

Nasopharynx evaluation in children of unilateral cleft palate patients and normal with cone beam computed tomography

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Mustafa Temiz¹, Suayip Burak Duman² ,
Ahmed Z. Abdelkarim³,
Ibrahim Sevki Bayrakdar^{4,5}, Ali Z. Syed⁶,
Gozde Eser², Duygu Celik Ozen²,
Hatice Tugce Gedik⁷, Mehmet Ugurlu⁸
and Rohan Jagtap⁹ 

¹Department of Oral and Maxillofacial Surgery, Istanbul Medipol University, Istanbul, Turkey

²Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Inonu University, Malatya, Turkey

³Division of Oral & Maxillofacial Radiology, Collage of Dentistry, The Ohio State University, Columbus, OH, USA

⁴Eskisehir Osmangazi University Center of Research and Application for Computer Aided Diagnosis and Treatment in Health, Eskisehir, Turkey

⁵Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Eskisehir Osmangazi University, Eskisehir, Turkey

⁶Department of Oral and Maxillofacial Medicine and Diagnostic Sciences, School of Dental Medicine, Case Western Reserve University, Cleveland, OH, USA

⁷Department of Anatomy, Faculty of Medicine, Ataturk University, Erzurum, Turkey

⁸Department of Orthodontics, Faculty of Dentistry, Eskisehir Osmangazi University, Eskisehir, Turkey

⁹Division of Oral & Maxillofacial Radiology, Department of Care Planning and Restorative Sciences, University of Mississippi Medical Center School of Dentistry, Jackson, MI, USA

Corresponding author:

Suayip Burak Duman, Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Inonu Osmangazi University, 44280 Malatya, Turkey.

Email: suayipburakduman@gmail.com



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Abstract

Objective: This study aimed to examine the morphological characteristics of the nasopharynx in unilateral Cleft lip/palate (CL/P) children and non-cleft children using cone beam computed tomography (CBCT).

Methods: A retrospective study consisted of 54 patients, of which 27 patients were unilateral CL/P, remaining 27 patients have no CL/P. Eustachian tubes orifice (ET), Rosenmuller fossa (RF) depth, presence of pharyngeal bursa (PB), the distance of posterior nasal spine (PNS)-pharynx posterior wall were quantitatively evaluated.

Results: The main effect of the CL/P groups was found to be effective on RF depth-right ($p < 0.001$) and RF depth-left ($p < 0.001$). The interaction effect of gender and CL/P groups was not influential on measurements. The cleft-side main effect was found to be effective on RF depth-left ($p < 0.001$) and RF depth-right ($p = 0.002$). There was no statistically significant relationship between CL/P groups and the presence of bursa pharyngea.

Conclusions: Because it is the most common site of nasopharyngeal carcinoma (NPC), the anatomy of the nasopharynx should be well known in the early diagnosis of NPC.

Keywords

Nasopharyngeal carcinoma, Rosenmuller fossa, cone beam computed tomography, cleft lip and palate, dentistry

Introduction

Pharyngeal recess (PR), also known as Rosenmuller fossa (RF), was first introduced by Johann Christian Rosenmuller in 1808. RF is a small bilateral diverticulum in the nasopharynx that is anatomically critical. RF is located posterior nasopharynx just below the skull base and posterior to the ostium of the Eustachian tube (ET). Its location becomes essential as it is separated from the internal carotid artery only by a thin tissue.¹ The posterior wall of the nasopharynx, which includes various anatomical landmarks such as RF, the opening of ET, and pharyngeal bursa (PB), is composed of loose connective tissue and may result in nasopharyngeal laceration if forceful insertion of the tube during the nasotracheal intubation.² Maxillofacial radiologists need to know more about this area because nasopharyngeal carcinoma (NPC), the most common malignant neoplasm of the nasopharynx, must be placed in the region.³ It has been reported that calcific formations such as rhinolith can be seen in this region.⁴ The epithelial residue of embryological origin of the posterior wall of the nasopharynx may result in PB,⁵ and Tornwaldt disease, which is cyst, abscess, or inflammation of the PB, may develop from PB.⁶

