applied sciences

MDPI

Article

The Spheno-Occipital Synchondrosis and Morphometry of Sella Turcica Association with Different Phenotype Factors Related to Ectopic Eye Tooth/Teeth

Mohammad Khursheed Alam [1,*,†], Anil Kumar Nagarajappa [2,†], Ahmed Ali Alfawzan [3], Fatema Akhter [4], Haytham Jamil Alswairki [5], Rakhi Issrani [1] and Vinod Bandela [6]

1. Preventive Dentistry Department, College of Dentistry, Jouf University, Sakakah 72345, Saudi Arabia; dr.rakhi.issrani@jodent.org
2. Division of Radiology, Department of Oral & Maxillofacial Surgery & Diagnostic Sciences, College of Dentistry, Jouf University, Sakakah 72345, Saudi Arabia; dr.anil.kumar@jodent.org
3. Department of Preventive Dentistry, College of Dentistry in Ar Rass, Qassim University, Ar Rass, Buraydah 52571, Saudi Arabia; ah.alfawzan@qu.edu.sa
4. Department of Surgical and Diagnostic Sciences, College of Dentistry, Dar Al Uloom University, Riyadh 11512, Saudi Arabia; mstfatima@dau.edu.sa
5. School of Dental Sciences, Universiti Sains Malaysia, Kota Bharu 16150, Kelantan, Malaysia; hitham.swerki@gmail.com
6. Department of Prosthetic Dental Sciences, College of Dentistry, Jouf University, Sakakah 72345, Saudi Arabia; dr.vinod.bandela@jodent.org

* Correspondence: mkalam@ju.edu.sa or dralam@gmail.com

† Mohammad Khursheed Alam and Anil Kumar Nagarajappa contributed equally and both are the 1st author.

Citation: Alam, M.K.; Nagarajappa, A.K.; Alfawzan, A.A.; Akhter, F.; Alswairki, H.J.; Issrani, R.; Bandela, V. The Spheno-Occipital Synchondrosis and Morphometry of Sella Turcica Association with Different Phenotype Factors Related to Ectopic Eye Tooth/Teeth. *Appl. Sci.* **2022**, *12*, 112. https://doi.org/10.3390/app12010112

Academic Editor: Gabi Chaushu

Received: 13 November 2021
Accepted: 21 December 2021
Published: 23 December 2021

Abstract: Objectives: This study investigates the prevalence of Spheno-Occipital Synchondrosis (SOS) and sella turcica morphometry (STM) association with different phenotype factors related to ectopic eye tooth/teeth (EET) using cone beam computed tomography (CBCT) imaging. Methods: This comparative retrospective study analyzed 252 CBCT images. Subjects in the EET group consisted of 197 CBCT images with the phenotype factor in number, i.e., unilateral (13, $n = 62$; 23, $n = 59$) or bilateral (1323, $n = 76$) and matched control ($n = 55$). SOS and STM were investigated using 3D OnDemand Software. Seven parameters of STM were measured. To test the association X2 used for SOS prevalence, disparities in STM were tested using ANOVA and post hoc Tukey test. Results: The prevalence of unfused SOS was 48.4% and 16.1% in the 1323 and control groups, respectively. Fused SOS prevalence was quite similar in all four groups. Phenotype factor in number, i.e., unilateral 13, 23, or bilateral EET group showed significant disparities in six out of seven parameters ($p = 0.044$ to $p \geq 0.001$). Additionally, phenotype factor in position, i.e., occlusal, buccal, or palatal group showed insignificant disparities ($p = 0.463$ to $p = 1.00$). Conclusion: SOS in the ectopic eye tooth group (EETG) was prevalent in the 1323 and buccal position groups. Differing from previous two-dimensional (2D) studies, there were statistically significant disparities in all seven measured variables of STM among control, and three different phenotype factors in numbers were revealed using three-dimensional (3D) CBCT imaging.

Keywords: Spheno-Occipital Synchondrosis; sella turcica; Ectopic Eye Tooth; CBCT

1. Introduction

Synchondrosis is a cartilaginous union between bones composed entirely of hyaline cartilage. They exist between ossification centers of developing bones, and gradually ossify [1]. Three important endochondral growth centers are identified in the craniofacial skeleton, namely the sphenoethmoidal synchondrosis, the intersphenoid synchondrosis and the Spheno-Occipital Synchondrosis (SOS) [2,3]. Synchondrosis of cranial base is crucial for the maturity of the craniofacial complex. SOS is related to maxillo-facial complex growth and plays an important role in orthodontic management and forensic anthropology [4].

Sella turcica (ST) is considered as one of the important guide points in the radiographic analysis of the craniofacial anatomy [5,6]. This guide point is centered in the ST, which accommodates the pituitary gland at the cranial base [5,6]. The architecture of the ST plays a pivotal role in the assessment of cephalometric measurements, cranial growth changes, and orthodontic treatment [7].

Evaluation of ST's anatomic position, its affiliation with the pituitary gland, and its evolution contributes to identification of various shape and size craniofacial pathologies. Previous studies have indicated that an aberrant size and shape of ST involves various anomalies such as hyperprolactinemia, pituitary adenoma, Williams syndrome, Down syndrome, cleft lip and palate [6,7]. These unusual morphological alterations of ST and their link with various craniofacial pathologies have been a matter of interest to the scientific community [5,7].

