80% of normal individuals and emphasized that not every sella turcica bridging points to an anomaly but also pointed out the high correlation with certain syndromes and diseases.

Studies that evaluate the correlation between dental anomalies and ponticulus posticus on cephalometric radiographs exist in the literature. For example, Dadgar et al.[5] found

a higher incidence of ponticulus posticus calcification in individuals with embedded canines compared to those with normal dentition. Kaya et al.[4] reported that Type I and Type II calcification of ponticulus posticus was more common in cases with embedded canines, tooth transposition, and third molar agenesis compared to control groups. Ghadimi et al.[3] found no significant relationship between ponticulus posticus calcification and palatally embedded canine teeth.

Current study, no statistically significant difference was observed in ponticulus posticus calcification among individuals with different malocclusions. The differences between our study and Bayraktar et al.'[25] study could be attributed to differences in age groups and classifications of ponticulus posticus.

When studies evaluating ponticulus posticus in terms of gender are examined, Dadgar et al.[5] and Ghadimi et al.[3] found no correlation, while Bayraktar et al.[25] reported that males had a higher incidence of calcification than females. In our study, no difference was observed in ponticulus posticus calcification among gender groups.

There are studies in the literature that suggest a correlation between sella turcica bridging and dental anomalies on lateral cephalometric radiographs. However, studies that assess sella turcica bridging and sella turcica dimensions based on skeletal malocclusions using two-dimensional radiographs have conflicting results. Afzal and Fida[26] and Sobuti et al.[27] reported that sella turcica bridging was more common in individuals with Class III malocclusion. Shresta et al.[28] stated that there was no difference in sella turcica bridging among individuals with different malocclusions. In our study, there was no difference in sella turcica bridging among individuals with different malocclusions.[28]

Sella turcica completes its development around the age of 15. Sella turcica's linear dimensions can vary from 5-16 mm in length and 4-12 mm in height.[24] The width, height, and length of sella turcica have generally been evaluated in two-dimensional radiographs, and some mathematical formulations have been developed to calculate its volume.[24] There are three studies evaluating the dimensions of the sella turcica using CBCT (Cone Beam Computed Tomography). Nadim[29] stated that the determination of sella turcica dimensions using CBCT was achieved with high accuracy. In Nadim's[29] research, as well as in the study by Chou et al.[31] no significant differences were observed in the linear measurement values of sella turcica among individuals with different sagittal malocclusions. However, Abdallah[30] reported that the depth of sella turcica is higher in individuals with a horizontal growth pattern compared to those with normal and vertical growth patterns. In our study, we aimed to calculate the volume of sella turcica using software programs instead of linear measurements on CBCT images, and no statistical differences were observed among individuals with different malocclusions. However, it was noted that sella turcica volume was higher in females compared to males.

The variables evaluated in the current study have been assessed not only for their association with sagittal skeletal malocclusions but also with transversal and vertical skeletal malocclusions. Seifeldin et al. have reported that there is no correlation between the morphology and bridging of the sella turcica and skeletal maxillary deficiency.[32] However, Yan et al. have associated the shape of the sella turcica with different skeletal vertical malocclusions. They have stated that in individuals with a low angle, the distance of the posterior clinoid is greater, the height of the posterior clinoid is less, and the incidence of sella turcica bridging is higher.[33] Recent literature has reported a positive correlation between individuals with cleft lip and palate and diseases such as migraine.[34,35] Sella turcica dimensions can vary by race, gender, and development, and the limited sample size and not evaluating them in vertical direction are limitations of our study.

CONCLUSION

Ponticulus posticus calcification, sella turcica bridging, and sella turcica volume do not differ based on skeletal malocclusions. Sella turcica volume is statistically higher in female individuals. It should be remembered that calcifications and shape changes in structures such as sella turcica and atlas bone can be indicators of certain diseases on lateral cephalometric radiographs. Moreover, it has been observed that having different malocclusions does not predispose to the genetic calsification of ponticulus posticus and bridging of sella turcica.

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Ethical Approval

The necessary ethical approval for this study was obtained from the Non-Interventional Ethics Committee of Van Yüzüncü Yıl University (2023/05-21).

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: SK, MT. Data collection or data entry: SK, MT. Analysis and interpretation: SK, MT. Literature review: SK, MT. Writing: SK, MT.

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