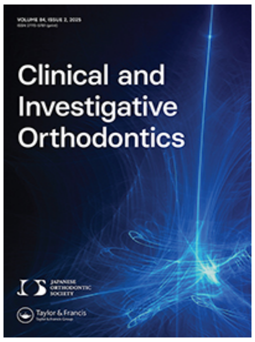

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Morphological variations of sella turcica bridging and their association with Y-axis angle

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ABSTRACT

Purpose: The sella turcica, located on the sphenoid bone, serves as a key landmark in cephalometric radiography, with variations like sella turcica bridging linked to craniofacial and systemic conditions. The Y-axis angle plays a vital role in vertical mandibular growth. This study investigates the relationship between sella turcica bridging and the Y-axis angle, focusing on gender differences.

Materials and methods: A total of 242 lateral cephalometric radiographs from 92 male and 150 female patients aged 18-45 years were analysed. Patients were undergoing orthodontic treatment or orthognathic surgery with no prior craniofacial anomalies, trauma or surgeries. Radiographs were taken in natural head posture, with the Frankfurt Horizontal plane. Sella turcica bridging was classified based on Leonardi et al. and the Y-axis angle measured using WebCeph Dental Imaging Software. Chi-square and Fisher-Freeman-Halton tests examined relationships between bridging types, Y-axis angles and gender.

Results: no significant differences in sella turcica bridging types between genders ($p = 0.270$). However, a significant difference in Y-axis angles was observed ($p = 0.018$), with females showing greater variability. Higher Y-axis angles were linked to more Type 2 sella turcica bridging ($p = 0.003$) in females. No significant differences were found among males based on Y-axis angles ($p = 0.584$).

Conclusion: This study shows a significant correlation between Y-axis angle and sella turcica bridging, particularly in females where higher Y-axis angles are linked to more Type 2 bridging. The findings highlight the importance of considering Y-axis angle in cephalometric assessments, especially in patients with vertical facial growth tendencies.

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Orthognathic; sella turcica; vertical growth; Y-axis angle

Introduction

The sella turcica, an anatomical structure resembling a saddle located on the intracranial surface of the sphenoid bone, plays a pivotal role in housing the pituitary gland [1]. It is bounded by distinct anterior and posterior walls known as the tuberculum sella and dorsum sella, respectively, and is characterized by two anterior and two posterior clinoid processes [1,2].

Lateral cephalometric radiographs are routinely employed in orthodontic diagnosis, treatment planning and skeletal development assessment [1–3]. These radiographs provide information on cranial, facial and cervical structures and serve as a key tool for evaluating craniofacial growth patterns [1–3]. Within this diagnostic framework, the sella turcica serves as a fundamental radiographic landmark, facilitating accurate evaluation of the neurocranial and neurofacial complex [1,4].

Despite its clinical significance, the sella turcica exhibits a wide range of anatomical variation among individuals [1,3,5]. Understanding these anatomical variations assumes paramount importance in clinical practice as it aids in discerning pathological deviations [1,3,5]. Embryologically, its development is closely linked with dental epithelial stem cells, highlighting its developmental role [3]. Furthermore, genetic factors may influence both sella turcica formation and midfacial growth, emphasizing the need to recognize these features when assessing craniofacial anomalies and genetic syndromes [1,3].

Sella turcica bridging defined as ossification of the interclinoid ligament or as a developmental variant of the sphenoid bone represents one such structural variation [2]. This feature has been associated with several skeletal and systemic conditions [1,2], including a higher frequency reported in diabetic patients [2]. Reported prevalence rates range from 3.6% to 13%, reflecting population-based differences and the need for careful radiographic assessment [2]. Recent studies have expanded interest in the craniofacial region, particularly in relation to sella turcica morphology, and have examined its associations with craniofacial classifications [2,3].

Becktor et al. reported a link between craniofacial anomalies and sella turcica bridging, outlining characteristic bridging patterns [5]. Subsequent

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investigations into its relationship with dental conditions have developed classification schemes that enhance the characterization of these structural variations [3,4].

Although previous studies have described different aspects of sella turcica morphology, none have clarified whether bridging is related to vertical skeletal growth as reflected by the Y-axis angle, and this study directly addresses this gap by being the first to examine this relationship.