Maxillary cuspids/ectopic eye teeth (EET) are among the most frequently impacted teeth in orthodontics, second only to wisdom teeth. Maxillary cuspid/EET impaction involves almost 2% of the community [8]. Untreated, EET contributes to the development of complications such as tooth malposition, root resorption, tooth mobility, ankylosis, midline shift, arch length deficiency and dentigerous cyst formation [9–11].

Few studies have observed associations between dental abnormalities such as impacted palatal canines, transposition, hypodontia, oligodontia, congenitally missing tooth, supernumerary tooth in altered ST size, morphology and sella turcica roofing (STR) [8]. Therefore, routine assessment of dimensions of the sella point are vital for describing atypical morphology, which will help clinicians to discover various craniofacial pathologies and syndromes [6,7]. Different investigative methods were used to study the closure of SOS [12]. An extensive literature search was conducted concerning the above two parameters of this study viz. morphometrics of STM and analysis of SOS with different phenotype factors related to EET. It was learned that most of the previous studies employed traditional 2D conventional radiography across different geographical locations with their local populations [5–7,13,14]. These conventional radiographs have shortcomings such as projection errors, geometric distortion and superimposition of craniofacial structures [1,2,7,12,15]. However, very few studies have employed advanced 3D imaging with only one of the above-mentioned parameters. Modern dentistry has leaped towards 3D imaging modalities, particularly CBCT, which is fast revolutionizing modern-day orthodontics. CBCT can give a better 3D reconstructed view and accurate dimensions at lower cost and radiation doses; hence, it plays a key role in the diagnosis and treatment of craniofacial malformations [4,11,12,15–17]. The development and availability of new 3D image viewing software has further encouraged orthodontists to seek more accurate dimensions, reproduction of the markers and early detection of craniofacial anomalies [6,16,17].

STM differs from person to person and may deviate from one population to another. The paradigm shift of 2D towards 3D imaging encouraged us to undertake this study to establish better norms for the local Saudi population. Our speculated hypothesis for this study would be is there any significant difference in the prevalence of SOS and abnormal morphometrics of STM and their association with different phenotype factors of EET? Very few Saudi based studies have investigated one of the above-mentioned parameters. With this background, the current investigation was undertaken to establish the following objectives:

1. Prevalence of SOS and its relation with EET.
2. Morphometrics of STM and its relation with:
    A. three different phenotypes of EET (unilateral 13, unilateral 23 and bilateral) and control.
    B. three different phenotype positions of EET (buccal, occlusal and palatal).

2. Materials and Methods

The present study was conducted in the Oral Radiology Section of College of Dentistry, Jouf University, Sakaka in the Kingdom of Saudi Arabia. Ethical clearance was obtained for the execution of the study from the Local Committee for Bioethics (LCBE no: 9-16-8/39). The study was conducted from the period June 2020 to January 2021. The study population included local Saudi subjects, aged between 15–30 years, attending the dental outpatient department (OPD) for various dental treatment purposes. The demographic details were obtained from the dental OPD. Over 780 high volumetric CBCT data sets were analyzed, and 252 volumetric data sets were shortlisted as per the set inclusion and exclusion criteria. The subjects with good quality CBCT images having EET and matched control, no history of orthodontic or craniofacial surgical treatment, and subjects with no anatomical variation in the ST and sphenoidal regions matched with healthy control without any EET were recruited into the study. Subjects using hormonal medications or corticosteroids were excluded from the study. Through a convenient sampling method, 252 subjects were distributed into different EET groupings as follows: 62 in (unilateral 13), 59 in (unilateral 23), 76 (bilateral 1323), and 55 in control groups. The sample size was decided based on 80.16% power (1-ß err prob), $\alpha = 0.05$, critical f = 1.87, and effect size (d) = 0.259 effect size (G*Power software version 3.0.10; Franz Faul Universitat, Kiel, Germany). Hence, the appropriate total sample size for this study (all 4 groups) was 252. The high volumetric CBCT images were acquired from Soredex (scanora 3D) CBCT machine manufactured by Soredex Imaging Systems (Tuusula, Finland). The data sets were analyzed using the On-Demand 3D software (Seoul, Korea). All of the CBCT scans were captured by the single radiographer from the period 2018–2020, with the subjects seated in upright position with teeth in centric occlusion. All of the scans were captured under the standard exposure settings of 70 kV, 10 mA, 2.4–6 s exposure time, with field of view of (FOV-XL + 240 × 165 mm). A total of seven parameters, a–g, were employed for the assessment of STM morphometrics [11,12,14,16,17]. SOS evaluation was performed based on SOS scoring followed from Alhazmi et al. [12]. The details of both evaluations are presented in Figure 1 and Table 1.