Cleft lip and palate (CL/P) is a frequently occurring congenital disability affecting facial appearance, hearing, and speech. CL/P occurs due to the complete or incomplete union of the medial nasal prominence(s) on one or both sides in the embryological period.⁷ Although children with isolated cleft lip often have normal or near-normal middle ear function, many children with CL/P experience chronic ET dysfunction, which may occur in the tympanic membrane (TM) retraction or recurrent acute otitis media.⁸ Godinho et al.⁹ showed in their studies that there might be changes in the normal anatomy of tensor veli palatine (TVP) muscle located laterally of RF. They contributed to opening ET orifice and levator veli palatine (LVP) muscle located anteriorly of RF.⁹ Cone beam computed tomography (CBCT) is preferred not only by dentists but also by

otolaryngologists thanks to the high image quality in the maxillofacial area, especially when it comes to hard tissue examinations such as bone.¹⁰ We used CBCT to view and evaluate nasopharynx anatomy, including RF, ET, and PB.

This study aims to examine morphologic features of the nasopharyngeal region, which includes RF, ET, and PB in unilateral CL/P children and non-cleft.

Materials and methods

The study consisted of 54 patients, of which 27 patients were unilateral CL/P (18 male, 9 female, 15 cleft line left, 12 cleft line right, average age 11.3 ± 1.9). The remaining 27 patients have no CL/P (16 male, 11 female average age 11.3 ± 1.9). CBCT images of 54 patients aged 8–14 years were obtained from the radiology archive of inonu University Faculty of Dentistry between the years 2014 and 2020. The Clinical Research Ethics Committee of the University Faculty of Medicine approved the study (approval no. 2021/2772). Legal guardians of all participants gave written informed consent before the CBCT. Patients were excluded if the patient's record did not ensure enough quality, craniofacial syndrome, history of nasopharyngeal surgery and any pathological formations in the nasopharynx region. It was confirmed that the patient did not swallow during the CBCT taken. All measurements and image evaluations were performed by an oral and maxillofacial radiologist and head and neck anatomist with more than ten years of experience in the area of head and neck imaging. The level of intra- and inter-examiner agreement was evaluated.

Radiological evaluation and measurements

All patients' records were obtained with New Tom 5G (QR Verona) dental volumetric systems, operating as follows, rotation 360° , a field of view (FOV) $15 \text{ cm} \times 12 \text{ cm}$, 18-s scan time and 3.6-s exposure time, 110 V kVp tube voltage, 1–11 mA and voxel size $0.2 \mu\text{m}$. Quantitative radiology-NNT software program version 2.21 was used to evaluate the posterior wall of the nasopharynx of all images.

ET orifice, RF, posterior nasal spine (PNS), basion (Ba), and PB are shown in the CBCT axial section presented in Figure 1. For measurement, the axial image where Ba (midline point of the anterior margin of the foramen magnum) and PNS (most posterior point of the bony hard palate on the mid-sagittal plane) are seen in the same frame is selected.

RF Depth: The shortest distance from the deepest point of the fossa with the line drawn from the Ba point and passing tangentially through the torus levatorius.

PNS-Pharynx Posterior Wall: The shortest distance from the PNS and posterior wall of the pharynx.

ET orifice: The widest part of the point where the ET opens into the nasopharyngeal space.

PB: A crypt in the posterior wall of the pharynx was evaluated and noted for presence or not randomly selected images were observed again by the same observer 2 weeks after the first observation to assess examiner consistency for all variables and found 0.82–0.90 coefficients.