Materials and methods

A study was conducted utilizing cephalometric radiographs of 92 male and 150 female patients aged between 18 and 45 years who sought orthodontic treatment or orthognathic surgery from 2021 to 2024.

As this study used anonymized radiographic data, informed consent was not required. The study cohort comprised patients who had no prior surgical interventions on craniofacial structures, nor a history of cleft lip and palate, craniofacial anomalies, syndromes, trauma, extensive reactive chemotherapy or severe craniofacial deviations necessitating additional surgical procedures.

The pre-treatment lateral cephalometric radiographs of the participants were acquired in natural head posture, with the Frankfurt horizontal plane parallel to the ground, and in centric occlusion, following head positioning using ear sticks and nasion support (X Radius Trio, Castellini, Italy). The radiographs utilized were of high diagnostic quality, sufficiently detailed to display craniofacial anatomy and sella turcica. Measurements were performed using WebCeph Dental Imaging Software (WebCeph Plus, Korea). Although WebCeph is an AI-assisted, online software, all automatically suggested landmarks and measurements were manually reviewed and corrected by the investigators to ensure measurement reliability.

Leonardi et al.'s classification was employed to assess interclinoid ligament (ICL) calcification based on the interclinoidal distance (sella length) and the widest anteroposterior diameter of the sella. The classification is as follows: Type 1—ICL calcification/no bridge, where the interclinoidal distance is equal to or greater than 3/4 of the anteroposterior diameter; Type 2—ICL partial calcification, where the interclinoidal distance is less than or equal to 3/4 of the anteroposterior diameter; Type 3—Complete ICL calcification, where the sella bridge is clearly visible on the radiograph [1].

Figure 1 shows representative radiographic images corresponding to Type 1, Type 2 and Type 3 ICL calcification.

Statistical method

Data were analysed using IBM SPSS V23. The statistical test for categorical variables was selected by evaluating the expected cell frequencies in the corresponding table. In the table comparing sella turcica bridging types by gender, all expected frequencies were ≥5, and therefore the Pearson Chi-square test was applied. In the table containing Y-axis angle categories (< 53°, 53–66°, >66°) [6], some cells had low or zero expected frequencies, and the Fisher–Freeman–Halton exact test was used. Multiple comparisons of proportions were assessed with the Bonferroni-corrected Z test. Categorical data were reported as frequencies and percentages, and the significance level was set at $p < 0.050$.

For reliability assessment, both intra- and inter-observer agreement were evaluated. Thirty cephalometric radiographs were randomly selected. For intra-observer reliability, the same examiner repeated all Y-axis angle measurements and sella turcica bridging classifications after a two-week interval. For inter-observer reliability, the same 30 radiographs were independently evaluated by a second examiner. The Intraclass Correlation Coefficient (ICC) was used for Y-axis angle measurements, and Cohen's Kappa statistic was used for bridging classification. Intra-observer reliability was excellent (ICC = 0.964; Kappa = 0.882), and inter-observer reliability also showed high agreement (ICC = 0.948; Kappa = 0.856).

Results

In Table 1, the distribution of interclinoid ligament (ICL) calcification types is stratified by gender to explore possible associations between sex and calcification morphology. No statistically significant differences were observed in the distribution of types based on gender ($p = 0.270$). Among female participants, 58% were classified as Type 1, 37.3% as Type 2 and 4.7% as Type 3. In contrast, among male participants, 57.6% were classified as Type 1, 32.6% as Type 2 and 9.8% as Type 3. These results indicate that the distribution of classification types does not vary significantly between genders.

In Table 2, the distribution of Y-axis angle categories is summarized across genders to assess potential differences in vertical skeletal orientation between male and female subjects. A significant difference was observed in the distribution of the Y-axis angle with respect to gender ($p = 0.018$). This difference is primarily attributable to the varying proportions of individuals within the <53° angle group across genders. Specifically, the Y-axis angle was <53° for 0% of female participants, compared to 4.3% of male participants.