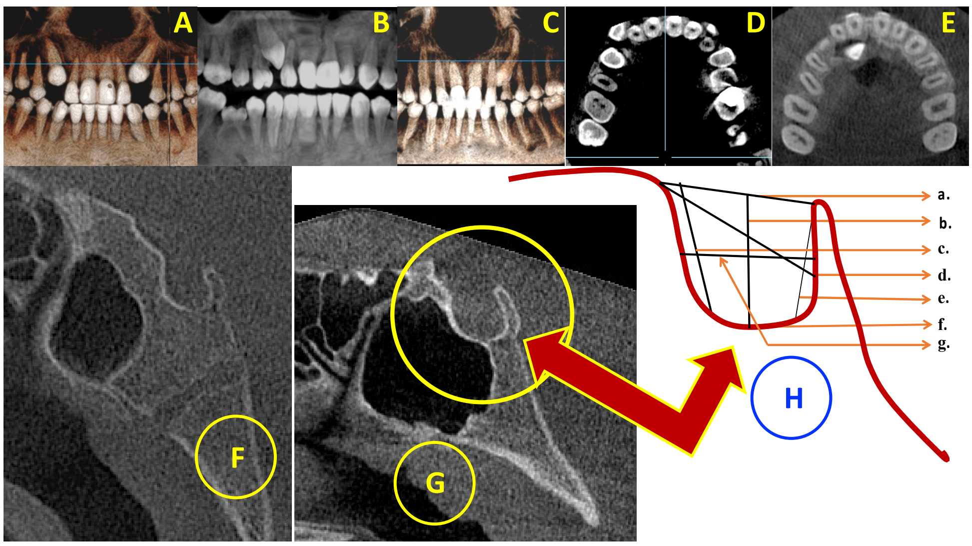

Figure 1. Showing different groups of study population. (**A**): 1323 (Bilateral), (**B**): 13 (Unilateral), (**C**): 23 (Unilateral), (**D**): Buccal, (**E**): Palatal, (**F**): Spheno-Occipital suture (open), (**G**): Sella turcica (**H**): Sella turcica morphometrics.

Table 1. Details of the methods.

STM Measurements (7 Parameters) [11,14,16,17]					
a	TS	tuberculum sella	The most anterior point of the contour of the ST	Sella length	TS-Pclin
b	DS	dorsum sellae	The posterior wall of the ST	Sella width	SA-SP
c	SF	sella floor	The deepest point on the floor of pituitary fossa	Sella diameter	TS-DS
d	Pclin	posterior clenoid	The most anterior point of the PClin process	Sella height anterior	TS-SF
e	SA	sella anterior	The most anterior point of the sella	Sella height posterior	PClin-SF
f	SP	sella posterior	The most posterior point of the sella	Sella height median	SM-SF
g	SM	sella median	A point midway between PClin and TS	Sella area	TS-SA-SF-SP-Pclin.
Spheno-Occipital Synchondrosis scoring [12]			Reliability assessment [Kappa and ICC test]: After 2-week interval, kappa test results of SOS prevalence agreement were excellent (intra and inter-examiner reliability ranged from 0.966–1.0). Reliability test, ICC results of STM for all 7 variables ranged from 0.858 to 0.934.		
Stages		Details			
0		Unfused			
1		<half-length fused			
2		>half-length fused			
3		Fused			

3. Results

The prevalence of 4 categories of SOS in control vs. 3 different phenotype EETG in number was 0 = 1323 > 23 > Control > 13, 1 = 13 > 23 > Control > 1323, 2 = 13 > 1323 > Control > 23 and 3 = 1323 > 23 > Control > 13, respectively (Figure 2). SOS in control vs. 2 different phenotype EETG in position are more prevalent in, 0, 1, 2 and 3 = buccal (Figure 3). Overall SOS prevalence was 0 = 12%, 1 = 7%, 2 = 9% and 3 = 72.22%, respectively (Figure 4).

Table 2 shows the details of descriptive and comparative disparities among control and 3 different phenotypes of EETG in position (13, 23 and 1323). Overall STM was presented, showing significant disparities in 6 out of 7 measured variables. In all 7 measured variables of STM, the common trends of shorter measurements were observed in the 1323 EETG group.

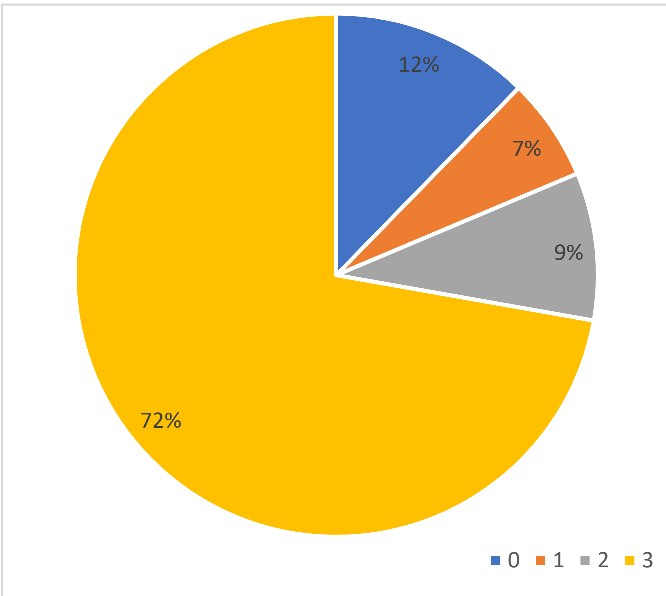

Figure 2. SOS prevalence.