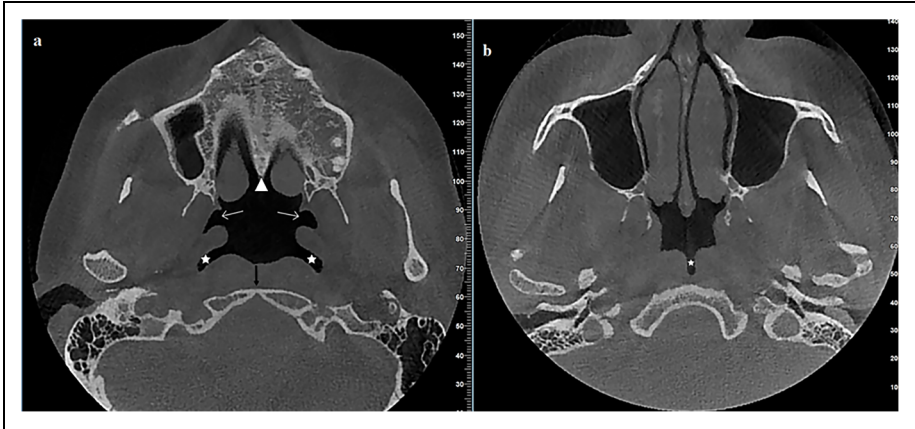


Figure 1. (a) Stars: Rosenmuller Fossa, White Arrows: Eustachian Tube orifice, Black Arrow: basion, Arrow Head: Posterior Nasal Spine. (b) Star: Pharyngeal Bursa.

Statistical analysis

Normality was assessed for all continuous variables using the Shapiro–Wilk test, and non-normally distributed data were transformed using the natural log (Ln) value where relevant (Eustachian-right (LN), Eustachian-left (LN)). Multivariate analysis of variance (MANOVA) was used to evaluate the relationship between groups and measurements. Pearson Chi-squared test was used to assess the relationship between CL/P groups and the presence of bursa pharyngea.

Results

Sample size calculation was performed with G*Power 3.1.9.2 software with 0.424 effect size, at 5% significance level, power of 0.86.¹¹ This yielded total 54 individuals divided between the CL/P groups and control groups. The main effect of the CL/P groups was found to be effective on Rosenmuller fossa depth-right ($p < 0.001$) and Rosenmuller fossa depth-left ($p < 0.001$). The interaction effect of gender and CL/P groups was not effective on measurements (Table 1). Rosenmuller fossa depth-right was found as 3.16 ± 1.17 in non-cleft and 5.21 ± 2.02 in CL/P patients. Rosenmuller fossa depth-left was found as 3.14 ± 1.45 and 4.69 ± 1.99 in CL/P patients. The measurements descriptive findings in terms of CL/P groups and gender were summarized in Table 2. The cleft-side main effect was found to be effective on Rosenmuller fossa depth-left ($p < 0.001$) and Rosenmuller fossa depth-right ($p = 0002$). Gender main effect was found to be no effect on measurements. The interaction effect of gender and cleft side was not effective on measurements (Table 3). Rosenmuller fossa depth-right was found as 3.6 ± 1.17 in non-cleft, 4.08 ± 1.48 in cleft side-right patients and 6.11 ± 1.97 in cleft side-left patients. Rosenmuller fossa depth-left was found as 3.14 ± 1.45 in non-cleft, 4.96 ± 1.27 in cleft side-right patients and 4.47 ± 2.44 in cleft side-left patients. The

Table 1. The statistical findings of relationship between CL/P groups and measurements using multivariate analysis of variance (MANOVA).

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
CL/P Group	Rosenmuller fossa depth-right ^a	49,875	1	49,875	18,449	<0.001	0270
	Rosenmuller fossa depth-left ^b	32,507	1	32,507	11,402	<0.001	0186
	PNS-basion ^c	0005	1	0005	0000	0.989	0000
	Eustchian-right (LN) ^d	0075	1	0075	1143	0.290	0022
	Eustchian-left (LN) ^e	0122	1	0122	1397	0.243	0027
Gender	Rosenmuller fossa depth-right	4787	1	4787	1771	0.189	0034
	Rosenmuller fossa depth-left	14,508	1	14,508	5089	0.028	0092
	PNS-basion	0117	1	0117	0005	0.946	0000
	Eustchian-right (LN)	0070	1	0070	1057	0.309	0021
	Eustchian-left (LN)	0181	1	0181	2079	0.156	0040
Group* Gender	Rosenmuller fossa depth-right	1858	1	1858	0687	0.411	0014
	Rosenmuller fossa depth-left	0024	1	0024	0009	0.927	0000
	PNS-basion	56,400	1	56,400	2229	0.142	0043
	Eustchian-right (LN)	0094	1	0094	1422	0.239	0028
	Eustchian-left (LN)	0021	1	0021	0246	0.622	0005

^aR-Squared = 0.055 (Adjusted R squared = -0.002).

^bR-Squared = 0.071 (Adjusted R squared = 0.016).

^cR-Squared = 0.046 (Adjusted R squared = -0.011).