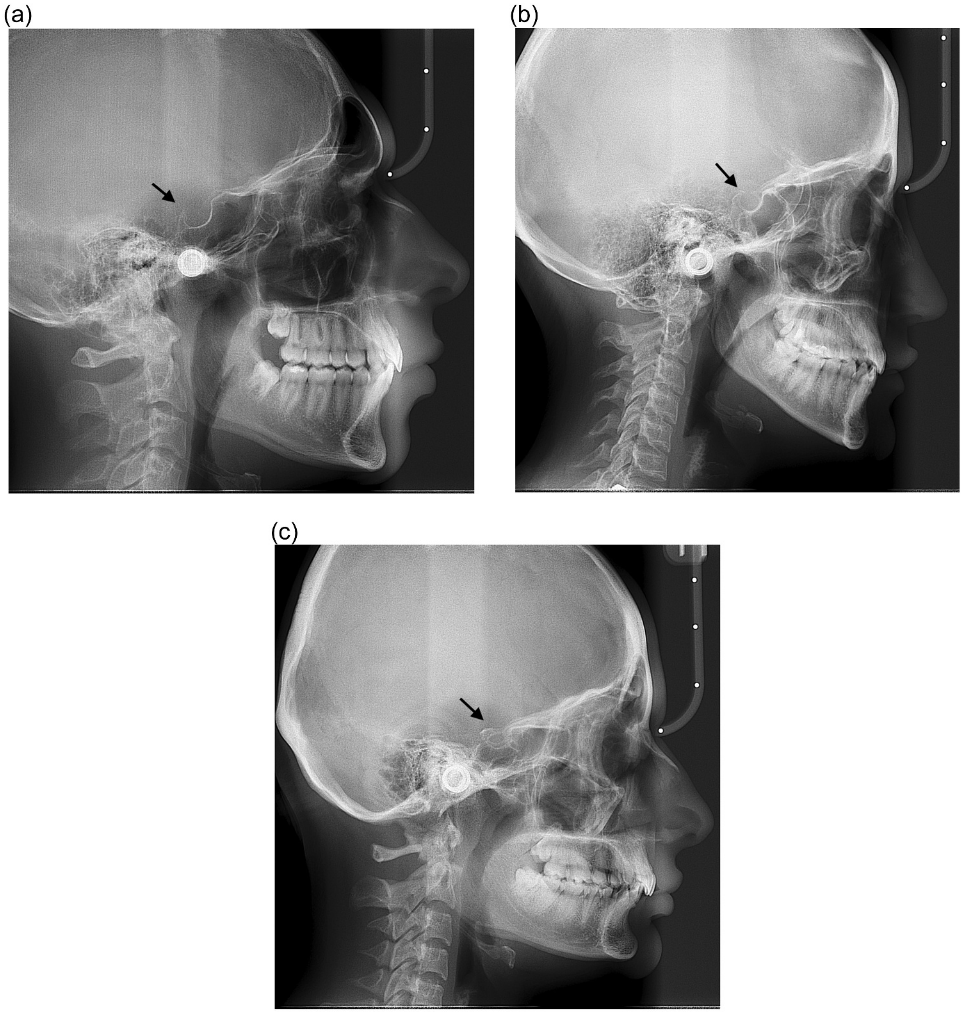

Figure 1. Interclinoid ligament calcification: A, Type 1; B, Type 2; C, Type 3.

Table 1. Comparison of types by gender.

Gender	Type 1	Type 2	Type 3	p value
Female	87 (58%)	56 (37.3%)	7 (4.75%)	0.270
Male	53 (57.6%)	30 (32.6%)	9 (9.8%)	

Frequency (percent).
Pearson Chi-square test.

Table 2. Comparison of the Y-axis angle by gender.

Gender	<53°	53–66°	>66°	p value
Female	0 (0%)a	135 (90%)	15 (10%)	0.018
Male	4 (4.3%)b	83 (90.2%)	5 (5.4%)	

a-b: There is no difference between angles with the same letter in each column, frequency (percentage).
Fisher-Freeman-Halton test.