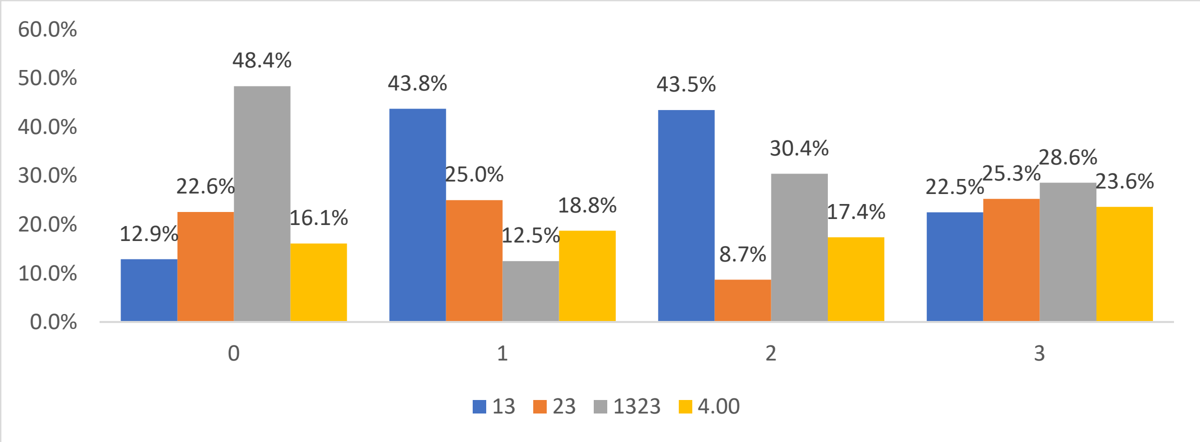

Figure 3. SOS prevalence in relation to EETG (13 and 23 = unilateral EET, 1323 = bilateral EETG, and 4 = control).

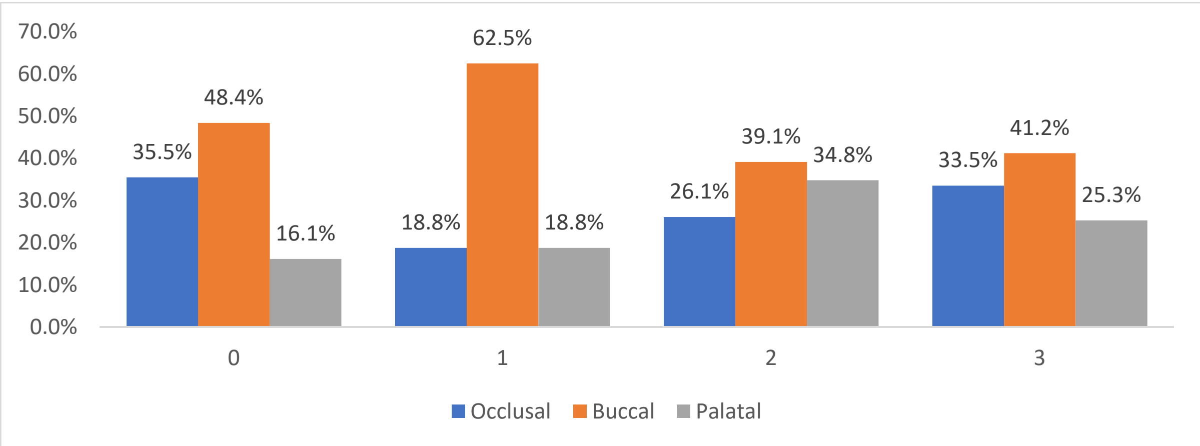

Figure 4. SOS prevalence in relation to EETG position.

Table 2. STM details and comparison in relation to EETG in number with matched control.

Variable		Mean (mm)	SD (mm)		MD (mm)	95%Confidence Interval Lower Bound	Upper Bound	*p* Value
a. TS-Pclin	13	8.726	1.327	13 vs. 23	−0.885	−1.732	−0.038	0.035
	23	9.611	1.983	13 vs. 1323	0.451	−0.346	1.248	0.801
	1323	8.274	1.774	13 vs. 4.00	−0.400	−1.263	0.463	1.000
	4.00	9.126	1.870	23 vs. 1323	1.336	0.528	2.144	<0.001
				23 vs. 4.00	0.485	−0.388	1.358	0.843
				1323 vs. 4.00	−0.851	−1.676	−0.027	0.039
b. SA-SP	13	8.380	1.537	13 vs. 23	−0.388	−1.159	0.382	1.000
	23	8.769	1.602	13 vs. 1323	0.597	−0.128	1.323	0.177
	1323	7.783	1.672	13 vs. 4.00	−0.165	−0.950	0.620	1.000
	4.00	8.546	1.535	23 vs. 1323	0.986	0.250	1.721	0.003
				23 vs. 4.00	0.223	−0.571	1.018	1.000
				1323 vs. 4.00	−0.762	−1.513	−0.012	0.044
c.TS-DS	13	9.798	2.429	13 vs. 23	−0.766	−1.915	0.384	0.466
	23	10.564	2.767	13 vs. 1323	0.322	−0.760	1.403	1.000
	1323	9.476	2.463	13 vs. 4.00	−0.751	−1.921	0.420	0.536
	4.00	10.549	1.617	23 vs. 1323	1.087	−0.009	2.184	0.053
				23 vs. 4.00	0.015	−1.169	1.199	1.000
				1323 vs. 4.00	−1.072	−2.191	0.046	0.068