^dR-Squared = 0.320 (Adjusted R squared = 0.280).

^eR-Squared = 0.247 (Adjusted R squared = 0.202).

measurements descriptive findings in terms of cleft side and gender were summarized in Table 4. There was no statistically significant relationship between CL/P groups and the presence of bursa pharyngea ($p = 0.398$). The findings of bursa pharyngea in terms of CL/P groups were summarized in Table 5.

Discussion

In recent years, our understanding of the genetic foundation of human disease and its impact on embryologic development has substantially advanced. A combination of poor migration and inadequate development of facial mesenchyma is thought to cause disorders of the first and second branchial arch. Because many head and neck structures migrate throughout fetal development, understanding embryologic development aids in determining the origin and nature of congenital abnormalities. A better knowledge of the pathophysiologic nature of craniofacial disorders is gained by familiarity with craniofacial embryology and its implications on the resulting anatomy. The first and second

Table 2. The measurements descriptive findings in terms of CL/P groups and gender.

CL/P groups	Gender	Rosenmuller fossa depth-right	Rosenmuller fossa depth-left	PNS-basion	Eustchian-right (LN)	Eustchian-left (LN)
Non Cleft	Male	2.75 ± 1.06	2.69 ± 1.2	12.51 ± 5.17	1.01 ± 0.23	0.92 ± 0.26
	Female	3.75 ± 1.12	3.81 ± 1.58	14.73 ± 5.26	1.02 ± 0.22	1.09 ± 0.3
	Total	3.16 ± 1.17	3.14 ± 1.45	13.41 ± 5.23	1.01 ± 0.22	0.99 ± 0.28
Cleft	Male	5.13 ± 2.17	4.34 ± 1.84	14.65 ± 5.2	1.02 ± 0.23	0.87 ± 0.34
	Female	5.37 ± 1.8	5.38 ± 2.2	12.62 ± 3.98	0.86 ± 0.37	0.95 ± 0.25
	Total	5.21 ± 2.02	4.69 ± 1.99	13.97 ± 4.85	0.96 ± 0.29	0.89 ± 0.31
Total	Male	4.01 ± 2.09	3.56 ± 1.76	13.64 ± 5.22	1.01 ± 0.23	0.89 ± 0.30
	Female	4.48 ± 1.64	4.52 ± 2	13.78 ± 4.73	0.95 ± 0.3	1.02 ± 0.28
	Total	4.19 ± 1.94	3.92 ± 1.89	13.69 ± 5	0.99 ± 0.26	0.94 ± 0.30

Table 3. The statistical findings of relationship between cleft side and measurements using multivariate analysis of variance (MANOVA).

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Cleft side	Rosenmuller fossa depth-right	81,827	2	40,913	19,137	<0.0001	0.0444
	Rosenmuller fossa depth-left	37,267	2	18,633	6970	0.0002	0.0225
	PNS-basion	1000	2	0500	0019	0.0981	0.0001
	Eustchian-right (LN)	0124	2	0062	0947	0.0395	0.0038
	Eustchian-left (LN)	0109	2	0055	0609	0.0548	0.0025
Gender	Rosenmuller fossa depth-right	5640	1	5640	2638	0.0111	0.0052
	Rosenmuller fossa depth-left	11,234	1	11,234	4203	0.0046	0.0081
	PNS-basion	4558	1	4558	0173	0.0679	0.0004
	Eustchian-right (LN)	0118	1	0118	1809	0.0185	0.0036
	Eustchian-left (LN)	0107	1	0107	1197	0.0279	0.0024
Cleft side* Gender	Rosenmuller fossa depth-right	3930	2	1965	0919	0.0406	0.0037
	Rosenmuller fossa depth-left	13,550	2	6775	2534	0.0090	0.0096
	PNS-basion	57,403	2	28,701	1090	0.0344	0.0043
	Eustchian-right (LN)	0245	2	0123	1873	0.0165	0.0072
	Eustchian-left (LN)	0065	2	0032	0362	0.0698	0.0015

^aR-Squared = 0.098 (Adjusted R squared = 0.004).

^bR-Squared = 0.084 (Adjusted R squared = -0.011).

^cR-Squared = 0.047 (Adjusted R squared = -0.052).