In Table 3, ICL calcification types are compared across different Y-axis angle groups, both within and across genders, to evaluate the relationship between vertical skeletal morphology and sella bridging patterns. Significant differences were observed in class distributions based on the Y-axis angle among females ($p = 0.003$). Specifically, 62.2% of those in the 53–66° angle group were classified as Type 1, compared to 20% in the >66° angle group. Conversely, 32.6% of individuals in the 53–66° angle group were classified as Type 2, while 80% of those in the >66° angle group were classified as Type 2. For males, the distribution of classes across Y-axis angle groups did not show significant differences ($p = 0.584$). However, when considering class distributions regardless of gender, there were significant variations ($p = 0.031$). This variation is particularly attributed to the distribution

Table 3. Comparison of classes within each gender and according to the angle of the axis without gender discrimination.

		Class			
Gender	Y-axis angle	Type 1	Type 2	Type 3	p value
Female	53–66°	84 (62.2%)a	44 (32.6%)a	7 (5.2%)	0.003
	>66°	3 (20%)b	12 (80%)b	0 (0%)	
Male	<53°	4 (100%)	0 (0%)	0 (0%)	0.584
	53–66°	45 (54.2%)	29 (34.9%)	9 (10.8%)	
	>66°	4 (80%)	1 (20%)	0 (0%)	
Total	<53°	4 (100%)	0 (0%)ab	0 (0%)	0.031
	53–66°	129 (59.2%)	73 (33.5%)b	16 (7.3%)	
	>66°	7 (35%)	13 (65%)a	0 (0%)	

a–b: There is no difference between angles with the same letter in each column, frequency (percentage).
Fisher–Freeman–Halton test.

of Class 2, which is observed at 0% in the <53° group, 33.5% in the 53–66° group and 65% in the >66° group.

Discussion

The sella turcica, situated on the intracranial surface of the sphenoid bone, was first designated by this term in Blancard's Dictionary in 1693, owing to its morphological resemblance to a Turkish saddle [7]. The pituitary gland, positioned within the confines of the sella turcica, is bordered by the sella turcica and the clinoid processes [3]. The phenomenon of interclinoid ligament ossification, which occurs between the clinoid processes, was first recognized as a developmental anomaly by Gaupp in 1902, later detailed by Hochstetter in 1940 and Kier in 1966 [3]. Özdoğmuş et al. emphasized that the anatomical proximity of the sella turcica bridging to critical structures may lead to calcifications exerting pressure on adjacent tissues, as supported by Platzer's cadaveric study of 220 dry skulls, where it was observed that in 25% of cases with sella turcica bridging, the internal carotid artery was notably stretched and traversed through the cavernous sinus [8]. Studies by Sobuti et al. and Alkofide et al. have established that the prevalence of sella turcica bridging spans from approximately 3.6% to 22%, with considerable variability driven by distinct craniofacial anomalies, the severity of cleft conditions and the demographic profiles of the populations examined [2,9]. In this study, a sella turcica bridge was observed in 46.79% of the patients. This prevalence is substantially higher than the 3.6–22% range reported in earlier literature. Several methodological and sample-related factors may account for this discrepancy. First, the present study employed the Leonardi classification, in which Type 2 (partial calcification) is included as a bridging category; prior studies using more conservative definitions often classified only complete ossification as true bridging, resulting in lower reported frequencies [10]. Second, our study population consisted exclusively of orthodontic or orthognathic patients – a group that has repeatedly been shown to present higher rates of craniofacial developmental variations, including sella turcica morphology anomalies, compared with general-population samples [11]. Furthermore, studies focusing on cleft, syndromic or skeletal malocclusion cohorts consistently report elevated bridging prevalence, supporting the notion that craniofacial morphologic imbalance is a contributing factor [9,12]. Taken together, these methodological differences and the craniofacial characteristics of the study cohort likely explain the comparatively higher prevalence of 46.79% observed in the present investigation. In line with the findings of Alkofide et al., this study also did not identify any significant differences between genders [10]. Relative to this study, Alan et al.'s[1] research reveals that, while both identify a higher prevalence of Type 1 sella turcica bridging in males, their findings indicate greater frequencies of Types 2 and 3 in females – a disparity likely attributable to differences in sample groups, measurement methodologies or demographic characteristics. To date, several studies have linked sella turcica bridging with various anomalies, and particularly, research associating this condition with hormonal, syndromic, tumoural and mental disorders has been pioneering, setting the stage for further investigations [3,12–15]. Inger Kjær's research elucidates a significant correlation between the development of the sella turcica and the pituitary gland, positing that developmental anomalies in the pituitary gland may precipitate corresponding morphological aberrations in the sella turcica, thereby underscoring the imperative of evaluating both structures in the comprehensive assessment of craniofacial anomalies [16]. In Williams syndrome, while sella turcica bridging is occasionally observed, the more commonly noted features are the reduced size and other morphological anomalies of the sella turcica, underscoring the syndrome's pronounced impact on craniofacial development [12]. In Axenfeld-Rieger syndrome, the occurrence of a sella turcica bridge, frequently accompanied by other craniofacial anomalies, underscores the notion that sella turcica abnormalities represent a key characteristic of this genetic disorder, likely associated with PITX2 mutations [13]. Kjær et al. demonstrate that in trisomy 21 foetuses, structural abnormalities in the sella turcica are closely associated with the morphology of the pituitary gland, underscoring the interconnected development of these structures and their potential role as indicators of broader cranial and axial skeletal anomalies [14]. Furthermore, the study conducted by M. Korayem and E. Alkofide demonstrates that individuals with Down syndrome exhibit significant differences in the size and morphology of the sella turcica compared to those without the syndrome. Notably, the diameter and depth of the sella turcica are considerably larger in individuals with Down syndrome [15]. Becktor et al. found sella turcica bridging in 18.6% of individuals with severe craniofacial deviations, suggesting that these structural anomalies may be linked to underlying developmental abnormalities in the pituitary gland. However, the exact nature of this relationship requires further investigation [11]. Jones et al. highlight the critical role of the sella turcica in housing and protecting the pituitary gland, noting that structural anomalies in the sella turcica may significantly impact the development and function of the gland, and that enlargement of the sella turcica can sometimes indicate the presence of intrasellar or juxtasellar tumours, though asymptomatic enlargements are also possible [17]. While the nature of sella turcica bridging remains a subject of debate, with some considering it a physiological condition associated with ageing and others viewing it as a developmental anomaly, Leonardi et al. contend that this bridging may arise from the intricate ossification process of the sphenoid bone [18]. In addition, Hochstetter and Kier propose that it constitutes a developmental anomaly integral to the formation of cranial foramina in foetuses and infants [3]. The findings of this report indicate that no previous studies have specifically examined the distribution of sella turcica bridging in relation to gender and Y-axis angle.

