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ORIGINAL ARTICLE

Evaluation of the anterior processes of the parotid gland: an ultrasonographic study

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Abstract

Objectives This study aimed to determine the prevalence of anterior extensions of the parotid gland (AEPG), namely the accessory parotid gland (APG) and the facial process of the parotid gland (FP), using ultrasonography.

Study design A total of 338 parotid glands were scanned bilaterally. APG was defined as a soft tissue mass with the same echogenic features as the main parotid gland (MPG) and not in contact with it, while FP was defined as an extension that exceeded the anterior border of the mandibular ramus and was continuous with the MPG. The anteroposterior, mediolateral, superoinferior dimensions and the mean distance from the MPG to the APG were measured.

Results The prevalence of APG and FP were 19.5% and 36%, respectively, resulting in an AEPG prevalence of 55.6%. The presence of APG was statistically higher in females than in males ($p = 0.039$). The mean anteroposterior, mediolateral, and superoinferior dimensions of the APG were 18.1 ± 0.57 mm, 0.35 ± 0.17 mm, and 12.3 ± 0.36 mm, respectively, and the mean distance from the MPG was measured as 12.1 ± 0.87 mm.

Conclusion This study can raise awareness among clinicians about the presence of AEPG in the differential diagnosis of mid-cheek masses.

Keywords Accessory parotid gland · Facial process · Prevalence · Ultrasonography

Introduction

The parotid gland is one of the major salivary glands and makes a pure and serous secretion [16]. Within the anterior region of the parotid gland, normal anatomical variants such as the accessory parotid gland (APG) and facial process (FP) may exist. The APG is a distinct salivary tissue separate from the main parotid gland (MPG) and is typically situated anteriorly, overlying the masseter muscle. The FP of parotid glands is described as lobes protruding to the front edge of the masseter muscle or the mandibular ramus [1, 21].

As these anatomic structures are situated in the mid-cheek area and classified as accessory salivary tissue, they present various problems including histological, pathological, radiological, and surgical aspects. Histologically, the APG shows both serous and mucous acini making them differ from the MPG [21]. Pathologically and radiologically, both the APG and FP of the parotid gland can mimic soft tissue masses like developmental, inflammatory, and neoplastic lesions [10, 12]. Lastly, surgical complications may occur if the anterior extensions of the parotid gland (AEPG) are not taken into account [11, 13].

Computed tomography, magnetic resonance imaging, and high-resolution ultrasonography are used for the imaging evaluation of parotid gland pathologies [2]. Ultrasonography stands out as the first-line technique for exploring parotid anomalies due to its ready accessibility, non-invasiveness, non-ionizing nature, and cost-effectiveness [3]. Also, ultrasound-guided fine-needle aspiration and core-needle biopsy serve as primary diagnostic tools especially when malignancy is suspected [14, 19].

Studies on AEPG have been primarily confined to cadaveric investigations, and some of them are quite dated [6, 21]. On the other hand, there have been a few radiological studies about AEPG [1, 20, 24]. To the best of our knowledge,

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there is no study concerning the ultrasonographic prevalence of APG and FP. Therefore, this study aims to determine the prevalence of AEPG, encompassing APG and FP, utilizing ultrasonography.

Materials and methods

Study participants

Building on the research by Ahn et al. [1] the study's sample size was set at a minimum of 169 participants, maintaining a 95% reliability and a 5% deviation, following the sample size formula for the known universe. Before starting this prospective study, ethical clearance was obtained from Akdeniz University Clinical Research Ethics Committee (Approval number: KAEK-160), adhering to the Helsinki Declaration guidelines.

The study commenced in January 2022 and concluded in July, involving a total of 338 parotid glands from 169 healthy participants who were selected on a voluntary and random basis. Informed consent was provided by all volunteers. Participants that had no mid-cheek mass, no history of head and neck radiotherapy, salivary gland disease, no history of head and neck trauma, and no history of surgery in the relevant region were included in the study. Demographic data such as presence, gender, age, and laterality were systematically recorded. Age groups were categorized into six groups according to decades: 20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, and 70–79 years.