^dR-Squared = 0.484 (Adjusted R squared = 0.430).

^eR-Squared = 0.322 (Adjusted R squared = 0.252).

branchial arch syndromes are characterized by hypoplasia and aplasia of the components that make up these arches. Since the CL/P and the Eustachian tube are both derived from the same (first) sac (pouch), it could be to responsible for the alteration in morphology of

Table 4. The measurements descriptive findings in terms of CL/P groups and gender.

		Rosenmuller fossa depth-right	Rosenmuller fossa depth-left	PNS-basion	Eustchian- right (LN)	Eustchian- left (LN)
Cleft side	Gender					
Right	Male	4.16 ± 1.97	5.19 ± 1.2	14.8 ± 5.29	0.96 ± 0.17	0.94 ± 0.27
	Female	3.98 ± 0.42	4.64 ± 1.44	12.88 ± 5.15	0.96 ± 0.44	0.92 ± 0.31
	Total	4.08 ± 1.48	4.96 ± 1.27	14 ± 5.08	0.96 ± 0.29	0.93 ± 0.28
Left	Male	5.75 ± 2.14	3.81 ± 2.01	14.55 ± 5.41	1.05 ± 0.27	0.82 ± 0.39
	Female	7.1 ± 1.1	6.3 ± 2.85	12.3 ± 2.59	0.73 ± 0.26	0.97 ± 0.19
	Total	6.11 ± 1.97	4.47 ± 2.44	13.95 ± 4.84	0.97 ± 0.3	0.86 ± 0.34
Non-cleft	Male	2.75 ± 1.06	2.69 ± 1.2	12.51 ± 5.17	1.01 ± 0.23	2.6 ± 0.74
	Female	3.75 ± 1.12	3.81 ± 1.58	14.73 ± 5.26	1.02 ± 0.22	3.08 ± 0.93
	Total	3.16 ± 1.17	3.14 ± 1.45	13.41 ± 5.23	1.01 ± 0.22	2.8 ± 0.84
Total	Male	4.01 ± 2.09	3.56 ± 1.76	13.64 ± 5.22	1.01 ± 0.23	0.92 ± 0.26
	Female	4.48 ± 1.64	4.52 ± 2	13.78 ± 4.73	0.95 ± 0.3	1.09 ± 0.3
	Total	4.19 ± 1.94	3.92 ± 1.89	13.69 ± 5	0.99 ± 0.26	0.94 ± 0.3

Table 5. The relationship between CL/P groups and presence of bursa pharyngea.

	Bursa pharyngea		Total	p
	Absence	Presence		
Non-cleft	19 (55.9%)	8 (40%)	27 (50%)	.0398
Cleft	15 (44.1%)	12 (60%)	27 (50%)	
Total	34 (100%)	20 (100%)	54 (100%)	

the anatomy in the nasopharyngeal area.¹² Cleft lip-palate deformity is a problem that can cause insufficiency in the midface and velopharyngeal region in all three dimensions. Three-dimensional evaluation of these patients before surgical reconstruction is usually done with CBCT images. In one study, it was reported that the incidental findings discovered in CBCT scans of CL/P patients were three times more than the healthy group.¹³ For this reason, when examining the radiological images of CL/P patients, not only the cleft line, but also every anatomical region within the imaging field should be interpreted carefully and comprehensively against the possibility of variability.

We have not encountered a study comparing the RF of children with CL/P and non-cleft children to our best knowledge. Looking at the results of this present study, RF depth was significantly deep in children with CL/P. Given the finding, it can be said that NPC diagnosis in RF location may be overlooked in CL/P patients. Increased RF depth may cause the NPC to hide in this fossa, and the NPC may not be detectable until it reaches considerable size.¹⁴ Because of the irregular shape of the NPC, it is recommended to be examined from different sections in radiological examinations.¹⁵ Hoe et al.,¹⁶ in a study of CT images of patients with biopsy-proven NPC, observed that asymmetry of the

mucosal airway contour with RF blunting associated with infiltration of the musculus levator palatini. The similarity of NPC and temporomandibular dysfunction (TMD) symptoms such as trismus, headache, facial and ear pain is an essential issue that oral radiologists should consider. While 36% of NPC patients have trismus as the first symptom,¹⁷ in another study, trismus was observed in 9% of NPC patients.¹⁸ Other pathologies may develop in RF other than NPC. A case report of RF rinolith presented by Shilston et al.¹⁹ with CT, RF based a lipoma case introduced by Kalan et al.²⁰ Also, a case report in the literature figures out the removal of bullets from RF.²¹