Table 2. *Cont.*

Variable		Mean (mm)	SD (mm)		MD (mm)	95%Confidence Interval		p Value
						Lower Bound	Upper Bound	
d. TS-SF	13	7.014	1.355	13 vs. 23	−0.784	−1.470	−0.097	0.016
	23	7.797	1.631	13 vs. 1323	0.345	−0.302	0.991	0.945
	1323	6.669	1.382	13 vs. 4.00	−0.310	−1.009	0.390	1.000
	4.00	7.324	1.294	23 vs. 1323	1.128	0.473	1.783	<0.001
				23 vs. 4.00	0.474	−0.234	1.181	0.458
				1323 vs. 4.00	−0.654	−1.323	0.014	0.059
e. PClin-SF	13	7.126	1.348	13 vs. 23	−0.321	−0.987	0.344	1.000
	23	7.447	1.464	13 vs. 1323	0.346	−0.281	0.972	0.861
	1323	6.780	1.334	13 vs. 4.00	−0.262	−0.940	0.416	1.000
	4.00	7.388	1.369	23 vs. 1323	0.667	0.032	1.302	0.034
				23 vs. 4.00	0.059	−0.627	0.745	1.000
				1323 vs. 4.00	−0.608	−1.256	0.040	0.079
f. SM-SF	13	7.459	1.404	13 vs. 23	−0.525	−1.182	0.133	0.208
	23	7.983	1.360	13 vs. 1323	0.315	−0.303	0.933	1.000
	1323	7.144	1.335	13 vs. 4.00	−0.174	−0.843	0.495	1.000
	4.00	7.633	1.335	23 vs. 1323	0.839	0.213	1.466	0.003
				23 vs. 4.00	0.350	−0.327	1.027	1.000
				1323 vs. 4.00	−0.489	−1.129	0.150	0.258
g. Sellaarea	13	60.329	15.731	13 vs. 23	−3.756	−12.166	4.655	1.000
	23	64.084	19.248	13 vs. 1323	5.309	−2.604	13.223	0.454
	1323	55.019	17.112	13 vs. 4.00	1.941	−6.625	10.507	1.000
	4.00	58.388	17.441	23 vs. 1323	9.065	1.041	17.088	0.018
				23 vs. 4.00	5.697	−2.971	14.364	0.490
				1323 vs. 4.00	−3.368	−11.555	4.818	1.000

Table 3 shows the details of descriptive and comparative disparities among occlusal and 2 different phenotypes of EETG (buccal and palatal). Overall STM was presented, showing insignificant disparities in all 7 measured variables. In 6 out of 7 measured variables of STM, the common trends of shorter measurements were observed in the palatal EETG group.

Table 3. STM details and comparison in relation to EETG positions.

Variable		Mean (mm)	SD (mm)		MD (mm)	95% Confidence Interval		p Value
						Lower Bound	Upper Bound	
a. TS-Pclin	Occlusal	9.191	1.814	Occlusal vs. Buccal	0.378	−0.260	1.017	0.463
	Buccal	8.813	1.835	Occlusal vs. Palatal	0.583	−0.151	1.318	0.170
	Palatal	8.608	1.740	Buccal vs. Palatal	0.205	−0.487	0.897	1.000
b. SA-SP	Occlusal	8.500	1.575	Occlusal vs. Buccal	0.248	−0.329	0.825	0.904
	Buccal	8.252	1.674	Occlusal vs. Palatal	0.267	−0.397	0.931	1.000
	Palatal	8.233	1.630	Buccal vs. Palatal	0.019	−0.607	0.645	1.000
c. TS-DS	Occlusal	10.577	1.717	Occlusal vs. Buccal	0.621	−0.223	1.464	0.232
	Buccal	9.957	2.505	Occlusal vs. Palatal	1.075	0.105	2.045	0.024
	Palatal	9.502	2.871	Buccal vs. Palatal	0.455	−0.460	1.369	0.695
d. TS-SF	Occlusal	7.089	1.293	Occlusal vs. Buccal	−0.089	−0.612	0.434	1.000
	Buccal	7.178	1.611	Occlusal vs. Palatal	−0.136	−0.738	0.465	1.000
	Palatal	7.225	1.460	Buccal vs. Palatal	−0.047	−0.614	0.519	1.000
e. PClin-SF	Occlusal	7.155	1.349	Occlusal vs. Buccal	−0.048	−0.543	0.447	1.000
	Buccal	7.203	1.462	Occlusal vs. Palatal	0.086	−0.483	0.655	1.000
	Palatal	7.069	1.351	Buccal vs. Palatal	0.134	−0.403	0.671	1.000
f. SM-SF	Occlusal	7.379	1.353	Occlusal vs. Buccal	−0.223	−0.713	0.268	0.826
	Buccal	7.601	1.436	Occlusal vs. Palatal	−0.201	−0.765	0.364	1.000
	Palatal	7.580	1.344	Buccal vs. Palatal	0.022	−0.510	0.554	1.000
g. Sella area	Occlusal	58.337	16.798	Occlusal vs. Buccal	−2.523	−8.751	3.704	0.989
	Buccal	60.861	17.291	Occlusal vs. Palatal	0.998	−6.165	8.162	1.000
	Palatal	57.339	19.157	Buccal vs. Palatal	3.522	−3.231	10.275	0.630

4. Discussion

The intent of this retrospective study was to uncover the prevalence of SOS, STM and their association with different phenotype factors related to EET using CBCT imaging in a Saudi population. After performing a literature search to the present date, this study was the first of its kind to try to figure out the above-mentioned associated factors. The endochondral growth centers of the cranial base have a close structural interconnection with the nasomaxillary regions during development, impacting the future position of the maxilla [4]. Examination of STM is crucial for the assessment of the pathology in the pituitary gland [11]. The result of this study will impact many fields of dentistry, i.e., orthodontics, implant dentistry, maxillofacial surgery, pediatrics, forensic medicine, anthropology, etc.