The Y-axis angle's close association with vertical facial growth patterns highlights the critical need to monitor this parameter in orthodontic and craniofacial assessments, particularly in cases prone to exacerbating vertical growth tendencies [19]. The Y-axis (Sella – Gnathion to Frankfort Horizontal) was originally defined by Downs (1948), who reported a mean value of approximately 59°. Subsequent cephalometric literature interprets values below 53° as indicative of horizontal growth and values above 66° as reflective of a vertical growth pattern [6]. Andria et al. found that an increased anterior cranial base angle (SN/FH) is linked to a more acute Y-axis, indicating a stronger vertical growth pattern in mandibular development, emphasizing the need to monitor this angle in orthodontic assessments [20]. Contemporary cephalometric studies indicate that skeletal Class II individuals consistently present with higher Y-axis angles and hyperdivergent vertical patterns, whereas Class III patients demonstrate reduced Y-axis values consistent with a more hypodivergent, forward-growth morphology [21,22]. These findings highlight that vertical facial growth direction and sagittal skeletal classification are inherently interconnected, reinforcing the need to interpret Y-axis measurements within the context of Class I, II and III patterns. Dasgupta P. et al. establish a strong association between an increased Y-axis angle and vertical facial growth patterns, highlighting its role in reflecting a downward and backward mandibular growth trajectory, particularly common in Class II malocclusion, thereby positioning the Y-axis angle as a critical cephalometric marker for assessing both mandibular and overall craniofacial development [23].

No statistically significant difference was observed between genders in the distribution of sella turcica bridging types ($p = 0.270$). Although gender was not identified as a significant factor, males exhibited a noticeably higher proportion of Type 3 bridging compared with females (9.8% vs. 4.7%). While this numerical difference did not reach statistical significance, it warrants biological consideration. Sexual dimorphism in cranial base morphology, the longer anterior cranial base length and increased sphenoid ossification tendency reported in males may predispose men to more extensive interclinoid ligament calcification [24]. Moreover, androgen-mediated variations in bone metabolism and the typically higher cortical bone density observed in males could facilitate progression from partial to complete calcification [25,26]. These subtle tendencies may remain undetected in moderately sized samples but may become significant in larger or more homogeneous study populations.