Even though nasotracheal intubation is necessary procedure, especially if working in the dental area, it could be a traumatic procedure such as epistaxis. Due to the left face slope of the tube facing away from the turbinates, thus crossing the vocal cords more efficiently, the general view is that nasotracheal intubation through the right nostril is safer than the one through the left nostril.²² Takasugi et al.²³ have studied that whether PR variations are effective in nasotracheal intubation in patients using multiplanar CT. Researchers have argued that during the nasotracheal intubation procedure, the tip of the nasotracheal tube may become trapped in the RF and cause unsuccessful nasotracheal intubation. They also stated that the tube tip might cause nasopharyngeal laceration and nasopharyngeal dissection during this procedure due to hitting the recess strongly.²³ Increasing RF depth may increase the difficulty of nasotracheal intubation, as demonstrated in CL/P patients in this study. ET morphology is one of the critical anatomical structures that can change in CL/P patients.¹¹ Because E/T dysfunction is connected to many problems such as chronic otitis media,²⁴ health E/T is considerably necessary for seamless hearing. Patients with CL/P often have ET problems because the levator veli palatini and tensor veli palatini muscles may not function normally. In addition to these, ETs of CL/P patients invite middle ear diseases, depicted as horizontal, short, and floppy.²⁵ In this study, only the opening of ET to the posterior nasopharyngeal region was measured, and no statistical difference was found. PB, which may host a Tornwaldt cyst, may develop in the posterior wall of the nasopharynx, which consists of loose connective tissue. Gallagher et al.²⁶ reported that their blind nasotracheal intubation attempt failed due to the presence of PB.

This study contains some limitations. First, although we obtained all patients in the same CBCT taken procedures because the recess walls can adhere to each other in the supine position, it has been suggested that PR can be hidden.²⁷ They claim that gravity can change oropharyngeal structures, especially in postural changes such as upright and supine positions. However, this study aimed to compare the morphological features of the nasopharyngeal regions in patients with CL/P and non-cleft, and since the images of the two groups included were obtained under the same procedures, it is thought that this situation did not adversely affect the results of the study. Secondly, we conducted the study with a limited population due to the insufficient number of unilateral CL/P patients.

Conclusion

Because RF is the most frequent site for NPC, it is crucial to have a thorough understanding of nasopharyngeal anatomy. In CL/P patients, RF depth may increase, and this should be considered while evaluating disorders in this region.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics approval


Ethical approval was obtained from ERC (Ethical Review Committee) (Approval/2021/2772).

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ORCID iDs

Suayip Burak Duman  <https://orcid.org/0000-0003-2552-0187>

Rohan Jagtap  <https://orcid.org/0000-0002-9115-7235>

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Author biographies

Mustafa Temiz holds a PhD in oral and maxillofacial surgery. His interests are orthognathic surgery and cleft lip and palate patients.

Suayip Burak Duman holds the title of associate professor in oral and maxillofacial. His interests are CBCT and artificial intelligence.

Ahmed Z. Abdelkarim holds a PhD in oral and maxillofacial radiology. His interests are CBCT and craniofacial disorders.

Ibrahim Sevki Bayrakdar holds the title of associate professor in oral and maxillofacial. His interests are CBCT and artificial intelligence.

Ali Z. Syed holds a PhD in oral and maxillofacial radiology. His interests are CBCT and craniofacial disorders.

Gozde Eser is research assistant in the field of oral and maxillofacial radiology. Her interests are CBCT and artificial intelligence.

Duygu Celik Ozen is research assistant in the field of oral and maxillofacial radiology. Her interests are CBCT and artificial intelligence.

Hatice Tugce Gedik holds a PhD in Anatomy. Her interests are dental anatomy and variations.

Mehmet Ugurlu has a specialist title in orthodontics. His interests are orthognathic disorders and craniofacial development.

Rohan Jagtap holds a PhD in oral and maxillofacial radiology. His interests are CBCT and craniofacial disorders.