Ultrasonographic examination

Subjects underwent ultrasonographic examinations conducted by the same observer, with the head slightly tilted left or right while in the supine position. The observer employed the Logic P9 system (General Electric Medical Systems, Milwaukee, WI, USA) featuring a 10-MHz linear array transducer and exerted minimal pressure on the tissue to achieve optimal imaging conditions, at an average depth of 4 cm. The region extending from the tragus to the oral commissure was scanned transversely and longitudinally with a sliding motion. The anterior pole of the MPG was detected in the transverse plane, then extensions of the parotid gland showing similar echogenic characteristics as the parenchyma were sought by advancing with the probe in the anterior direction. If present, a tissue that is continuous with the MPG and is crossing the anterior margin of the ramus was defined as the facial process of the parotid gland (Fig. 1). On the other hand, if it was completely separate from the MPG, then defined as the accessory parotid gland [1, 21] (Fig. 2). Measurements were taken in the identified accessory parotid glands: anteroposterior and mediolateral dimensions at their longest region in the transverse plane (Fig. 3a and b), while the superoinferior dimension was measured in the longitudinal axis by rotating the probe (Fig. 3c). Lastly, the distance between the MPG and the APG was measured (Fig. 3d). To ensure reliability, a second observer independently reassessed the presence of accessory extensions of the parotid gland and performed all measurements to evaluate interobserver agreement.

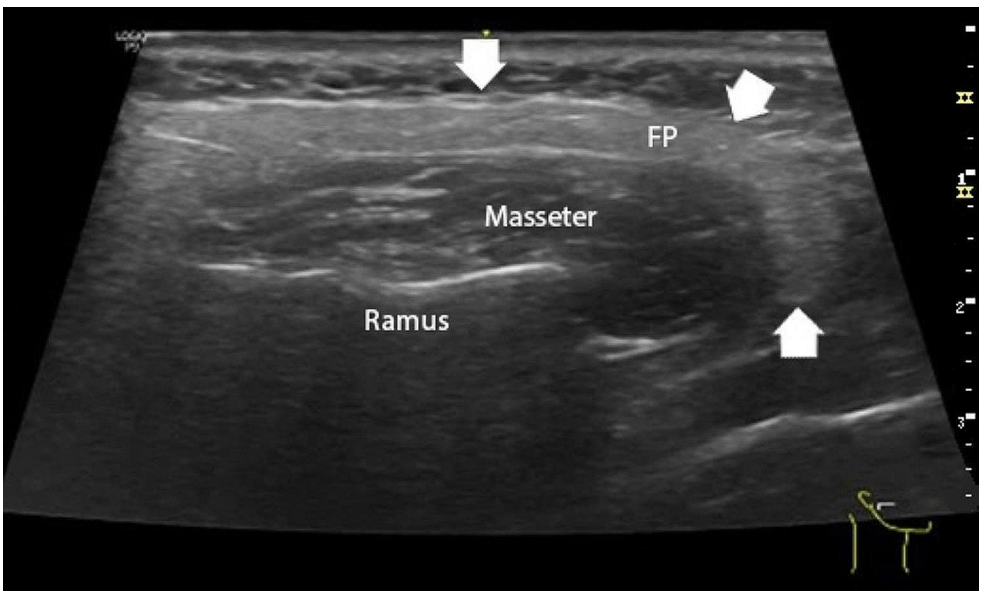

Fig. 1 Ultrasonographic image of FP of the parotid gland (arrows)