However, a significant association was identified between Y-axis angle classifications and sella turcica bridging patterns among females ($p = 0.003$), suggesting that the vertical skeletal growth pattern reflected by the Y-axis angle may exert a more pronounced influence on bridging morphology in women than in men. Although the present study identified a strong association between the Y-axis angle and Type 2 bridging in females, several biological mechanisms may account for this sex-specific pattern. Oestrogen is known to regulate condylar cartilage activity and vertical facial growth, with experimental studies showing that oestrogen receptor-β signalling suppresses condylar proliferation and alters vertical growth dynamics [27,28]. Women also display distinct bone turnover and mineralization patterns driven by oestrogen-dependent pathways, which may favour partial rather than complete interclinoid ligament ossification [25,29]. Additionally, genetic influences, particularly PITX2-related craniofacial regulation, have been shown to affect sella morphology and vertical growth direction, supporting a potential genetic contribution to this relationship [13,30,31]. Together, these hormonal, metabolic and genetic factors provide a plausible explanation for why Type 2 bridging is more closely associated with Y-axis angle in females.

The observed association between increased Y-axis angle and sella turcica bridging, particularly the strong relationship with Type 2 calcification in females, may also have meaningful clinical implications for orthodontic and orthognathic treatment planning. A vertically increased Y-axis angle reflects a downward and backward mandibular growth tendency, a pattern strongly linked to clockwise rotation during orthognathic surgery and increased risk of postoperative vertical instability [32,33]. Patients exhibiting both a high Y-axis angle and sella turcica bridging may therefore represent a subgroup with altered cranial base morphology and potentially reduced adaptive capacity of the TMJ and associated skeletal structures. Previous studies have shown that sella turcica bridging is associated with variations in sphenoid and cranial base morphology, and such anatomical configurations are known to influence mandibular rotation biomechanics during surgical repositioning. Recent 3D analyses have demonstrated that alterations in cranial base angulation and sphenoid morphology can modify mandibular rotational patterns and condylar positioning during orthognathic movements [34]. Accordingly, incorporating sella morphology into preoperative evaluation may enhance risk stratification, regarding relapse potential, condylar seating behaviour and vertical control challenges in hyperdivergent Class II patients. Future research integrating 3D imaging and long-term postoperative follow-up is warranted to clarify whether sella turcica morphology may serve as a predictive cranial base biomarker for orthognathic stability and individualized treatment planning.

Limitations of the study

This study focused exclusively on the examination of sella turcica bridging, without considering dimensional and volumetric measurements. Additionally, the study was conducted using 2D radiographs; therefore, linear measurements of the interclinoid distance would yield more accurate results if performed using 3D imaging. Future research should aim to investigate the dimensional and anatomical characteristics of sella turcica bridging and its impact on the Y-axis angle more comprehensively through tomographic sections and larger sample sizes, employing various measurement methodologies to further explore these relationships.

Conclusion

Although the distribution of classification types is similar between genders, females exhibit greater variability in class distributions across Y-axis angle groups compared to males. These findings highlight significant variations in class distributions according to the Y-axis angle, with particular emphasis on Class II, indicating a more pronounced influence of the Y-axis angle on class categorization among females.

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Author contributions

CRediT: **Deniz Gölpek:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing; **Serhat Yalçın:** Supervision, Validation, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Deniz Gölpek: Study conception and design; data collection; radiographic evaluation; statistical interpretation; manuscript drafting and critical revision.

Serhat Yalçın: Methodological oversight; supervision; critical revision for intellectual content; final approval of the manuscript.

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Data availability statement

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request. No publicly archived dataset is associated with this study.

Ethical approval

This retrospective study was approved by the Non-Interventional Clinical Research Ethics Committee of Biruni University (Approval No: 2024/86–103; Date: 24 January 2024). All procedures complied with the STROBE guidelines.