Our study revealed the prevalence of un-fused SOS of 48.4% in the EETG (1323) and 62.5% in the buccal position group. Limited research data are available at this juncture for comparison; at this point, ours is the only study that has sought to unearth the association between un-fused SOS and different phenotype factors connected with EET using CBCT imaging. Most research studies conducted thus far have focused on correlation of SOS closure with factors such as cervical vertebrae maturation [1]. Onset of puberty [8], age estimation [18–21], and association with cleft lip and palate patients [13].

This study investigated the relationship of STM with EET in Saudi nationals. It considered seven parameters of STM and six phenotype factors associated with EET, i.e., number (13, 23 or 1323) and position (occlusal, buccal or palatal). The STM was in accordance with a few research studies conducted in the past, wherein they measured all seven parameters similarly to our study [11,14,16,17]. Hasan et al. conducted two separate CT morphometric analyses of ST in both Iraqi and Malaysian populations and compared them with the global data [11,16]. In both the populations they studied the STM, shape and performed multiple analyses to establish connections between age and sex [11,16]. They found ST morphometrics similar to our study and no significant differences between genders [11,16]. Islam et al. examined 166 Bangladeshi subjects' CT scans and compared them with world data [17]. They investigated seven parameters of STM, shape and morphology of the ST [17]. Analysis of ST morphometrics was in total agreement with the current study [17]. Shresta [13], Tepedino [22], and Sinha et al. [23] traced lateral cephalograms to determine and compare the shapes, sizes, and bridging of the ST in individuals with different skeletal patterns. In contrast to the present study, they measured only three parameters: the length, anteroposterior diameter and depth of ST; all three parameters were consistent with our study [13,22,23]. Shah et al. analyzed lateral cephalometric radiographs of 180 subjects and estimated the size, shape and dimensions of the ST among three different skeletal classes [24]. They reported that no significant difference was found in linear dimensions of ST between the genders and different skeletal groups [24]. However, the liner dimensions were greater and inconsistent with the current study [24]. Elnour et al. evaluated 210 Saudi subjects for shape and size of sella turcica using CT [25]. They measured anteroposterior dimension, length, depth and volume of ST; the first three parameters (except the last parameter) were consistent with the current study. The volume of ST was not measured in the current study [25]. Badri et al. analyzed 175 lateral cephalometric radiographs for ST size and morphology in three skeletal malocclusions [26]. They estimated length, depth and anteroposterior diameter of ST using cephalometric software 'Vista Dent' [26]. Except for the length, the remaining two parameters of the ST were consistent with our study [26]. Szu-Ting Chou et al. investigated 159 CBCT volumes for estimation of ST dimensions in three different craniofacial skeletal patterns [15]. They divided ST into right and left regions and included nine parameters for estimation of ST dimensions. Their results were inconsistent with the current study [15]. This inconsistency could be related to several factors, such as age of the subjects (18–40 years), gender, genetic factors and measurement method employed [15].

Sinha et al. studied 300 lateral cephalograms for the linear dimensions and morphology of ST in cleft and non-cleft subjects [27]. They observed normal dimensions of length, depth and diameter in non-cleft subjects, which was in agreement with the current study [27].

Alam and Alfawzan investigated lateral cephalograms and OPGs of 123 cleft subjects from Kingdom of Saudi Arabia for ST morphometrics, bridging, and associated anomalies [14]. All seven parameters measured in four groups—bilateral cleft lip and palate (BCLP), unilateral cleft lip and palate (UCLP), unilateral cleft lip (UCL), and unilateral cleft lip and alveolus (UCLA)—were in accordance with the current study except the non-cleft group; also, the BCLP group exhibited smaller values when compared with other groups [14].

Most of the previous studies employed two-dimensional conventional imaging, which has its own limitations such as superimposition of other cranial bones, landmark identifications and tracing errors. This could be one of the factors responsible for the differences in the measurements of STM [14,20,28,29]. This study employed advanced three-dimensional CBCT imaging, which allowed effective three-dimensional viewing of the SOS and ST free of superimpositions [4,8,12,15,18,19]. CBCT can accurately spot the position of the impacted maxillary canines. The location of the impacted tooth plays an important role in determining the feasibility of the surgical approach and the proper direction for the application of orthodontic forces [8].

A few drawbacks of this study could be that it studied the subjects from a single-center Saudi population and also did not compare with global data. The difference in STM morphometrics could be due to different evaluation methods employed. Future studies could involve a wider, multi-center sample size and compare with global data involving many populations.

Our study found an increased prevalence of unfused SOS in the 1323 EETG (Figure 2). No similar studies evaluating connection between SOS with EET were found in the literature. Phenotype factor in number, i.e., unilateral 13, 23 or bilateral EET group showed significant disparities in six parameters out of seven (Table 2). The clinical significance of the present study is that it may assist in the early detection of EET. The timing of preventive treatment of EET is of vital importance for successful treatment outcomes. Therefore, if EET is detected early and interceptive measures are promptly undertaken, the ongoing dilemma associated with EET could be avoided. Additionally, it could result in a reduction in the duration, expense, and effort of orthodontic treatment.