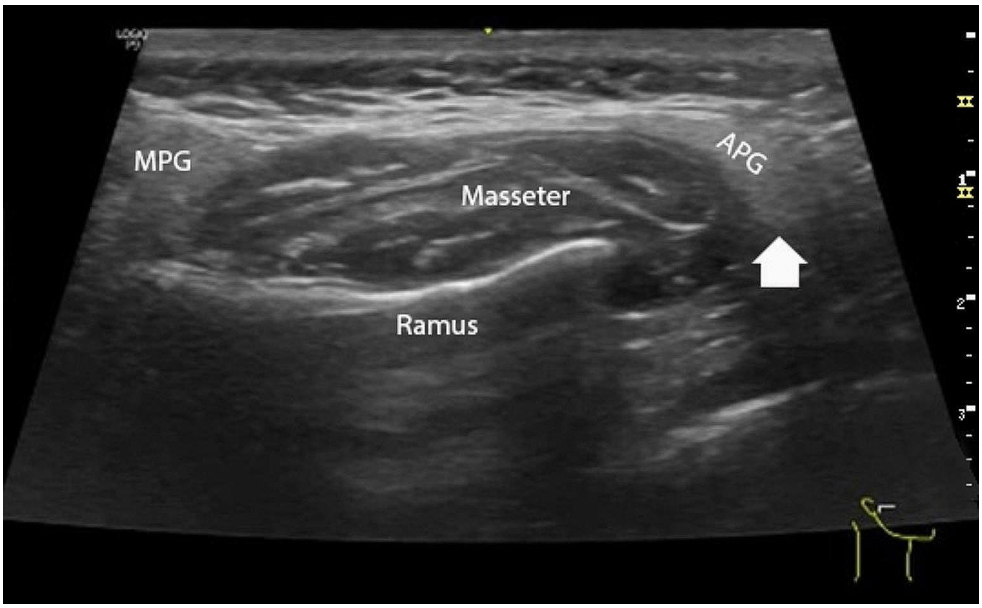

Fig. 2 Ultrasonographic image of the APG (arrow)

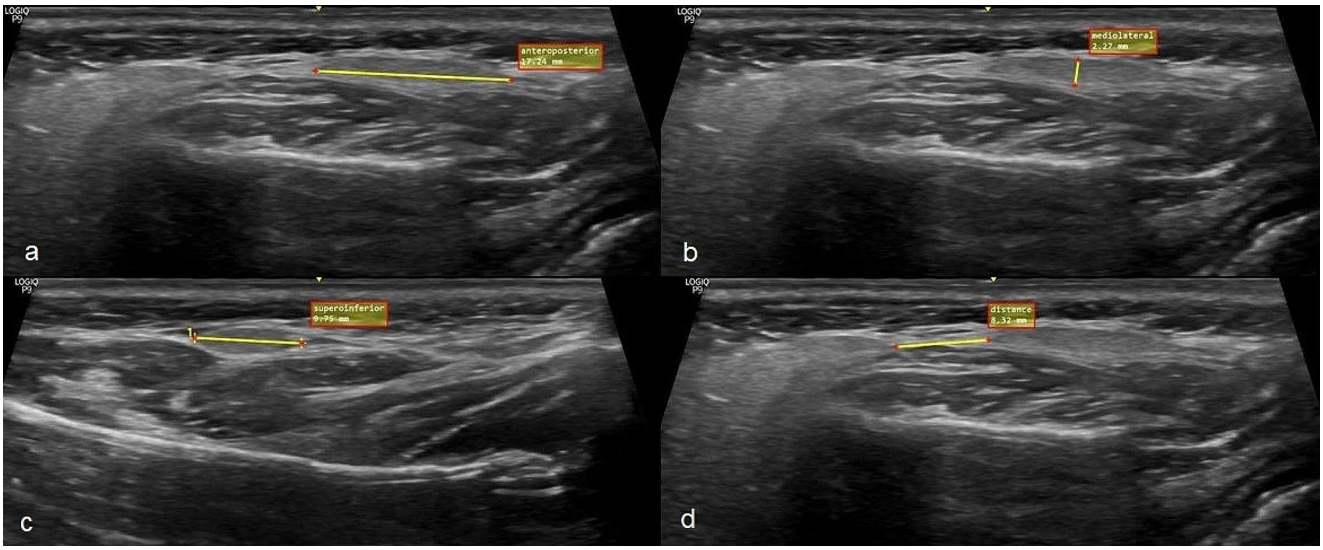

Fig. 3 Measurements performed on APG. Anteroposterior (**a**), mediolateral (**b**), superoinferior (**c**) measurements with the distance between the MPG and APG (**d**)

Statistical analysis

The data were statistically analyzed using IBM SPSS Statistics (Version 22, Armonk, NY). The normality assumption was evaluated using the Shapiro-Wilk method. The Shapiro-Wilk method was employed to evaluate the normality assumption. Descriptive statistics and frequencies were computed for age, gender, presence of FP, and presence of APG.

For comparisons between two groups, the independent samples t-test was used for normally distributed data, while the MannWhitney U test was utilized for data that did not display a normal distribution. When analyzing differences among more than two groups, One-way ANOVA and the Kruskal-Wallis test were applied for normally and non-normally distributed data, respectively.

Pearson chi-square test was used to analyze the difference between categorical variables, and the Spearman correlation test was used to analyze relationships. Intra-observer reliability was assessed via the interclass correlation coefficient and the kappa coefficients. Statistical significance was assumed at $p < 0.05$.