Abbreviations

AI	Artificial intelligence
ICC	Intraclass correlation coefficient
ICL	Interclinoid ligament
SPSS	Statistical Package for the Social Sciences

References

[1] Alan A, Akçam Ö, Orhan K. Sella tursika köprüsü ve Angle malokluzyon ilişkisi. Selcuk Dent J. 2019;(Suppl Kongre):365–372. Available from: https://dergipark.org.tr/en/download/article-file/852128

[2] Sobuti F, Dadgar S, Seifi A, et al. The relationship between bridging and dimensions of sella turcica with classification of craniofacial skeleton. Pol J Radiol. 2018;83:e120–e126. doi: 10.5114/PJR.2018.76153

[3] Deniz Y, Arslan S. Investigation of the relationship between maxillary deficiency and sellar bridge. Yeditepe Dent J. 2020;16(3):231–236. doi: 10.5505/yeditepe.2020.59389

[4] Sadry S, Koca C. Relationship of impacted maxillary third molar teeth with sella turcica morphology. SDU Saglik Bilim Derg. 2019;10(2):155–160. Available from: https://dergipark.org.tr/tr/pub/sdusbed/issue/58681/639305

[5] Marşan G, Öztaş E. Incidence of bridging and dimensions of sella turcica in class I and III Turkish adult female patients. World J Orthod. 2009;10(2):99–103.

[6] Downs W. Variations in facial relationships; their significance in treatment and prognosis. Am J Orthod. 1948;34(10):812–840. doi: 10.1016/0002-9416(48)90015-3

[7] Mutluer S. Sella turcica. Childs Nerv Syst. 2006;22(4):333. doi: 10.1007/s00381-006-1278-x

[8] Tulay CM, Gurdal E, Uzün I, et al. Ossification of interclinoid ligament and its clinical significance. Neuroanatomy. 2003. Available from: http://www.neuroanatomy.org

[9] Alkofide EA. Sella turcica morphology and dimensions in cleft subjects. Cleft Palate Craniofac J. 2008;45(6):647–653. doi: 10.1597/07-058.1

[10] Alkofide EA. The shape and size of the sella turcica in skeletal class I, class II, and class III Saudi subjects. Eur J Orthod. 2007;29(5):457–463. doi: 10.1093/ejo/cjm049

[11] Becktor JP, Einersen S, Kjaer I. A sella turcica bridge in subjects with severe craniofacial deviations. Eur J Orthod. 2000;22(1):69–74. doi: 10.1093/ejo/22.1.69

[12] Axelsson S, Storhaug K, Kjaer I. Post-natal size and morphology of the sella turcica in Williams syndrome. Eur J Orthod. 2004;26(6):613–621. doi: 10.1093/ejo/26.6.613

[13] Meyer-Marcotty P, Weisschuh N, Dressler P, et al. Morphology of the sella turcica in Axenfeld-Rieger syndrome with PITX2 mutation. J Oral Pathol Med. 2008;37(8):504–510. doi: 10.1111/j.1600-0714.2008.00650.x

[14] Kjaer I, Keeling JW, Reintoft I, et al. Pituitary gland and sella turcica in human trisomy 21 fetuses related to axial skeletal development. Teratology. 1998;57(2):80–88. doi: 10.1002/(SICI)1096-9926(199802)57:2<80:AID-TERA3>3.0.CO;2

[15] Korayem M, Alkofide E. Size and shape of the sella turcica in subjects with Down syndrome. Orthod Craniofac Res. 2015;18(1):43–50. doi: 10.1111/ocr.12059

[16] Kjaer I. Sella turcica morphology and the pituitary gland: a new contribution to craniofacial diagnostics based on histology and neuroradiology. Eur J Orthod. 2015;37(1):28–36. doi: 10.1093/ejo/cjs091

[17] Jones RM, Faqir A, Millett DT, et al. Bridging and dimensions of sella turcica in subjects treated by surgical-orthodontic means or orthodontics only. Angle Orthod. 2005;75(5):714–718.