5. Conclusions

1. SOS is associated with EET; it is more commonly observed with phenotype factors 1323 and buccal position group.
2. This study revealed statistically significant disparities in six out of seven parameters of STM.
3. This study revealed statistically insignificant disparities with phenotype factor position.

Author Contributions: Conceptualization, M.K.A., A.K.N., A.A.A., F.A., H.J.A., R.I. and V.B.; methodology, M.K.A. and A.K.N.; software, M.K.A. and A.K.N.; validation, M.K.A. and A.K.N.; formal analysis, M.K.A. and A.K.N.; investigation, M.K.A. and A.K.N.; resources, M.K.A., A.K.N., A.A.A., F.A., H.J.A., R.I. and V.B.; data curation, M.K.A. and A.K.N.; writing—original draft preparation, M.K.A. and A.K.N.; writing—review and editing, M.K.A., A.K.N., A.A.A., F.A., H.J.A., R.I. and V.B.; funding acquisition, M.K.A. All authors have read and agreed to the published version of the manuscript.

Funding: The authors extend their appreciation to the Deanship of Scientific Research at Jouf University for funding this work through research grant no. (DSR-2021-01-0383).

Institutional Review Board Statement: After obtaining the approval from the Ethical Committee of Jouf University (LCBE#9-16-8/39), CBCT from the local Saudi population were obtained in the oral clinical radiology section of the College of Dentistry, Jouf University, for various dental treatments (for the purpose of implant, maxillofacial, surgical and orthodontic therapy), in compliance with the Declaration of Helsinki. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed to design and conduct the study.

Informed Consent Statement: Written informed consent was obtained from all subjects (one of the parents, either father and/or mother, or legal guardian for adolescent subjects).

Data Availability Statement: The data used to support the findings of this study are included in the article.