Table 1 Age and gender distribution of participants

age groups	male (n/%)	female (n/%)	total (n/%)
20–29 years	19/36.5	33/63.5	52/100
30–39 years	8/30.8	18/69.2	26/100
40–49 years	20/46.5	23/53.5	43/100
50–59 years	14/66.7	7/33.3	21/100
60–69 years	13/61.9	8/31.1	21/100
70–79 years	6/100	0/ 0	6/100
total	80/47.3	89/52.7	169/100

n: number of participants; %: percentages

Results

The the kappa coefficients were 0.974 and 0.953 for FP and APG, respectively and the interclass correlation coefficient values indicated good reliability for each measurement (above 0.90).

A total of 338 parotid glands were bilaterally examined in 169 patients, aged between 20 and 79 years. The mean age of the patients was 40.9 ± 15.6 years. Gender and age distribution among participants are presented in Table 1. A statistically significant difference was observed between gender and age ($p = 0.004$).

Prevalence and features of anterior extension of the parotid gland

Among the participants, the prevalence of AEPG, encompassing either FP or APG, was found to be 55.6% (188 out of 338). The mean ages of the patients with and without the AEPG were 40.72 ± 15.43 (age range between 20 and 75 years) and 41.59 ± 16.24 (age range between 21 and 79 years), respectively. The difference in ages between these groups was statistically insignificant ($p = 0.741$). Table 2 shows the distribution of AEPG, FP and APG according to gender, age, and laterality. The difference between right and left side was statistically significant ($p = 0.016$). 60 out of 169 (35.5%) participants had bilateral AEPG. Spearman correlation analysis revealed no significant relationship between the presence of AEPG and gender (r = -0.11, $p = 0.884$) or age groups (r = -0.006, $p = 0.937$) (Fig. 4).

Prevalence and features of facial process

Among 338 parotid glands from 169 participants, 122 parotid glands (36.1%) had facial processes. The mean ages of the patients with and without the FP were 41.5 ± 15.59 (age range between 20 and 72 years) and 40.31 ± 15.65 (age range between 21 and 79 years), respectively. Notably, the difference in ages between these groups was statistically insignificant ($p = 0.688$). Table 2 shows the distribution of AEPG, FP and APG according to gender, age, and laterality.

The difference between right and left side was statistically significant ($p < 0.001$). 34 out of 169 (20.1%) participants had bilateral FP.

Spearman correlation analysis showed no relationship between the presence of FP and gender (r = -0.15, $p = 0.051$) and age groups ($r = 0.044$, $p = 0.57$) (Fig. 4).

Prevalence and features of accesory parotid gland

Accessory parotid gland was observed in 66 of the 338 parotid glands (19.5%). Patients with the APG had a mean age of 37.2 ± 14.4 years (age range between 21 and 75 years), while those without the APG had a mean age of 43 ± 15.9 years (age range between 20 and 79 years). This difference between the ages was statistically significant ($p = 0.027$). Table 2 shows the distribution of AEPG, FP, and APG based on gender, age, and laterality.

The difference between right and left side was statistically insignificant ($p < 0.906$). Six out of 169 (3.6%) participants displayed bilateral APG. Additionally, Spearman correlation analysis revealed a positive and significant relationship between gender and the presence of APG ($r = 0.159$, $p = 0.039$). Conversely, a negative and significant

Table 2 Distribution of anterior extension of the parotid gland, facial process and accessory parotid gland according to gender, age, and laterality

		AEPG (n/%)	*p*	FP (n/%)	*p*	APG (n/%)	*p*
gender	female	67/75.3		40/44.9		38/42.7	
	male	61/76.3	0.883	48/60	0.05	22/27.5	0.039*
age	20–29 years	40/76.9		26/50		24/ 46.2	
	30–39 years	19/73.1		13/ 50		10/ 38.5	
	40–49 years	33/76.7	0.302	23/53.5	0.434	14/32.6	0.303
	50–59 years	14/66.7		9/42.9		7/33.3	
	60–69 years	19/90.5		15/71.4		4/19	
	70–79 years	3/50		2/ 33.3		1/16.7	
laterality	right side	96/56.8		57/33.7		39/23.1	
	left side	92/54.4	0.016*	65/38.5	< 0.001*	27/16	0.908

n: number of participant; %: percentages; AEPG: anterior extension of the parotid gland; FP: facial process; APG: accesory parotid gland; *: $p < 0.05$