[18] Leonardi R, Barbato E, Vichi M, et al. A sella turcica bridge in subjects with dental anomalies. Eur J Orthod. 2006;28(6):580–585. doi: 10.1093/ejo/cjl032

[19] Liu Y, Zhao T, Ngan P, et al. The dental and craniofacial characteristics among children with obstructive sleep apnoea: a systematic review and meta-analysis. Eur J Orthod. 2023;45(3):346–355. doi: 10.1093/ejo/cjac074

[20] Andria LM, Leite LP, Prevatte TM, et al. Correlation of the cranial base angle and its components with other dental/skeletal variables and treatment time. Angle Orthod. 2004;74(3):361–366. doi: 10.1043/0003-3219(2004)074<361:COTCBA>2.0.CO;2

[21] Zawawi KH, Alsulaimani FF, Al-Dharrab AA, et al. Morphological features of class I, II and III malocclusions of Saudi adolescents. Saudi J Biol Sci. 2021;28(6):3534–3539. doi: 10.1016/j.sjbs.2021.03.026

[22] Plaza SP, Reimpell A, Silva J, et al. Relationship between skeletal class II and class III malocclusions with vertical skeletal pattern. Dent Press J Orthod. 2019;24(4):63–72. doi: 10.1590/2177-6709.24.4.063-072.oar

[23] Dasgupta P, Sen S, Srikanth HS, et al. Sella turcica bridging as a predictor of class II malocclusion: an investigative study. J Stomatol Oral Maxillofac Surg. 2018;119(6):482–485. doi: 10.1016/j.jormas.2018.05.005

[24] Derkowski W, Kędzia A, Dudek K, et al. Morphometric evaluation of the anterior cranial fossa during the prenatal stage in humans and its clinical implications. PLOS ONE. 2024;19(12):e0309184. doi: 10.1371/journal.pone.0309184 Erratum in: PLOS ONE. 2025;20(3):e0321125. doi:10.1371/journal.pone.0321125.

[25] Zhang YY, Xie N, Sun XD, et al. Insights and implications of sexual dimorphism in osteoporosis. Bone Res. 2024;12(1):8. doi: 10.1038/s41413-023-00306-4 Erratum in: Bone Res. 2024;12(1):25. doi:10.1038/s41413-024–00329-5.

[26] Chen JF, Lin PW, Tsai YR, et al. Androgens and androgen receptor actions on bone health and disease: from androgen deficiency to androgen therapy. Cells. 2019;8(11):1318. doi: 10.3390/cells8111318

[27] Chen J, Kamiya Y, Polur I, et al. Estrogen via estrogen receptor beta partially inhibits mandibular condylar cartilage growth. Osteoarthr Cartil. 2014;22(11):1861–1868. doi: 10.1016/j.joca.2014.07.003

[28] Kamiya Y, Chen J, Xu M, et al. Increased mandibular condylar growth in mice with estrogen receptor beta deficiency. J Bone Min Res. 2013;28(5):1127–1134. doi: 10.1002/jbmr.1835

[29] Khosla S, Monroe DG. Regulation of bone metabolism by sex steroids. Cold Spring Harb Perspect Med. 2018;8(1):a031211. doi: 10.1101/cshperspect.a031211

[30] D'haene B, Meire F, Claerhout I, et al. Expanding the spectrum of FOXC1 and PITX2 mutations and copy number changes in patients with anterior segment malformations. Invest Ophthalmol Vis Sci. 2011;52(1):324–333. doi: 10.1167/iovs.10-5309

[31] Berry FB, Lines MA, Oas JM, et al. Functional interactions between FOXC1 and PITX2 underlie the sensitivity to FOXC1 gene dose in Axenfeld–Rieger syndrome and anterior segment dysgenesis. Hum Mol Genet. 2006;15(6):905–919. doi: 10.1093/hmg/ddl008

[32] Arnett GW, Gunson MJ. Facial planning for orthodontists and oral surgeons. Am J Orthod Dentofac Orthop. 2004;126(3):290–295. doi: 10.1016/j.ajodo.2004.06.006

[33] Proffit WR, Turvey TA, Phillips C. The hierarchy of stability and predictability in orthognathic surgery with rigid fixation: an update and extension. Head Face Med. 2007;3(1):21. doi: 10.1186/1746-160X-3-21

[34] Hayashi Y, Tachiki C, Morikawa T, et al. Three-dimensional analysis of the cranial base structure in patients with facial asymmetry. Diagnostics. 2023;14 (1):24. doi: 10.3390/diagnostics14010024