Acknowledgments: The authors extend their appreciation to the Deanship of Scientific Research at Jouf University for funding this work through research grant no. (DSR-2021-01-0383).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Fernández-Pérez, M.J.; Alarcón, J.A.; McNamara, J.A., Jr.; Velasco-Torres, M.; Benavides, E.; Galindo-Moreno, P.; Catena, A. Spheno-Occipital Synchondrosis Fusion Correlates with Cervical Vertebrae Maturation. *PLoS ONE* **2016**, *11*, e0161104. [CrossRef]
2. Kanchan, T.; Krishan, K. Evaluation of spheno-occipital synchondrosis: A review of literature and considerations from forensic anthropologic point of view. *J. Forensic Dent. Sci.* **2013**, *5*, 72–76. [CrossRef] [PubMed]
3. Funato, N. New Insights into Cranial Synchondrosis Development: A Mini Review. *Front. Cell Dev. Biol.* **2020**, *8*, 706. [CrossRef]
4. Vale, F.; Francisco, I.; Lucas, A.; Roseiro, A.; Caramelo, F.; Sobral, A. Timing of Spheno-Occipital Synchondrosis Ossification in Children and Adolescents with Cleft Lip and Palate: A Retrospective Case-Control Study. *Int. J. Environ. Res. Public Health* **2020**, *17*, 8889. [CrossRef] [PubMed]
5. Dasgupta, P.; Sen, S.; Srikanth, H.S.; Kamath, G. Sella Turcica Bridging as A Predictor Of Class II Malocclusion–An Investigative Study. *J. Stomatol. Oral Maxillofac. Surg.* **2018**, *119*, 482–485. [CrossRef] [PubMed]
6. Alkofide, E.A. The shape and size of the sella turcica in skeletal Class I, Class II, and Class III Saudi subjects. *Eur. J. Orthod.* **2007**, *29*, 457–463. [CrossRef]
7. Axelsson, S.; Storhaug, K.; Kjaer, I. Post-natal size and morphology of the Sella turcica. Longitudinal cephalometric standards for Norwegians between 6 and 21 years of age. *Eur. J. Orthod.* **2004**, *26*, 597–604. [CrossRef]
8. Manne, R.; Gandikota, C.; Juvvadi, S.R.; Rama, H.R.M.; Anche, S. Impacted canines: Etiology, diagnosis, and orthodontic management. *J. Pharm. Bioallied Sci.* **2012**, *4*, 234–238. [CrossRef]
9. Ortiz, P.M.; Tabbaa, S.; Flores-Mir, C.; Al-Jewair, T. A CBCT Investigation of the Association between Sella-Turcica Bridging and Maxillary Palatal Canine Impaction. *Biomed Res. Int.* **2018**, *2018*, 4329050. [CrossRef]
10. Dadgar, S.; Alimohamadi, M.; Rajabi, N.; Rakhshan, V.; Sobouti, F. Associations among palatal impaction of canine, sella turcica bridging, and ponticulus posticus (atlas arcuate foramen). *Surg. Radiol. Anat.* **2021**, *43*, 3–99. [CrossRef]
11. Hasan, H.A.; Alam, M.K.; Abdullah, Y.J.; Nakano, J.; Yusa, T.; Yusof, A.; Osuga, N. 3DCT Morphometric Analysis of Sella Turcica in Iraqi Population. *J. Hard Tissue Biol.* **2016**, *25*, 227–232. [CrossRef]
12. Alhazmi, A.; Vargas, E.; Palomo, J.M.; Hans, M.; Latimer, B.; Simpson, S. Timing and rate of spheno-occipital synchondrosis closure and its relationship to puberty. *PLoS ONE* **2017**, *12*, e0183305. [CrossRef] [PubMed]
13. Shrestha, G.K.; Pokhare, P.R.; Gyawali, R.; Bhattarai, B.; Giri, J. The morphology and bridging of the sella turcica in adult orthodontic patient. *BMC Oral Health* **2018**, *18*, 45. [CrossRef]
14. Alam, M.K.; Alfawzan, A.A. Evaluation of Sella Turcica Bridging and Morphology in Different Types of Cleft Patients. *Front. Cell Dev. Biol.* **2020**, *8*, 656. [CrossRef] [PubMed]
15. Chou, S.T.; Chen, C.M.; Chen, P.H.; Chen, Y.K.; Chen, S.C.; Tseng, Y.C. Morphology of Sella Turcica and Bridging Prevalence Correlated with Sex and Craniofacial Skeletal Pattern in Eastern Asia Population: CBCT Study. *BioMed Res. Int.* **2021**, *2021*, 13. [CrossRef]
16. Ali Hasan, H.; Alam, M.K.; Yusof, A.; Mizushima, H.; Kida, A.; Osuga, N. Size and Morphology of Sella Turcica in Malay populations: A 3D CT Study. *J. Hard Tissue Biol.* **2016**, *25*, 313–320. [CrossRef]
17. Islam, M.; Alam, M.K.; Yusof, A.; Kato, I.; Honda, Y.; Kubo, K.; Maeda, H. 3D CT Study of Morphological Shape and Size of Sella Turcica in Bangladeshi Population. *J. Hard Tissue Biol.* **2017**, *26*, 1–6. [CrossRef]
18. Sinanoglu, A.; Kocasarac, H.D.; Noujeim, M. Age estimation by an analysis of spheno-occipital synchondrosis using cone-beam computed tomography. *Leg. Med.* **2016**, *18*, 13–19. [CrossRef]
19. Bassed, R.B.; Briggs, C.; Drumer, O.H. Analysis of time of closure of the spheno-occipital synchondrosis using computed tomography. *Forensic Sci. Int.* **2010**, *200*, 161–164. [CrossRef]
20. Kocasarac, H.D.; Altan, A.B.; Yerlikaya, C.; Sinanoglu, A. Correlation between spheno-occipital synchondrosis, dental age, chronological age and cervical vertebrae maturation in Turkish population: Is there a link? *Acta Odontol. Scand.* **2017**, *75*, 79–86. [CrossRef]
21. Fayad, R.; Kassis, A.; Akl, R.; Ghoubril, J.; Khoury, E. Correlation between fusion of spheno-occipital synchondrosis and cervical vertebral maturation: A CBCT and cephalometric assessment. *Int. Orthod.* **2020**, *18*, 749–757. [CrossRef] [PubMed]
22. Tepedino, M.; Laurenziello, M.; Guida, L.; Montaruli, G.; Troiano, G.; Chimenti, C.; Colonna, M.; Ciavarella, D. Morphometric analysis of sella turcica in growing patients: An observational study on shape and dimensions in different sagittal craniofacial patterns. *Sci. Rep.* **2019**, *9*, 19309. [CrossRef]
23. Sinha, S.; Shetty, A.; Nayak, K. The morphology of Sella Turcica in individuals with different skeletal malocclusions—A cephalometric study. *Transl. Res. Anat.* **2020**, *18*, 100054. [CrossRef]
24. Shah, A.M.; Bashir, U.; Ilyas, T. The shape and size of the sella turcica in skeletal class I, II & III in patients presenting at islamic international dental hospital. Islamabad. *Pak. Oral Dent. J.* **2011**, *31*, 104–110.

25. Elnour, H.; Al-Otaibi, A.; Al-Otaibi, M.; Arab, N.; Thobaiti, R.A.; Murad, R.; Al-Otaibi, S. Evaluation of Shape and Size of Sella Turcica Using Computerized Tomography in Saudi Populations. *Sch. J. Appl. Med. Sci.* **2020**, *8*, 2058–2063. [CrossRef]
26. Badri, M.K.; Alhojaily, A.A.; Qutub, A.S.; Alshanqeeti, F.K.; Jarallah, R.A. Retrospective analysis of size and morphology of sella turcica in different skeletal patterns in Madinah, Saudi Arabia. *IP Indian J. Orthod. Dentofac. Res.* **2019**, *5*, 137–142. [CrossRef]
27. Sinha, S.P.; Shetty, A.; Nayak, K. The morphology of sella turcica in cleft and non-cleft individuals. *Saudi Dent. J.* **2020**, *32*, 86–92. [CrossRef]
28. Divya, S.; Urala, A.S.; Prasad, G.L.; Pentapati, K.C. Sella turcica bridging a diagnostic marker for impacted canines and supernumerary teeth. *J. Int. Oral Health* **2018**, *10*, 94–98. [CrossRef]
29. Pasini, M.; Giuca, M.R.; Ligori, S.; Mummolo, S.; Fiasca, F.; Marzo, G.; Quinzi, V. Association between Anatomical Variations and Maxillary Canine Impaction: A Retrospective Study in Orthodontics. *Appl. Sci.* **2020**, *10*, 5638. [CrossRef]