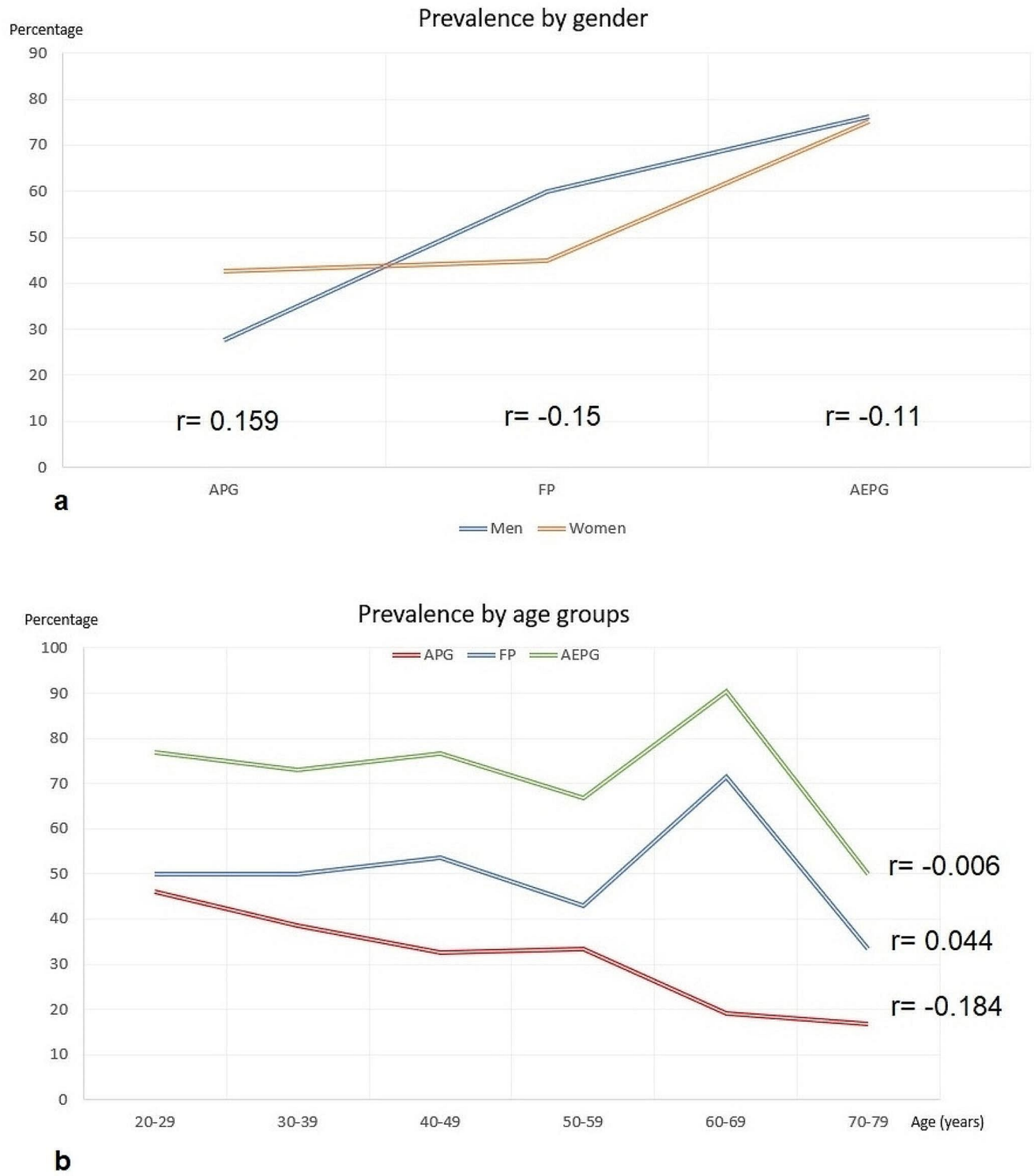

Fig. 4 Changes in the prevalence of APG, FP, and AEPG according to gender (**a**) and age (**b**)

relationship was found between age groups and the presence of APG ($r = -0.184$, $p = 0.017$) (Fig. 4).

The mean dimensions of the APG were as follows: anteroposterior size 18.1 ± 5.7 mm (range between 5.3 mm and 33.8 mm), mediolateral size 3.5 ± 1.7 mm (range between 1.6 mm and 10.6 mm), and superioinferior size 12.3 ± 3.6 mm (range between 5.7 mm and 24.1 mm). Additionally, the mean distance between the APG and the MPG

was 12.1 ± 8.7 mm (range between 2.1 mm and 36.2 mm). Measurements of the APG based on gender and age groups are presented in Table 3, indicating no significant differences among all measurements based on gender and age groups.

Discussion

This study offers a novel perspective on the prevalence of AEPG through the utilization of ultrasonography, a non-ionizing imaging method widely employed in salivary gland examinations [23]. There have been several cadaveric [6, 21] and radiological [1, 20, 24] studies conducted to measure the prevalence of AEPG. While in 1995, Tart et al. [20] used computed tomography and magnetic resonance image to describe buccal space and buccal space masses, in 2016, Zhu et al. [24] investigated role of the APG in the etiology of parotitis. In addition, in 2017, a study identified the AEPG with contrast-enhanced computed tomography [1].

The swift, safe, cost-effective, and non-ionizing nature of ultrasonography renders it advantageous over other imaging modalities for clinical applications [2, 9]. Consequently, the authors assert that ultrasound, as a primary imaging modality, proves to be an effective means for assessing the accessory tissues of the parotid gland.

In the present study, the prevalence of AEPG, FP, and APG was determined as 55.6%, 36.1%, and 19.5%, respectively. Previous studies primarily focused on the treatment and follow-up of existing APG or tumors arising from mid-cheek masses, rather than investigating the prevalence of AEPG.

Interestingly, the prevalence of AEPG and FP was only explored in Ahn et al.'s study [1], where they reported a lower prevalence compared to our findings (38.4% for AEPG and 28.3% for FP). This discrepancy suggests that ultrasonographic evaluation might be more effective in detecting these variations than computed tomography.

While no significant difference was observed between the presence of AEPG and gender in both studies, Ahn et al. found a significant difference between the presence of FP and gender ($p = 0.005$). However, in the current study, this prevalence was also insignificant at the cut-off value ($p = 0.05$). Ahn et al. categorized age groups into decades, similar to our study, but they did not detail the distribution of AEPG prevalence by decades in their article. In the present study, AEPG was detected mostly in participants aged 60–69 years (Table 2). Considering the prevalence of FP according to age groups, while Ahn et al. detected highest prevalence in the 70–79 years age group (34.5%), whereas in our study, the highest prevalence was observed in the 60–69 years age group. The number of participants in the 70–79 years age group in our study was notably smaller (Table 2), possibly contributing to the disparity between the two studies. Ahn et al.'s study, being retrospective, possibly allowed for the inclusion of a larger participant pool compared to our current study.

Despite the fact that there was no correlation between increasing age and the prevalence of FP in current study, this relationship was found to be positively correlated in Ahn et al.'s study. Although they hypothesized that the increase in volume with aging made accessory parotid attach to the main gland and become FP, there is actually no consensus on a positive correlation between aging and parotid volume [8, 15], especially when body mass index is taken into account [22].

In a recent meta-analysis conducted by Rosa et al., the overall pooled prevalence of an APG was 32.1% [17]. Our current study found a relatively high prevalence of APG (19.5%) compared to one computed tomography study (10.2%) [1], while another study reported a higher prevalence (35%) [20]. Conversely, it was notably lower when compared to findings from a sialographic research (38.7% for the healthy group) [24], and also lower in comparison to findings from cadaveric studies [6, 21].

Table 3 Measurements of accessory parotid gland according to gender and age groups

		APG to main parotid gland	anteroposterior size of APG	mediolateral size of APG	superoinferior size of APG
gender	male	1.29 ± 0.93	1.94 ± 0.71	0.36 ± 0.16	1.31 ± 0.48
	female	1.17 ± 0.85	1.73 ± 0.48	0.35 ± 0.17	1.18 ± 0.28
	p	0.523	0.221	0.419	0.595
age	20–29 years	1.28 ± 0.86	1.86 ± 0.62	0.3 ± 0.09	1.19 ± 0.36
	30–39 years	1.04 ± 0.53	1.76 ± 0.28	0.3 ± 0.1	1.21 ± 0.27
	40–49 years	1.26 ± 0.9	1.799 ± 0.47	0.41 ± 0.19	1.17 ± 0.24
	50–59 years	1.43 ± 1.45	1.63 ± 1.03	0.47 ± 0.34	1.25 ± 0.69
	60–69 years	0.69 ± 0.42	1.93 ± 0.31	0.32 ± 0.06	1.51 ± 0.22
	70–79 years*	1.29	1.84	0.39	1.77
	p	0.742	0.265	0.433	0.125

APG: accessory parotid gland

The measurements in the table show the mean ± standard deviation

*: There is no standard deviation, since there is only one patient in the 70–79 years group with an APG

The lower prevalence of APG in radiographic studies could potentially be attributed to the oversight of small APGs in imaging methods. While Ahn et al. [1] did not find a significant difference between the presence of APG and gender, our current study demonstrated such a difference ($p=0.039$). Moreover, a positive and significant relationship between gender and the presence of APG ($r=0.159$, $p=0.039$) was identified in our study.

The prevalence of APG showed a negative correlation with increasing age in our current study. Previous studies have highlighted significant microscopic changes in the parotid gland's architecture with age, leading to a gradual reduction of the gland's parenchyma and its replacement with adipose and fibrovascular tissue [7, 18]. These alterations in cell structure with aging might influence the gland's echogenic properties, causing the actual accessory parotid to be misidentified as other mid-cheek tissues. In addition, the declining prevalence of anatomical variants such as the accessory parotid gland and ectopic accessory parotid system with advancing age may potentially be attributed to developmental or age-related alterations within the region demarcated by the line extending from the tragus to the oral commissure. This line delineates the embryological fusion point between the maxillary and mandibular processes [4, 5]. Hence, the observed decrease in prevalence of such variants over time may potentially be attributed to developmental transformations occurring within this anatomical region, which could shed light on the phenomenon.

The morphology and morphometry of APG, ranging from rice-like to pea-sized, were well described in cadaveric studies [6, 21]. Unfortunately for the current study, it was not possible to determine the three-dimensional shape of APG due to the B-mode ultrasonography which allows two-dimensional imaging.

APG can be located just anterior to the main gland lying on the masseter muscle or at the buccinator side of the anterior border of the masseter muscle [1, 21]. Toh et al. specifically described a deeply lying APG [21]. Moreover, in our observations, we identified another variation—a deeply located FP positioned once again along the buccinator side of the anterior border of the masseter muscle (Fig. 1).

Ahn et al. [1] found the mean sizes APG were: 15.8 mm anteroposteriorly and 5 mm mediolaterally, however, in the current study these dimensions were found as 18.1 mm and 3.5 mm, respectively. Elongation of the anteroposterior dimension and contraction of the mediolateral dimension could be explained by involuntary pressure from the operator during the ultrasonographic examination. we measured the mean superoinferior dimension of the APG, which was determined to be 12.3 mm. Interestingly, this distance was higher than that reported in the cadaveric study [6], but consistent with findings from the tomography study [1].

The present study has some inherent limitations. Ultrasonography relies on the echogenic properties of the examined tissue. In line with this principle, our study depended on diagnosing tissues displaying salivary gland echogenicity situated in front of the MPG, either continuous with it or separate. Although our findings are relatively consistent with other studies, factors such as operator dependency and the limitations of being a dynamic, two-dimensional imaging modality might contribute to potential false-negative results. Another limitation is the absence of histological confirmation through biopsy. Furthermore, due to the two-dimensional nature of the imaging modality, we were unable to provide information regarding the volume and three-dimensional shape of the APG. Despite these limitations, we believe that the current study may guide further studies as there is an insufficient study on this topic.

In this study, the prevalence of AEPG, FP, and APG was 56.6%, 31.6%, and 19.5%, respectively, and it was observed that the prevalence of APG decreased with age. The authors hope that this study will heighten clinicians' awareness regarding the presence of AEPG in the differential diagnosis of mid-cheek masses and emphasize the importance of utilizing ultrasonography for their detection.

Author contributions Protocol/project development H.T. Data collection or management T.A.U. Data analysis H.T. Manuscript writing/editing T.A.U. All authors reviewed the manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

Ethical approval World Medical Association Declaration of Helsinki is followed. Ethical approval was taken from Akdeniz University Clinical Research Ethics Committee (KAEK-160). Patients' consent to participate and publication approval can't be provided. However, unsigned version of consent document translated into English can be provided if desired.

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